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Medium Term Thermal Comfort of College Dormitories in Western Cold Region

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Abstract: During the middle period of heating in winter, the author studied the characteristics of thermal comfort and thermal adaptation of 4 dormitories of a college in the west. At the same time, a questionnaire on subjective thermal sensation was conducted, and 500 questionnaires were distributed to the subjects. Finally, 462 valid questionnaires were obtained.Through the study of data, the function of real average thermal sensation and indoor operating temperature has been obtained. The results show that the thermal neutral temperature is 19.8 degrees, the male and female thermal neutral temperatures are 19.5 and 20.1 degrees respectively, and the acceptable ranges of 80% and 90% for males are 16.5℃~23.0℃、17.7℃~21.3℃.The acceptable range of 80% and 90% for females is 16.2℃~24.0℃, 17.8℃~22.4℃.

Keywords: University Dormitory; Thermal Comfort; Adaptive Behavior; Field Investigation

Tsinghua University energy conservation research center in 2011, China's urban heating energy consumption is larger, accounting for 24.2% of all energy consumption in buildings. In the following years, the proportion of heating energy consumption increased gradually, and the severe cold area was the most prominent[1] according to the existing code for design of heating, ventilation and air conditioning in civil buildings, the calculated temperature of all heating areas should be 18℃ [2], however, in many heating areas, the temperature of the heating season has already exceeded this temperature. Singaporean scholar Wong[3]studied the relationship between floors and thermal comfort through a thermal comfort vote, and concluded that the air velocity has a great relationship with thermal comfort. Through research, Morgan[4] concluded that clothing resistance is affected by psychological factors in addition to outdoor temperature. Although these scholars have done a lot of research on the thermal comfort of campus buildings and office buildings, there is little research on the revision of the thermal comfort model for the dormitory heating season in the cold area of western region. This paper takes the dormitory building of a university in the area as the research object, and studies the thermal comfort and thermal adaptation through subjective questionnaire survey and objective measurement. It provides an accurate basis for the design and evaluation of the thermal environment of the interior space of winter buildings in the region.

1. Research method

1.1 Thermal comfort research method

The research method of thermal comfort is based on the measurement of environmental parameters and questionnaire survey. The instrument used in indoor environmental parameters test is the TR001 heat and humidity self recording instrument. The instrument has designed the parameters on the computer before testing. The parameter is to record the temperature and humidity with 10min as an interval, and 5 points in each dormitory. The height of the ankle is 0.1M at the height of the sitting body, the height of the waist is 0.6 meters, and the wall of the head is 1.1m. The main content of the questionnaire is 7 level scale (cold, cool, slightly cool, neutral, slightly warmer, warmer, hotter), and the time of the respondents' answers is recorded. The temperature at the same time measured by the TR001 temperature and humidity self recording instrument is compared with that of the TR001,

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followed by an interval of 0.5 degrees centigrade. They are divided into n intervals. In these intervals, the temperature is taken as the independent variable, and the patients are given the thermal sensation vote in the form of questionnaires.

1.2 The subjective and objective thermal comfort

The subjective thermal comfort PMV model is about the human body's thermal radiation model, which means that the parties are in a relatively stable hot ring. The heat load of the human body determines the thermal comfort of the human body. When the heat load of the human body is above zero, the greater the value of the body, the hotter the human perception; when the heat load of the human body is below zero, its value is smaller.The colder of human perception. Fanger professor in thirteenth Century in the United States and Denmark extracted a number of subjects conducted experiments on thermal comfort, and obtained the research content of human thermal sensation and load. According to the standards of indoor thermal and wet environment evaluation criteria for civil buildings, the relevant values of measured humidity, wind speed, mean radiation temperature, clothing resistance and metabolic rate are taken into the PMV formula to calculate the predicted thermal sensation vote values. The thermal comfort evaluation of building environment began in the early nineteenth Century. Since 1919, the American Institute of heating and Ventilating Engineers pioneered the research of steady thermal comfort. Based on the laboratory data, Professor Fanger took the human heat balance equation and the seven point scale of the American Institute of heating, refrigeration and air conditioning as the starting point.

2. Data research and analysis

2.1 Analysis of measured air temperature and relative humidity

Figure 1 is the average of 4 quarters of the indoor air temperature and relative humidity for 16 days in the middle term of heating. The chart shows that the trend of daily average temperature and average humidity in the temperature range tends to be stable, the trend of the two is negatively correlated and the indoor humidity decreases when indoor temperature rises. The air humidity is within the range of 30%~52%, and the air temperature is within the range of 20 degrees~27.6 degrees Celsius. This area belongs to the frigid zone. In winter, the middle temperature of heating is low, and the behavior of opening windows is less. Therefore, the indoor environment is near windless. The wind speed 0~0.1m/s.

$$t_{mrt}=t_g+2.4v^{0.5}(t_g-t_a) \quad (1)$$

Upper form: t_{mrt}、TG and V represent the average radiation temperature, the black sphere temperature (c) and the air velocity (m/s) respectively.

