The application of natural ventilation of residential architecture in the integrated design

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Abstract: As one of the important parts in the architecture design, ventilation fully reflects one important factor of energy conservation to some extent. To ensure that decreasing use of energy resources to the maximum extent in architectures and make architectures harmonize with their surroundings, which have become important pursuing gradually for residential architecture, at present, integrated design of residential architecture should not only highlight natural ventilation technique, but also should integrate natural ventilation and main feature of local climate, etc. What's more, designers shall carry out unified analysis on the base of taking all factors into consideration. This point is more important. By this way, architecture technique can be more comprehensive and complete. With the guidance of sustainable development concept, natural ventilation as one of ecological technologies is applied extensively in many architecture designs owing to its economic effect and health benefit.

With the rapid development of society and progress of times, health issue has attracted people’s eyes. To make indoor air fresh, people always open windows regularly to welcome fresh air enter and make the original polluted air go out for four seasons. Meanwhile, health factor is taken into full consideration. When designing the residential architectures, designers need to carry out comprehensive application on the base of detail knowing to natural ventilation designing methods. They use this way to improve indoor environment to the greatest extent and build a good and comfortable living environment for people.

1. Important meaning of natural ventilation
At present, owing to health concept and economic effect of natural ventilation, it is applied extensively in the integrated design for a large number of residential architectures. So it can replace the position of air conditioner and other systems to some degree and decrease consumption of all kinds of energy resources to the great extent.

On one hand, natural ventilation of residential architecture enables effectively realizing passive cooling. When humidity and temperature of outdoor environment are lower relatively, natural ventilation can automatically carry out some activity to decrease humidity and lower temperature without using any energy resources. This can provide a good and comfortable living environment. Besides that natural ventilation can reduce usage of all varieties of energy resources and cut down environment pollution, which corresponds to sustainable development concept advocated by the nation principle of complete harmony. On the other hand, natural ventilation of residential architecture brings new wind that is fresh enough to a great extent. This plays an important part in improving health and emotion of people. One of important reasons why current indoor air quality is not good and decreases is that there is no enough new wind and new wind is not fresh enough. The long usage of air conditioner leads to a series of problems. But natural ventilation enables effectively clearing out stale
air and smell to a great extent. And it benefits to realize harmonious development of people and nature.

2. Main principles of natural ventilation
Natural ventilation of residential architecture can be divided into two models complete natural ventilation and machine assisting ventilation according to the source of driving force. Complete natural ventilation has direct relation with density difference between indoor air and outdoor air and wind pressure.

2.1. The function of wind pressure
To a large degree, the forming of wind has direct relation with pressure difference existing in the air. The function of wind pressure is that using mainly pressure difference existing in windward side and leeward side to have ventilation. When wind blows from the left side of architecture, windward side can produce a positive pressure that is 1.5-1.8 times of the dynamic pressure under normal wind speed with the air promotion. Leeward side produces a negative pressure that is 1.3-1.4 times of dynamic pressure under normal wind speed with strong influence of air flowing around. Under the effects of positive and negative pressure, natural ventilation of wind pressure type that can have air changing comprehensively is formed owing to this, but there is a matter that wind pressure around architecture can be influenced by many factors, for example buildings’ geometries, concrete positions, wind speed, surrounding environment and others, as the following picture 1-1.

2.2. Heat pressing function
The forming of heat pressing relates to temperature difference between the indoor temperature and outdoor temperature to a great degree. Somehow, the principle that natural ventilation is under the effect of heat pressing is similar to the principle of hot air rising. House building designers usually set some certain air outlet on the upper side of architectures, which is to exhaust indoor polluted air in time and introduce outdoor fresh air. It realizes effective conversion between indoor air and outdoor air. Meanwhile, owing to the influence of temperature difference, there is some certain density difference; baric gradient also produces towards the direction that is perpendicular to the wall. If indoor temperature is higher obviously than outdoor temperature, pressure above the architecture will be higher than the temperature below the architecture; when there are some certain orifices on the upper part and below part of architecture, air can enter from the lower orifice and flow out from the upper. If outdoor temperature is higher than indoor temperature, the direction of air flowing is totally opposite. So an important conclusion can be drawn that heat pressing has a direct relation with temperature difference of indoor air and outdoor air and height difference of orifice.

