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The Current Status of Natural Ventilation- Enabling Noise Reduction Devices in Urban Green Buildings

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ABSTRACT

In the process of urbanization, in order to reduce energy consumption and improve indoor environmental quality, natural ventilation system is widely used in many green buildings. But under the interference of noise pollution, it is difficult to balance the relationship between ventilation and denoise. This paper summarizes the current status of natural ventilation- enabling noise reduction devices in urban green buildings, and focuses on the sound insulation properties of windows, balconies and ventilation pipes. Compared with traffic administration, green belts and noise barriers, the devices are easier to implement and have higher cost-effective. Furthermore, this paper also analyzes the drawbacks of existing and the development prospects of the devices.

Keywords: Noise, Ventilation, Green Buildings
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1. INTRODUCTION

Noise can lead to auditory and nonauditory effects on health, especially following long-term exposure. These effects are the result of psychological and physiological distress, as well as a disturbance of the organism's homeostasis and increasing allostatic load [1]. Under the urban canyon effect, noise will intensifies its interference to citizens, especially in a city with high-density high-rise buildings. Although high-rise buildings alleviate the contradiction between the rapidly increase of urban population and the shortage of land, they also exacerbate the difficulty of controlling urban noise pollution. How to provide a satisfactory indoor acoustic environment for households has been a growing concern of policy makers and the public.

Generally, road traffic noise is considered to be the major factor of urban noise. According to the China Environmental Noise Prevention and Control Annual Report, the average daytime road traffic noise in municipalities and provincial capitals is 68.9dB (A), which is far higher than 53dB decibels strongly recommended by the World Health Organization[2-3]. With the vigorous promotion of urbanization in China, urban vehicles are becoming more and more saturated, it is difficult to adjust traffic management policies (e.g. changing vehicle speed, traffic intensity or traffic composition) in time to cope with the situation. Compared with the relatively stable urban noise in the daytime, intermittent noise at night is more harmful to households [4-6].

It is considered extravagant to use large amounts of land to set up road noise barriers

and greenbelts, especially where the roads are very narrow. Noise can easily diffuse through diffraction or multiple reflections from the facades of high-rise buildings on both sides. So for households, the most direct way to reduce noise is to close the windows, but again, this is achieved at the expense of natural ventilation and indoor air quality. Although mechanical ventilation system can provide indoor ventilation, it does not meet the concept of sustainable development of green buildings and zero-energy buildings. How to satisfy the requirement of natural ventilation and at the same time attenuate external noise is the design concept of natural ventilation-enabling noise reduction device.

In this paper, the research and development status of natural ventilation-enabling noise reduction device in recent years is briefly described, and the future development of such devices is prospected.

2. NATURAL VENTILATION - ENABLING NOISE REDUCTION DEVICES

Plenum window is the key content and the main means of noise reduction in the sound insulation renovation of existing residential buildings. Generally, plenum windows are defined as windows with air intakes (outdoors) and air outlets (indoors), which form S-shaped ventilation streamlines in the ventilation chamber; transverse or vertical perforated panels are set in the chamber to separate the cavity, or silencing passages containing sound absorption materials are used to block the cavity. Under the condition of complete closure, the sound insulation capacity of external windows of civil buildings can reach 20-40dB.

Research on ventilation window structure mostly focuses on the size of the opening, location of the openings, the relative displacement of the openings in the two layers. In order to systematically analyze different structural parameters for natural ventilation-enabling noise reduction device with staggered open structures, Egzon Bajraktari et al studied the combination of multiple openings, so that the influence of different system parameters can be evaluated by experience and calculation[7].This experiment is a few, which can systematically analyze the influence of various structural parameters on the noise reduction performance of ventilation windows.

In order to enhance the noise reduction performance of ventilation windows, researchers often add sound-absorbing materials/devices to the inner walls of windows. In principle, it is similar to installing sound absorbing materials in road noise barriers. Tang studies the possibility of installing rigid cylindrical arrays in the window cavity to improve the sound insulation loss of the ventilation window, and analyses in detail the sound field in the inflatable window and its relationship with the enhancement of sound transmission loss[8].Similar to the principle of adding sound absorption device, Hsiao Mun Lee et al. designed a new acoustic crystal window. The SC window can attenuate additional 4.59 and 9.40 dBA white noise in the full frequency range from 700 to 1400 Hz, respectively[9].The most important thing is that the experiment is not only based on the data measured by the sound level meter, but also takes into account the psychology of the subjects.

Although the noise reduction provided by these two ventilation windows is not much, there is a great breakthrough in principle compared with the simple installation of Micro-Perforated panels. Because the noise reduction performance of Micro-Perforated panels has a great relationship with the perforation rate, it is difficult for ordinary small

window manufacturers to master. Therefore, the technology of making natural ventilation sound insulation windows by this technology is more difficult, and consequently the cost is higher.