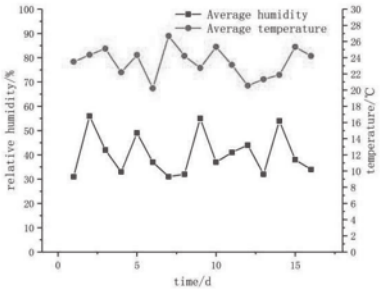

Figure 1. distribution of temperature and humidity the middle stage of heating

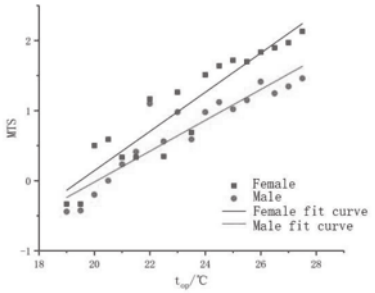

Figure 2. relationship between male and female MTS and in indoor operating temperature

2.2 Research and analysis of subjective thermal comfort and objective thermal comfort

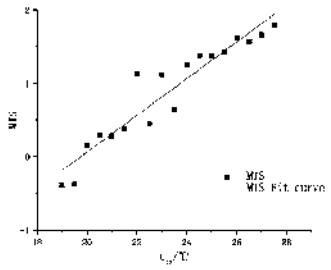

Figure 3. relationship between MTS and indoor operating temperature

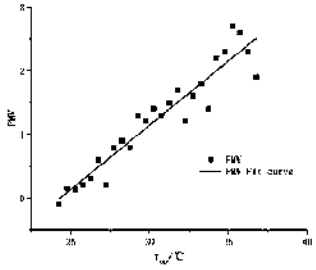

Figure 4. relationship between PMV and operating temperature

The temperature frequency method is also applied to the test of male and female heat sensation, that is to say, the subjective vote of thermal sensation is an interval of indoor temperature at intervals of 0.5 degrees. A weighted fitting of the subjective thermal sensation MTS and the internal operating temperature top of male and female is performed, as shown in formula 2 and formula 3, and the obtained function is:

$$MTS_{male} = 0.27974t_{op} - 5.45096,\ R^2 = 0.87552 \quad (2)$$

$$MTS_{female} = 0.22027t_{op} - 4.42468,\ R^2 = 0.86421 \quad (3)$$

$$MTS = 0.25t_{op} - 4.93782,\ R^2 = 0.89753 \quad (4)$$

From figure 2 and figure 3, we can see the relationship between the average thermal sensation and the operating temperature of men and women. The function of female weighted fitting is basically the same as that of male weighted fitting. It is always below the male level. Through the regression equation, it is concluded that the medium temperature of the middle school students in this University dormitory in winter is 19.8 degrees.The 80% acceptable range of temperature for students is 23.2~16.4℃ , 90% the acceptable temperature range is 21.8~17.8℃ , the neutral temperature of men and women is divided into 19.5 and 20.1 degrees respectively. Male 80% is acceptable for temperature range of 16.5~22.5℃ , and the range of acceptable temperature is 16.5℃. 90% of the acceptable temperature range is 17.8~22.4℃. The author takes the measured parameters of temperature, humidity and wind speed into the formula (1) to get the PMV value and fit the data to get the regression curve between PMV and operating temperature in summer. The function is:

$$PMV = 0.202t - 4.909\ (R^2 = 0.901) \quad (5)$$

As shown in figure 4, with the increase of operating temperature T, the predicted value of thermal sensation increases. When PMV is 0, the predicted neutral temperature is 24.3℃ , and the thermal comfort temperature range of 80% acceptability is 20.1~28.5℃ .

2.3 Comparison and analysis of subjective and objective models

As can be seen from the above, the difference between PMV function and MTs function is larger than that of slope function and neutral temperature. The main reason is that students have adopted adaptive behaviors in cold environment, such as increasing clothing, closing doors and windows, drinking hot water, and heating the body locally. PMV model does not take into account these adaptive mediation behaviors of students.

3. Conclusion

(1) The median temperature of men and women in Dormitories in China's severe cold regions.During the winter heating season is 19.5℃, 20.1℃ and 23.6℃, respectively. The neutral temperature of a man and the neutral temperature of women are all below the average temperature of 23.6 degrees Celsius. In view of the students' thermal comfort and energy saving, it is suggested to reduce the heating temperature.

(2) Dormitories in China's severe cold regions winter heating medium students 80% acceptable temperature range is 23.2~16.4 degrees, 90% of the acceptable temperature range is 21.8~17.8 degrees, of which male 90% is acceptable temperature range is 17.7~21.3 degrees, 80% acceptable temperature range is 16.5~16.5 degrees; female acceptance temperature range is at -80% the acceptable temperature range is 16.2~24℃ .

(3) The difference between PMV and MTs's function is mainly due to the adaptive mediation behavior of students in colder environment.

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