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Experimental Study on the effects of layered air supply angle and air supply temperature on indoor environment

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Abstract

In this paper, the experimental research method was used to explore the effect of the temperature and the angle of the air supply on the indoor thermal comfort in the condition of stratum ventilation. The temperature range of air supply was 19~22 Celsius degrees and the air supply angle range was 30~150 degrees. When the supply air temperature was 19 degrees Celsius, the indoor PPD at different angles were large relatively and reached the maximal value when the angle of the air supply was 90 degrees. When the air supply temperature was 22Celsius degrees, the effect of air supply angle on the PPD value was less and reached minimal value when angle of the air supply was 45degrees. When the air supply angle was 90 degrees, the PPD value was more than 10% in different air supply temperatures which did not meet the requirement of indoor thermal comfort. The PPD value could meet the requirement in other conditions.

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1. Introduction

With the economic development and the improvement of science and technology, the proportion of people staying indoors increases ceaselessly. According to the statistics, the time that the vast majority of people living in the indoor accounted for 70% to 90%. The quality of the indoor air was closely related to human health. The indoor

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environmental quality requirements of people are also getting higher and higher. Meanwhile, Good indoor air quality has a positive effect to improve the efficiency of indoor staff and to ensure production efficiency and quality. In architectural interior environment, heating and air conditioning was created a relatively isolated indoor environment from the natural environment. Modern HVAC technology has also been fully developed[1].

With environmental pollution and the world energy crisis continues to intensify, Asian countries proposed make appropriate increase with the temperature of the indoor air-conditioning in summer to in response to the energy crisis and mitigate the greenhouse effect. China mainland raised the summer guidance temperature of public buildings to 26℃, Hong Kong 25.5℃, Taiwan recommended 27℃, Japan and South Korea to 28℃. Even the ANSI / ASHRAE standard 55-2013 also recommended to increase the summer wind speed to eliminate thermal uncomfortable caused by increasing the door design temperature[2]. For indoor staff, the air quality of the human respiratory zone was directly related to the body's health and work efficiency. From the development history of the HVAC ventilation, the air quality control from global to local was the trend of development in future. How to reduce the building energy consumption under the prerequisite of increasing the air supply temperature without affecting the thermal comfort of the building indoor has become a hot topic in the current academic research. Taking into account those general elements, Lin Zhang of the City University of Hong Kong had proposed the concept of stratum ventilation for small to medium sized rooms[3].

T.Tchow，C.Ftsang，K.F.Fong，L.S.Chan made relevant experimental and numerical studies, and those studies shown that stratum ventilation could improve the design temperature of air-conditioned rooms without reducing the thermal comfort[4]. Lin Zhang, Zhou Tiantai and Zeng Zhichuan of the City University of Hong Kong had optimized the air supply parameters through experimental and numerical simulations[5]. The study of Tian Lin et al demonstrated that the stratum ventilation could achieve good thermal comfort, and the diffusion of CO_2, toluene and formaldehyde was studied by the experiment and numerical simulation. The results show that the ventilation of stratum can ensure good ventilation Air quality[6]. Tian Lin et al also studied the diffusion of particulate matter under stratum ventilation and the results showed that the concentration of particulate matter in the breathing zone was less than that of displacement ventilation[7]. For the hot neutral temperature, the stratum ventilation was 2.5℃ higher than the mixed ventilation and 2.0℃ higher than the displacement ventilation, which allowed the stratum ventilation to ensure thermal comfort when the room temperature reaches 27℃[8].

In this paper, we study the effect of stratified air supply temperature and air outlet angle on the thermal environment of the office through the experiment on the comprehensive test bench.

Nomenclature

σ	indoor temperature non-uniformity coefficient
$\overline{t}$	average temperature℃
t_i	temperature of measure point℃
PPD	predicted percentage of dissatisfaction

2. Experimental introduction

Figure 1 to Figure 5 showed influence of air supply temperature difference on indoor temperature distribution at the different air angle. The results show that when the air supply angle was 120 degrees (Fig.4), the air supply air temperature had the least effect on the indoor temperature distribution, and the indoor temperature difference under the air temperature condition was reduced. The temperature difference between the head and foot was the smallest under all operating conditions. In the same height plane, the average temperature difference under different temperature conditions was very small. When the air supply angle was 60 degrees (Fig. 2), the average temperature difference under the different air temperature conditions was the biggest and the air supply temperature has a great influence on the indoor temperature distribution under the condition of this air supply angle. The trend of air supply temperature and indoor temperature distribution was basically the same under the conditions of the air supply angle of 30 degrees (Figure 1) and 150 degrees (Figure 5), but under the conditions of the air supply angle of 150 degrees,

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