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Study on Emporium cooling load distribution and Airflow Optimization indoor

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Abstract. On-the-spot survey, we get the lighting and body cooling load in three emporium, based on the summary of load distribution, Put forward suggestions for improvement airflow form in emporium, demonstrated the improvement of system ventilation efficiency and the decrease of energy consumption after improved.

Keywords: emporium; cooling load; airflow distribution; ventilation efficiency

1 Introduction

Emporium, as a large public building, in where air conditioning applications is very common exist. Studies have shown that, most of the emporium have installed air conditioning system, but the system 's energy efficiency is generally not high enough [1], because of the characteristics of indoor load distribution did not fully consider when designed the air conditioning system, supply and return air have been arranged unreasonable, thus the lower ventilation efficiency.

Air conditioning loading characteristics in the three large-scale comprehensive emporiums, have been depth tested and researched. The density and distribution of lighting and body cooling load in emporium is of great difference from it widely recognized currently in project. This kind of indoor load characteristics is been investigated, and proposed air distribution solutions for the above features, which can effectively improve the efficiency of air conditioning and ventilation in emporium, reduce air conditioning energy consumption.

2 About the study

The surveyed emporiums are located in commercial focus area in the urban, which are comprehensive retail businesses, business area were 35,000 square meters, 42,000 square meters, 43,000 square meters, sales in good condition.

The three shopping centers are all installed full air conditioning system; airflow organization is top-supply and top-return air by diffuser, which evenly arranged.

To facilitate the analysis and description for the distribution of lighting and body

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cooling load inside the mall, according to the characteristics of the internal arrangement inside the mall, business area will be divided into two parts, one is counter area, the main function of it is to display commodity, it's area accounted for about 60% - 70% of the business area; the other is aisle area, the main function is to provide customer or service staff to walking or stay, it's area accounted for about 30% - 40% of the business area.

3 The Characteristics of Interior building lighting and body cooling load

3.1 density and distribution of lighting cooling load

According to the characteristics of the lamp arrangement, lighting in mall can be divided into local lighting which located above the counter and overall lighting which evenly distributed across the top of the mall space. The three malls mainly rely on artificial lighting indoor, so lighting load has a high density, and with commodity type and layout of the mall, it's distribution showing extremely uneven features in horizontal and vertical

(1)Because of the large presence of local lighting facilities in counter area, after summarized with the overall lighting, the lighting load density in the three mall is 45.1W/m^2, 52.3W/m^2, 59.6W/m2. But in the personnel area there is only overall lighting, It's load density is only 14.1 W/m^2、15.4W/m^2，16.9W/m^2.

(2)Since most of the lighting is mounted in ceiling, a larger portion of the lighting heat would get into the closed chandeliers first, and then heat the ceiling before get into the interior space by convection. The air temperature inside the ceiling of the three mall is 31.5℃、31.7℃，32.1℃，which temperature is 4 ℃-5 ℃higher than the work space.

3.2 Personnel cooling load density and distribution

In the current technical measures, the recommended values of personnel density in emporium are shown in Table 2.

Table 2. Recommended values of personnel density[2]

Room Name	Personnel area index(㎡/person)	Personnel density(person/㎡)
General store business hall	3	0.33
Boutique shopping	4	0.25

After the survey, we found a large difference between the density of personnel

load and the recommended values in manuals, and the distribution also reflects a certain regularity. In the table1,we can find that:

Personnel density is much less than the recommended value. The measured data is peak values of passenger flow(Test date is a Saturday in August), for the three malls, the maximum data of personnel density in a whole day is only 0.12person/m^2、0.13person/m^2，0.15person/m^2, it not more than half the recommended value in manual. The main reason is most of the internal field area had been occupied by counter and commodity, the remainder area for passageway is lesser. Therefore, it looks crowded, however, the total number of people is not too much ; furthermore，more and more shopping malls appear, with the improvement of the shopping environment, personnel density of shopping mall is decrease.

