Analysis on Application of Design Principle of Passive Natural Draft in Foreign Green Buildings

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Abstract
In this paper, based on a practical engineering design case in Northeast China, and combined with the actual engineering situation and the local climatic conditions, the technical method for integrated design of solar water heater and building is investigated. This provides reference and guidance for the application of solar energy in the residential building design, and it is conducive to promoting the wide use of renewable energy in the green residential building.

Keywords: passive manner, natural draft, design principle, green building

1. Introduction
The green building concept in "Green building evaluation criteria" is refers to maximum energy savings in the whole life cycle, protecting the environment and reducing pollution to provide healthy and efficient spaces and architectures with natural and harmonious coexistence for people [1]. From the concept of green building, the development and utilization of new energy and renewable energy is one of the main contents to achieve green buildings. The rise of green building in China is an inevitable component of the conservation oriented country. Green building complies with the trend of the times and needs of the people's livelihood. It is the further development and optimization of building energy saving. According to the development situation of green buildings at home and abroad, the development and utilization of solar energy, wind energy, geothermal energy and biomass energy have been realized in the green building. In recent years, the utilization of wind energy has been paid more attention by people [2].

Wind energy is one of the most important energy sources on the earth. The use of wind energy includes wind power generation, promoting indoor draft and so on, and
the latter is the main way to use wind energy in the green building. Under the guidance of a full range of passive design concept, without the use of special machinery and equipment, but heat energy naturally flows through the buildings by using convection, and the heat flow can be controlled by the performance of the building itself so as to obtain the effect of cooling [3]. The utilization of wind energy is closely related to the interior plane and space combination and the architectural form of the building. Wind energy utilization in the passive design concept is to make full use of natural draft, to exclude polluted indoor air, to improve the indoor environment and to ensure that the psychological needs of communication between man and nature. Natural draft is an essential measure to heat insulation in building and improve the indoor environment, and its advantages are energy saving, no pollution to the environment and convenient management.

2. The basic principle of passive natural draft [2]

Natural draft refers to that air flow through the purposeful opening such as doors, windows, chimneys and so on under the pressure of wind and heat, that people commonly refer to as "draft". There is the air pressure difference between windward and leeward side to produce the air flow, reduce the surface temperature, promote the indoor air circulation, improve the indoor thermal environment and satisfy the comfort of the human body. The size of wind pressure is related to the local wind environment, building form, the angle between the building and the wind, the surrounding buildings layout and so on [4]. Heat pressing is related to air temperature difference and dispersion of air inlet and outlet. Therefore, the layout and space design of the building have a direct influence on the ventilation.

In general, the building direction should be perpendicular to the local summer dominant wind direction, and unobstructed path should be designed in the building interior space. For the building that could not be very good use of the summer dominant wind direction, we can set some components for catching wind to lead the wind into the room. Vertical ventilation can also be obtained in the building by using the characteristics of vertical distribution of wind energy and air chimney effect. The air flow moves along a specific path under the wind pressure and heat pressing to promote the indoor air circulation, improve the indoor thermal environment and satisfy the comfort of the human body in urban built-up area, thus achieving the purpose reducing the use of air conditioner throughout the year and improving the frequency of ventilation and air quality.

3. Case analysis of foreign architectural design

There are many passive natural draft technical measures that are worth learning in foreign green building designs. The methods and measures of wind energy utilization for practical project design in some countries are introduced and summarized as follow.

(1) The office building of Watford Building Research Establishment, UK.

The office building of Watford Building Research Establishment in the UK is located in the south of England Waterford City, construction area of 2024 square
meters, including office and conference room. This building is a more successful green ecological architecture using passive building design and the advanced energy-saving technology, which has got the UK Green Building Excellence Award.

The building is perpendicular to the local summer dominant wind direction and takes full advantages of the natural draft to improve the indoor environment (shown in Fig 1). At the same time, the interior floor appearance of building is done some appropriate processing (shown in Fig 2), and the floor surface is wavy to promote natural draft. There are also five wind towers on the south facade of the building to keep drafty, and each wind tower is 1.2 meters in diameter and 4.5 meters high.

Figure 1. The office building of Watford Building Research Establishment in the UK.

Figure 2. The profile and real map of the building interior floor.

(2) Jubilee campus, the University of Nottingham, UK.

Jubilee campus, the University of Nottingham, UK, covers an area of 120 thousand square meters, construction area of 41 thousand square meters, including information center, teaching center, service center and other architectural features. The building was awarded the annual Sustainability Award for the Journal of the Royal Society of architecture.

Figure 3. A diagram of passive ventilation. Figure 4. The wind scoop of building roof.

