学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

Optimized Open Space Design for Spatial Behavior based on Microclimate in Winter Cities
(北方都市における空間利用行動のためのオープンスペースデザイン最適化手法の構築)

Over the past few decades, the pursuit of urban life quality is increasingly important. How to create outstanding open space which satisfy different requirements of outdoor activities and create relatively comfortable sensation become the focus of attention. A burgeoning number of studies have researched the relationship between outdoor thermal comfort and outdoor activities influenced by microclimate as a goal in urban planning and design. However, almost of all the research were conducted at the warmer area with hot and humid conditions. Only few have focused on extreme situations in both hot and cold seasons. In addition, microclimate, behavior and space design are characterized by a separation among climatologists, behavior researchers and designers. It is also unrealizable to apply the research results to the space design because of the gap created by the interdisciplinarity.

Therefore, this study chooses the downtown central open spaces in northern China with extreme temperature difference during summer and winter and northern Japan with heavy snow and low temperature during cooling period to research the open space design. From microclimate perspective, taking people's comfort and spatial behaviors as criterions, field survey and wind simulations are used to discuss how the open space forms affect microclimate, thus affect comfort sensations and spatial behaviors. Optimized open space design guidelines are also put forward based on the above research.

The thesis consists 7 chapters as following:

Chapter 1 gives a general introduction about the research background including the definition and the classification of open space, the important role of open space in urban area, the research scale of urban microclimate and spatial characteristics of street canyon. Current research, development direction on such topics and the originality of this research which explain orientation of this thesis are presented in this chapter. Winter city is the main topic introduced in this chapter on dealing with the relationship between open space design and human behavior to pursue desirable outdoor open space in cold area.

Chapter 2 introduces the urban conditions in Shenyang and Sapporo, including geographical locations, climate characteristics, urban structures, and the reason for selecting these two cities on open space research. Shenyang has long severely cold winter, relatively short summer and huge annual temperature range. Sapporo has long cooling period in the early and late winter. Since many similarities like locations, climate characteristics, living habits and different characteristics like urban layouts, spatial scales can be realized, these two winter cities have representative and typical research value for this thesis.

Chapter 3 figures out how the open space forms affect microclimate, thus affect comfort sensations and spatial behaviors by taking people's comfort and spatial behaviors as criterions in hot summer and cold winter in public open space in Shenyang. Results shows that microclimate obviously affected people's comfort. In hot season, shade and air-flow play crucial roles in outdoor comfort. People tend to stay outside in the shade and the area with higher air velocity. After sunset is popular period for outdoor activities. In cold season, at the same ambient temperature, lower air velocity will raise

the comfort level. Shade also has influences on comfort sensation but do not affect spatial behaviors significantly.

Chapter 4 clarifies the relationship between outdoor environmental conditions and the behaviors of people in outdoor public spaces in three public spaces and analysis of the microclimate and sitting behaviors in these spaces during the cooling period (8 - 20 degree centigrade) in downtown Sapporo. At air temperature higher than 20 degree centigrade, the outdoor environment do not affect the spatial behaviors. At temperatures below 5 degree centigrade, almost no sitting behaviors are observed. Increasing sunlight and reducing the wind can extend the duration of use of outdoor public spaces during the cooling period in winter cities.

Chapter 5 conducts the wind tunnel and CFD (computational fluid dynamics) simulations to evaluate the open space in Shenyang and several assumptions about canyon orientation and building types are proposed. Depending on the results, figuring out the prevailing wind directions during hot and cold periods in a monsoon climate city and making the winter wind direction perpendicular to the main street will significantly improve wind comfort. The urban layouts which affect wind situation at pedestrian height are found to cause five types of airflow as followings: (1). Wind shadow area with native pressure created by high-rise buildings will reduce the wind speed at pedestrian height. (2). The skyway acted as a wind diverter causes the increased air velocity to under it. (3). Funnel effect formed by narrow street with buildings running continuously along both sides causes the accelerated air velocity. (4). Roofs can resist head wind to create lower wind speed at pedestrian height. (5). The streamlining of the building edges changes the air duct area and causes a higher wind speed at the narrow section.

Chapter 6 indicates the climate-responsive open space approaches. The suitable outdoor microclimate situation and activity time during hot summer, cold winter and cooling period are clarified. Combining with the results of field surveys and wind simulations, this chapter gives comprehensive conclusions on how the open space forms affect microclimate, thus affect comfort sensations and spatial behaviors. In the research area, funnel shape entrance and skyway will bring higher wind speed, thus make people feel comfortable in summer. Building corners, high-rise and low-rise building groups will reduce the wind speed resulting higher comfort sensation in winter. The roof and podiums can also resist the head wind. Shade formed by roof , building structures and landscape facilities will make the open space attractive.

Chapter 7 proposes optimized open space design guidelines from the general perspective to specific design details with examples. First, thinking mode of open space evaluation is put forward. Secondly, the optimization street canyon layout including ideal type, orientations and desirable microclimate situations are introduced. Based on the above proposals, specific design methods are given from 3 aspects as followings: (1). In the wind and buildings part, the wind situations of isolated high-rise building and building groups, channeling effect, downwash effect, stepping effect are clarified. (2). In the human and open space part, the paths of outdoor activities and the spatial scale should be noticed during the open space design. (3). In the human and environment part, design strategies with comfortable microclimate creation, landscape facilities arrangement like roofs, skyways, sun rooms, waterside and vegetation are introduced with several examples to explain the guidelines.