4 Air flow optimization for indoor load distribution characteristics

The pros and cons of airflow distribution have significant impact on ensuring indoor air environment and reducing air conditioning energy consumption of the buildings. Airflow impact on indoor air environment, which can be represent as the ventilation efficiency of the system Ec, the steady-state expression is:

$$E_{\mathrm{c}} = {c_e - c_s}\Big/{c_i - c_s} \tag{1}$$

Ventilation efficiency is a index which represent the ability of ventilation system to exclude contaminants, the main factors that affect the index is both the location of the air inlet, outlet and the location of contamination sources and it's dissemination characteristics.

In the three shopping mall, air distribution forms is up-outlet and up-return air by diffuser, which evenly arranged, as shown in Figure 1. The Internal area no matter for the crowded aisle or for commodity display, is the area burden by a pair of outlet and return air. The interior space is assumed to be divided into two part, upper and lower. Supply air flux is expressed as Q, secondary circulation air flux is βQ, and β is mixing coefficient, which is the ratio of secondary circulation air flux and primary one.

Studies have shown that, for this evenly arranged up-outlet and up-return air pattern, the ventilation efficiency of the system in workspace is relatively low[3]. However, because of the limitation of condition, for the relatively efficient way airflow such as lower blow and lateral blow, it is difficult to apply in such a large space in the mall[4]. Then, on the premise of the same basic ways of up-outlet and up-return air, how to improve the efficiency of ventilation as much as possible? Obviously, whether it is evenly arranged or inside and outside arranged, the characteristics of the internal load in mall did not fully be considered. especially for the distribution of personnel and lighting cooling load.

According to the characteristics of the lighting, personnel load distribution, change

the uniformly for personalized supplying air. increase the number of outlet for personnel relatively concentrated region, and increase the number of return air and exhaust ports for counters area more lighting but few persons, as shown in. Fig 1. This would increased air volume for personnel concentrated region, also played a mobile guide of indoor air from personnel area to counters area.

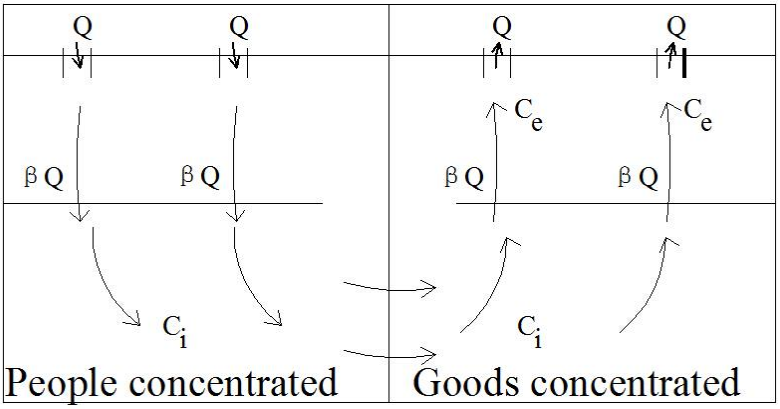

Fig1. Indoor air distribution diagram of improved location of supply, return air

Because the air conditioning supply, return air were rearranged according to the layout inside the mall, supply air is the main way in the personnel region, to exhaust the air in the commodity region. There formed a transverse air flow between the personnel region and the commodity region, that is to say, after the supply air blowing through the personnel region then blowing transverse through the commodity region, last to leave the room through return air inlet above the commodity region. Thus, if the personnel region is analysis separately, where airflow is no longer a top-supply and top-return air, but become a top-supply and lower-return air, in[3] and [5], the two patterns had been theoretical analyzed, and their ventilation efficiency curves had given in Fig 2, under the same value of β, top-supply and top-return air's ventilation efficiency is much lower than top-supply and lower-return air. Such as when $\beta = 2$, the two ventilation efficiency is 0.58 and 1.1. evidently, the adjusted system ventilation efficiency greatly improved

5 Conclusions

(1) There is a big difference between the value of many shopping mall actual cooling load constitute and recommended value in design manuals, interior lighting, body cooling load are not evenly distributed in shopping mall, but reflects a certain

regularity with the internal arrangement of the mall.

(2) After fully considered lighting, personnel distribution characteristics, personalized arrangement of delivery, return air can improve the ventilation efficiency and reduce air conditioning energy consumption.

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