Therefore, when we carry out integrated design to natural ventilation of residential architecture, we can use fully piping shaft, pull air shaft, stair half, atrium and other vertical cavities to adapt and meet the height difference between foot entering and air outlet. Then it can exhaust a large amount of hot air existing in the architecture in time, which makes ventilation effect of architecture become perfect, as the following picture 1-2.

![Fig.1 Under the action of wind pressure of natural ventilation](image1)

![Fig.2. Under the action of thermal natural ventilation](image2)
2.3. Combined action of air pressure and heat pressing

As a matter of fact, natural ventilation in the residential architecture is the result with combined action of air pressure and heat pressing. However air pressure and heat pressing are influenced by all varieties of factors, e.g. climate, shape of architecture, specific direction of outdoor air and surrounding environment situation and others. And the effects of these two pressures are not just the linear superposition, for example, in the same architecture, if the heat pressing is below the windward side, to ensure that direction of wind pressure effect is consistent, air entering volume should be bigger than the one under the effect of heat pressing. But if wind pressure on the upper part of windward side is much bigger than the heat pressing, correspondingly air can’t be exhausted from the upper hole. Air will flow backward.

Meanwhile, outdoor wind speed and wind direction change all the time, in order to ensure good natural ventilation effect, wind pressure usually is not taken into consideration in the calculation, but wind pressure exists all the time. Its influence on natural ventilation exists, so it is possible that alternate using the effect between wind pressure and heat pressing.

2.4. The effect of machine assisting

In some big architecture designs relatively, ventilation path usually is bigger, which produce very strong flow resistance. Under this condition, if just depending on the combined effect of wind pressure and heat pressing to realize natural ventilation, it is not real at all. For the cities polluted seriously, like noise and air pollution, if having ventilation directly, it will take the outdoor pollution into indoor room. This is harmful to people’s health to a great degree. At this time, use related machine assisting effect to have natural ventilation, which can achieve good ventilation result.

3. Integrated design methods and natural ventilation design methods

To some certain degree, integrated design method is a method taking organic combination, mainly including spiraling and integrated platform. Natural ventilation of residential architectures usually can view the whole building as a organic integrated system in the integrated design. Then they can carry out unified process and consideration from the whole period of life. On the base of these, residential architecture can adapt better to local geography condition, climate features and others. It mainly includes building concept, structure concept, energy and environment concepts about houses. Realizing these concepts can’t be separate with the interaction of many majors.

However, integrated design method is not perfect. There are very serious problems in these aspects ventilation, getting heat, light selecting, floodlight and other energy resource consumption. So it is necessary to take natural ventilation, light selecting, heat keeping and others into consideration in the design. And it is possible that effectively decrease the consumption of important energy resources.

What’s more, in the natural ventilation design of residential architecture, all kinds of assisting measures for decreasing temperature are required to decrease the indoor temperature in the summer. In the process of decreasing indoor temperature, natural ventilation and air conditioner play their roles. This can decrease effectively consumption of related energy resources. So when designers use natural ventilation, they are required that considering fully the basic requirements of local architecture, climate feature and other factors. On the base of these, natural ventilation can play a perfect role.

4. The application of natural ventilation in the integrated design

4.1. Designing natural ventilation under the different climate conditions

There are many factors influencing natural ventilation of residential architecture, e.g. layout of building, location and others. If designers can have scientific layout to building, it can achieve perfect natural ventilation result. Meanwhile, natural ventilation of residential architecture is influenced greatly by climate condition. So designers need to choose geography location reasonably and scientifically, consider fully space range of climate. Generally, climate condition concludes the following factors.
Firstly, designers should consider Chinese real climate region in the design. Chinese climate region mainly includes season changing region which refers to that wind direction changes with the season changing. Most frequent wind direction region refers to that wind direction doesn’t change within one year, as Nei Monggol, Tibetan plateau and others. There are the most frequent wind direction region, which refers to that wind direction always changes within one year. If the building is located here, designers need to consider wind speed. (Quasi-stationary wind is that wind speed is below 1.5 meters) Secondly, take local climate into consideration; local climate is called local circumfluence including water and land wind, forest and plain wind and others, keep building orientation be consistent with the wind direction. Thirdly, fully consider local micro climate. On the base of knowing micro climate, consider building layout, separation distance and the influence of surrounding vegetation on natural ventilation.