In recent years, although the development of sound absorption devices/materials is very difficult and the cost of testing is very high, it is the focus of researchers. Patent inventors provide more structural solutions, and few of them really analyze windows systematically. Most of the people engaged in noise pollution control are in research institutes and universities, but there are few practical talents.

In addition to ventilation windows, balconies also have good noise reduction performance. Balcony, as a buffer space of heat insulation and sound insulation, plays an important role in providing comfortable noise control environment for residents by blocking the sight of the ground noise source directly from the receiver. But between two adjacent high-rise buildings, the noise can easily enter the interior of the balcony from the exposed semi-enclosed balcony after many reflections on the uneven wall, and form a local reverberation field through multiple reflections on the interior wall of the balcony to reduce the noise reduction performance of the balcony[10,11]. Even if the balcony is reconstructed into a fully enclosed balcony, the noise reduction ability is not improved much compared with the semi-enclosed balcony. It is also found that the closed balcony will lead to lower cross-hall wind effect, lower indoor wind power and lower wind speed.

Future green buildings in natural ventilation and noise reduction efforts to do not only ventilation windows or soundproof balconies, it should be developed into the ventilation system of the whole building. Taking the noise reduction project of an international convention and Exhibition Center as an example, in the early stage of the project, the author carried out noise detection for 8 ventilation equipment rooms and their corresponding functional areas. The noise of each fan room is between 77.1-80dB(A), and the average noise of each functional area is between 63.2-67.5dB(A), except for the presidential suite. Although insulating layers with porous materials are installed on the outer walls of all ventilation pipes, their noise reduction performance is limited.

Therefore, we hope that we can predict the noise problems we may face at the beginning of construction, and choose the building materials to be installed accordingly. But in fact, with the increasing functionality of cities, the dominant factor of urban noise is not only traffic noise. New urban noise, mainly loudspeakers, also interferes with households'rest. Compared with traffic noise, this kind of noise has great difference in amplitude and frequency ,and brings great difficulty to the research of ventilation and noise reduction device.

3. CONCLUSION

From the analysis of the research and application status and existing problems of natural ventilation, it can be seen that natural ventilation is an integral concept of architectural design, and involves many contents. At present, most of the research work is scattered and no fully integrated technology has been formed. The sound insulation performance of the building as a whole is easily damaged by the sound insulation

performance of a single device and becomes very poor.

How natural ventilation can be applied to various buildings in cities or suburbs normally and successfully still needs a lot of research work. Considering the building envelope structure, material, natural ventilation mode, ventilation control and service life, the development of integrated natural ventilation technology in buildings under special urban climate needs further exploration, but it is bound to be the development direction of natural ventilation.

4. REFERENCES

1. Basner M, Babisch W, Davis A, et al, "*Auditory and nonauditory effects of noise on health*", Lancet, 2014, 383, 1325-32
2. Ministry of Ecology and Environmental of the People's republic of China, "*China Environmental Noise Prevention and Control Annual Report*", 2018
3. "*Environmental noise guidelines for the Euroean Region*", World Health Organization: Bonn, Germany, 2011.
4. Ali-Mohamed Nassur, Damien Leger, Marie Lefevre, et al, "*The impact of aircraft noise exposure on objective parameters of sleep quality: results of the DEBATS study in France*", Sleep Medicine, 2019, 54, 70-77
5. E.Öhrström, A.Skanberg, "*Sleep disturbances from road traffic and ventilation noise-laboratory and field experiments*", Journal of Sound and Vibration, 2004, 271, 279–296.
6. Laurie Thiesse, Franziska Rudzik, Karine Spiegel, "*Adverse impact of nocturnal transportation noise on glucose regulation in healthy young adults: Effect of different noise scenarios*", Environment International 2018, 121, 1011–1023
7. Egzon Bajraktari, Josef Lechleitner, Ardeshir Mahdavi, "*Estimating the sound insulation of double facades with openings for natural ventilation*", Energy Procedia 2015, 78, 140 – 145
8. S.K.Tang, "*Reduction of sound transmission across plenum windows by incorporating an array of rigid cylinders*", Journal of Sound and Vibration 2018, 415, 25-40
9. Hsiao Mun Lee, Long Bin Tan, Kian Meng Lim, "*Sound Quality Experiments in a Student Hostel with Newly Designed Sonic Crystal Window*", Acoust Aust 2017, 45, 505–514
10. S.K.Tang, "*Noise screening effects of balconies on a building fa ɕade*", J. Acoust. Soc. Am, 2015, 118, 213-221
11. May D. N, "*Freeway noise and high-rise balconies*", J. Acoust. Soc. Am, 1979, 65, 699-704