The strategies of wind energy utilization used in the architectural design include two aspects: passive air cycle and the design of wind scoop. First of all, while designing ventilation, there are many ventilating shutters on the ground floor by using the characteristics of the construction near the lake (shown in Fig 3). The airflow
moved through the atrium space and fled to the stairs of the back façade, and the airflow rose up due to the stack effect and gone out from the windvane of 3.5 inch. This is a low energy consumption and passive air cycle process. Secondly, the wind scoop designed on the building roof (shown in Fig 4), could work well at the wind speed 2-40m/s and it leads air indoor to go out naturally due to vacuum effect. The windvane always turns with the wind and this is conducive to the exhaust.

The strategy of wind energy utilization in the design of Jubilee campus, the University of Nottingham, UK can be called heat recovery and low pressure mechanical ventilation, which is a hybrid system and it can use the natural draft and an effective mechanical ventilation device. The wind scoop energy dissipation in the design is 1/100 of the fan, and this design can achieve a good economic effect and meet the concept of environmental protection and energy saving green building.

(3) Tjibaou Cultural Centre.

Tjibaou Cultural Centre (shown in Fig 5) is located a beautiful island in the South Pacific Center, 1500 km distance from the east of Queensland, Australia. The building includes the exhibition hall, multimedia library and so on and combined the green ecological technology with the local culture. The passive ventilation is achieved by double skin system. The design won the Pulitzer Prize for architecture.

Figure 5. Tjibaou Cultural Centre.

Figure 6. A diagram of the double skin system of Tjibaou Cultural Centre.

In order to form a passive ventilation in the building, the double skin system is designed by Piano (shown in Fig 6). The exterior of building is divided into two layers: the external curved rib and the inner vertical ribs, and the two layers are made of plywood. The double skin system can let the air flow freely between the two rids under the heat pressing. An opening in the outer layer is used to guide the monsoon from the ocean, or to guide the airflow, while the skylight at the top is used to regulate the airflow. When there is a breeze, the skylight opens to promote ventilation. And when the wind is strong, the skylight is closed. In addition, when the outer roof
reaches $50^\circ$C, the top of the inner roof is only about $30^\circ$C, so the double layer roof system has received good results due to the air between the two layers helping to slow down the indoor temperature rise.

(4) Other foreign architecture.

There are also many buildings using natural draft or wind catcher and other wind energy utilization measures, such as the headquarters building of Commerzbank called as tower of ecology. The 49-storey tower is a triangular plane surrounded by an arc, and three columns are arranged in three corners and form a triangular atrium (shown in Fig 7). A number of air gardens are set up respectively in different directions to effectively organize the natural draft of office space. The building is also utilizing the external double skin design (shown in Fig 8). The outer layer is a fixed monolayer glass, while the inner layer is an adjustable double-layer Low-E insulating glass, and there is a hollow part of the 165mm thick between the two layers. The outdoor fresh air and indoor not fresh air can come into the hollow part to complete air exchange.

![Figure 7. Triangle atrium plan.](image)

![Figure 8. A diagram of external double skin design.](image)

![Figure 9. Natural draft principle.](image)

The headquarters of Barclay Card is a model of the contemporary office building with low energy consumption in UK and got the good rating in the evaluation of environmental assessment method of Building Research Center. The project has made a full use of natural draft and the lake near the building to reduce the indoor
temperature, and the natural draft principle is shown in Fig 9. Green business center in India used two wind towers to take the fresh air into the building and the wind towers can precool air to make the indoor air $5-6^\circ$C lower than the outdoor air. Two water cooling machines spray water at night to cool buildings and fan can exhaust the heat. School of environmental science and management in University of California, took the advantages of the sea breeze and natural light, heat and cold air to achieve the natural draft. Interactive floor space layout can be conducive to the natural airflow into the laboratory by using the chimney effect.

4. Conclusion

Through the above design case analysis, we can know that the passive natural draft as the idea in the architectural design and wind energy can be effectively used by some technical measures, the specific measures are summarized as follows:

1. Make full use of the natural conditions to achieve the natural draft, such as the building designed to be perpendicular to the local summer dominant wind direction, sea breeze, lake wind and other favorable conditions.

2. The layout form as well as wind towers, wind scoop, inner courtyard and so on could produce the chimney effect or vacuum effect, and the passive natural draft will be achieved under the wind pressure.

3. The external double skin design and the heat pressing can promote ventilation and the exchange of indoor and outdoor air so the natural draft will be completed and the indoor environment will be improved.

In short, the above measures can achieve a good natural draft and the goal of energy saving and environmental protection, and the technology and architecture could be a very good combination. Green building in our country is at the initial stage, and the experience of foreign architectural design is worth summarizing and learning to realize the green building in our country.

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References