4.2. Designing natural ventilation scientifically and reasonably according to building features
Firstly, take these factors including building material, structure, psychology of resident into consideration, then ascertain the storey height of the whole building. Storey is usually divided as stratum, high-rise and multilayer. Height of building decides the number of layer. But in the real design, high-rise mainly includes small high-rise, super high-rise. Generally, there are many factors influencing the number of layer, e.g. real using condition of local land resource, related laws and regulations and others, so designers need to think of above factors and design the number of layer reasonably and scientifically. Somehow, use this point to ensure good natural ventilation result.

Secondly, wind speed spreading in the vertical direction of building will increase with the increasing of number of layer. So when carry out specific building design, think of wind speed.

Thirdly, in the integrated design of natural ventilation, the design of hole setting can influence indoor air circulation and real wind amount. In the most cases, hole opening is bigger, wind amount will be bigger. But designers also need to consider solar radiation, wind speed and building location.

4.3. Designing natural ventilation reasonably and scientifically according to the details of building
Firstly, main methods for designing the size of window
Windows as the detail part of building is the main media of light selecting and ventilation of buildings, it plays an important part in the natural ventilation. In the process of designing size of windows, designers should not only consider the opening hole, but also should choose scientific and reasonable way to open windows, as the window-blinds, sliding window and others. These window opening methods have a good ventilation result.

Secondly, designing the specific shade form
In the integrated design of natural ventilation, designers ought to think of shade results with different forms, choose appropriate shade form according to real situations of buildings.

Conclusions
Ventilation as one of the important parts in the architecture design can give the full representation of energy saving result to a certain degree; decrease the usage of energy resource to the great extent; make it be a part of surrounding environment. Integrated design method is a method taking organic major combination, mainly including spiraling and integrated platform. This paper introduces briefly meaning of natural ventilation. It explains main natural ventilation principles from wind pressure effect, heat pressing effect, combined effect of wind pressure and heat pressing and machine assisting effect. Next, this paper describes that designing natural ventilation under different climate conditions, designing natural ventilation reasonably and scientifically according building’ features and details. And introduce species application of natural ventilation in the integrated design.

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References:

[1] Jin xi, shen shouyun, xie mingjing. architecture designing strategy based on ecology technology concept [j]. journal of central south university of forestry and technology, 2013, (02).

[2] Leng yanfeng, zhao hui, yuan rubing. study on natural ventilation measures of residential architecture in the area with hot summer and cold winter [j]. construction science, 2011, (02).

[3] Wang jie, wei jia. exploration and practice of integrated design in the green residential area [j]. architecture design managing, 2011, (10).

[4] tan hongwei, ji liang, pu zhen. natural ventilation concept and efficiency under the condition with changing wind [j]. journal of central south university (science and technology)

[5] Wan xin, su yaxin. the application of natural ventilation technology in the modern architecture [j]. architecture and saving energy, 2007, (09).

[6] Zhou min. study on ventilation design of chinese traditional residential architecture— as old street of nanjing [j]. urban studies, 2015, (12).

[7] Zhang wei, wang chuan. discussion about architecture’ integrated design with the concept of sustainable development [j]. journal of shenyang jianzhu university (social science edition), 2009, (03).

[8] Zhang qun, che xiaomin, liu jiaping, hui shankang, wu xiaoxiang. real measure analysis and design strategy of natural ventilation in the sunan region [j]. journal of xi’an university of architecture and technology (science and technology), 2015, (01).