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【論文の内容の要旨】

Nowadays, multi-unit residence has become the main type of home in China. Economic growth and improvements in living standards led to an urgent demand on comfortable and healthy environments for residences with a corresponding sharp increase in energy consumption in China. In addition, because of different climate conditions, lifestyles, and energy consumption awareness, there are wide variations in indoor thermal environments and energy consumption of multi-unit residences. However, there is little research that simultaneously compares the different climate zones in China and that comprehensively considers the indoor thermal environment and energy consumption.

In order to achieve a good balance between the environmental quality and the energy saving in multi-unit residences, it is crucial to grasp the status of indoor thermal environments and identify the actual energy demand in different climate zones in China. In addition, the feasible solutions should be sought to improve the indoor thermal environment and to reduce energy consumption.

The main purpose of this study is to demonstrate how to achieve a suitable thermal performance in multi-unit residences that can provide reasonable indoor comfort at a low energy cost.

This study mainly clarified the actual condition of thermal environments and energy demand in multi-unit residences within different climate zones in China via literature investigation, field measurement, questionnaire analysis and simulation analysis. Based on these findings, rational proposals were put forward to improve the comfort of indoor thermal environments and energy

consumption in multi-unit residences in China.

This thesis is mainly divided into six chapters as follows:

Chapter 1 described the background, the previous research status, the purpose and significance as well as the major research approach of this study.

Chapter 2 summarized the relevant literature pertaining to the multi-unit residences published in the past 15 years in different climate zones. The statistical results show that the extant literatures about the multi-unit residences were mainly concentrated in the cold zone and the hot summer and cold winter zone. On such basis, the research focus is presented.

Chapter 3 mainly researched the actual condition of indoor thermal environments and energy consumption in winter in multi-unit residences in three colder climate zones in China via field measurement and questionnaire analysis. The main conclusions can be drawn as follows: (1) Due to the effect of district heating, the indoor environment was in a relatively hot and dry state in the severe cold zone, while it was slightly improved in the cold zone. The energy consumption of district heating in the severe cold zone and the cold zone was the major part of total energy consumption. (2) In contrast with these zones, the indoor environment in the hot summer and cold winter zone which has no district heating system was in a cold condition, and the total energy consumption was lower in this climate zone. (3) As a result, the indoor environments in each climate zone need to be improved urgently. 1) For the severe cold zone and the cold zone, the district heating temperature should be appropriately reduced to improve indoor comfort and to save energy. At the same time, the household heat-regulating system should be put into practice as soon as possible to avoid the overheating phenomenon. 2) For the hot summer and cold winter zone, the envelope performance should be improved to reduce heat dissipation. Meanwhile, the economy and comfort should be simultaneously taken into account to decide whether to adopt the district heating system.

Chapter 4 mainly researched the actual condition of indoor thermal environments and energy consumption in summer in multi-unit residences in three hotter climate zones in China. The main conclusions can be drawn as follows: (1) For the cold zone, cooling equipment was seldom used; natural ventilation became the main cooling method. Despite this, the indoor thermal environment was mainly in a neutral state, and the risk of heatstroke was low. Therefore, proper room layout and direction of residence that are better for summer natural ventilation should be constructed in this zone. (2) For the hot summer and cold winter zone, the indoor thermal environment was poor because of higher temperature and relative humidity as well as less use of air conditioning. The risk of heat stroke in summer was relatively high. Therefore, the frequency of using air conditioning should be increased to effectively reduce indoor temperature and relative humidity. (3) For the hot summer and warm winter zone, the longer service time and lower setting temperature of air conditioning significantly reduced the risk of heat stroke. However, the usage pattern of air conditioning including the service time, setting temperature and switching behavior can directly

affect the cooling energy consumption. Therefore, the thermal environment and energy consumption should be comprehensively considered to design the usage pattern of air conditioning depend on human thermal sensation.

Chapter 5 compiled four different parameters and performed dynamic building energy simulations to study annual energy demand and indoor thermal comfort in all five climate zones in China. The effects of building design parameters on energy performance and thermal environment were estimated. Based on the simulation results, the improvement measures are suggested for each climate zone. The results are as follows: (1) Energy saving strategies in China should be implemented accordingly in response to different climatic and geographical conditions. (2) The quality of the wall insulation is the main contributor to the indoor thermal environment in winter for all climate zones. (3) In the severe cold and the cold climate zones that require greater levels of heating in winter, the air tightness of buildings should be considered a priority, because better air tightness can deliver a significant heating energy reduction. (4) On the contrary, in southern China, where comfort in summer is regarded as the main concern, the improvement of external window performance and the addition of external shading are the key issues that need to be addressed. (5) Compared with the poor effects of lowering the heating temperature in northern China, raising the cooling temperature in the south is relatively an effective method to save energy without causing a sharp deterioration of indoor thermal environment.

Chapter 6 summarized the conclusions of each chapter and put forth the direction of future research.