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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

With the expansion of urban and suburban areas, the urban heat island effect in combination with compact design of houses with reduced green spaces makes it difficult to live comfortably in the hot-humid summer heat of Tokyo only using passive cooling methods such as natural ventilation and solar shading. In these circumstances, residents opt to use air conditioners instead of natural ventilation to maintain a comfortable indoor thermal environment. However, its constant use can worsen the indoor air quality of a building due to lack of fresh air, which can affect the health of occupants and productivity. Therefore, it is important to provide a comfortable indoor thermal environment during summer by improving the outdoor microclimate. In return, users can opt for either using natural ventilation or air conditioners (mixed mode ventilation) to maintain a comfortable indoor microclimate.

The usage of passive cooling methods in cities and residential areas is an adaptive measured employed to deal with such severe thermal environments. It is evident that the usage of trees and green covers is one of the most effective ways. However, with urbanization, there is limited amount of green spaces to grow trees and shrubs to achieve a higher cooling performance. Thus, alternative solutions of outdoor microclimate design using a combination of passive cooling methods (PCMs) is recommended to improve the natural ventilation in urban residences.

A two-step research, comprising a field measurement and CFD simulation, was conducted to study and improve the outdoor and indoor microclimates of a passive house in Japan using PCMs, including evaporative cooling louver, vegetation, and sunscreen, installed in the semi-outdoor space and different ventilation settings at the indoor space, respectively. Both conducting field experiments and CFD simulation are important because the measured microclimate data can be used to verify the CFD model, which can be used to conduct multiple parametric studies. Previous research have conducted field measurements on outdoor, indoor or combination of both microclimates, however, most of them records its data with one measurement point height at around 1 to 2 meters above the ground. Similarly, for numerical simulation and validation there has been limited discussion on the effects of cool microclimates for a spatial scale less than 1 meter, with the detailed vertical distribution formed by vegetation and cool materials. In contrast, in this study the field measurement and validation of the CFD simulation was conducted using multiple points horizontally and vertically to evaluate the vertical temperature distribution in outdoor, semi-outdoor and indoor spaces.

This study was carried out in several parts in order to find the most effective: (1) PCMs configuration for optimal cool microclimate formation in a semi-outdoor space; (2) ventilation strategies for optimal

induction of cool air formed in a semi-outdoor space for natural ventilation; in order to provide design recommendations for generating cool microclimates inside buildings. Firstly, (1) a field measurement was carried out to examine the characteristics of the distribution of cool air formed in a semi-outdoor space by PCMs in front of a window and induction of cool air for natural ventilation. It was found that combination of watered louver, surrounding vegetation and shorter louver-window distance provided a better microclimate than when no vegetation and a large louver window distance was used. It was also found that induction of cool air was not fully obtained. Thus, in order to conduct a parametric study a (2) CFD simulation was conducted and validated using field measurement data. The validation results of the CFD simulation with detailed modeling of PCMs showed good correlation between the experiment and simulation for Spaces A and Space B demonstrating that the model can effectively predict the cooling effect of PCMs for semi-outdoor spaces. The R^2 was between 0.93 and 0.99 for all measurement points. Therefore, these results show better accuracy than that previously reported in the literature. The validated case was then used to conduct a (3) sensitivity analysis to reproduce the cooling effect between different louver watering conditions; and effect of different amount of PCMs in the formation of cool microclimate. (4) An optimization of the validated case is conducted in order to find the best PCMs and indoor conditions that improves both outdoor microclimate and indoor microclimate simultaneously. The best optimization method was evaluated under different wind directions. It was found that in order to generate cool microclimates inside buildings a combination of reduction of ambient temperature and improving the natural ventilation is necessary. The evaporative cooling louver can generate cool microclimates inside buildings under certain conditions: install the louver in a semi-enclosed space; close to the target area; and parallel to the window and perpendicular to the predominant wind direction. Shade surroundings; use during daytime when relative humidity is about 50-70% and outdoor temperatures below 29 ° C, to aid mixed mode ventilation; and natural ventilation techniques such as stack and cross ventilation are applied. This study encourages the implementation of passive cooling methods in microclimate design to help mitigate uncomfortable urban thermal environments and ensure the health and quality of life of present and future generations.