HOKKAIDO UNIVERSITY

Title	Efficient Public Space Design for Pedestrian Network in Cold-Climate Cities [an abstract of dissertation and a summary of dissertation review]
Author(s)	Krivorotko, Margarita
Degree Grantor	北海道大学
Degree Name	博士(工学)
Dissertation Number	甲第16348号
Issue Date	2025-03-25
Doc URL	https://hdl.handle.net/2115/95039
Rights(URL)	https://creativecommons.org/licenses/by/4.0/
Type	doctoral thesis
File Information	Krivorotko_Margarita_abstract.pdf, 論文内容の要旨

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　Krivorotko Margarita

学 位 論 文 題 名

Efficient Public Space Design for Pedestrian Network in Cold-Climate Cities
(寒冷都市における歩行者ネットワークのための効果的な公共空間デザイン)

According to UN Habitat, the world is undergoing an active process of urbanization, attracting more and more people to cities, many of which face the issues of creating comfortable pedestrian environment. In cold city conditions, original design is required to create an all year protected public space against severe weather conditions with an intensive pedestrian use that can fulfil the needs of the user as well as encourage social and economic interactions. One such design solution is enclosed (underground and skyway) space network. Nowadays, not many studies have focused on the activity and comfort of users of urban environments in cold climate. However, some of them detect a drop in the intensity of pedestrian flows in outdoor public spaces when ambient temperatures decrease. In this regard, indoor warm public spaces become attractive for residents of cold cities. Thus, there is a need to find approach to connect the three-level structure of above-ground pedestrian space, underground and skyway and evaluate the impact of seasonal changes on the utilization of enclosed space and outdoor public space, as well as the influence of its design and layout features on the formation of a balanced pedestrian flow in cold climates.

This study investigates the design of pedestrian systems in cold cities to create comfortable open and indoor transit public space for users. It also complements and structures existing research in unlinked and interdisciplinary studies, which generally include only open or enclosed spaces, by linking climate conditions, pedestrian traffic, underground and above-ground public spaces. Discussed issues include how pedestrian flows are distributed and shifted with changing seasonal temperatures from street level and open space to underground and back again, and how design of location contributes to the distribution of pedestrians in response to climate and ambient temperature change. In addition, proposals are made for the design of pedestrian systems based on the conducted research.

The thesis consists of 6 chapters as following:

Chapter 1 includes a general introduction to the context of the study, definition of urban pedestrian networks, its fundamental importance in urban structure, sets the framework of the research, shows the originality of the study, purpose, methodology and structure of the study.

Chapter 2 describes the existing research experience on the design (configuration and form) and adaptation of public spaces, both open and indoor, in cold climates, the relationship between the influence of climate such as sun, wind and air temperature during the cooling period on user behavior, the relationship between location design and user behavior in pedestrian systems. The availability of indoor (underground) and elevated systems in cities with cold climates becomes an important element in the formation of a comfortable urban environment, protecting from severe weather conditions, improving transport connectivity and complementing open spaces. The fundamental need for special design for cities in cold climates is described. A majority of scholars highlight significant factors, such as temperature, precipitation and wind speed, which affect pedestrian activities. In cold-climate cities, pedestrian traffic outdoor may be reduced by up to 20% in winter. Also, pedestrian traffic in underground spaces may be reduced by up to 50% compared to street level. Despite the number of studies covering a number of the above climatic factors, user behavior in public spaces in different cold cities have different dependence on weather. One can infer that the microclimate, environmental configuration, and local behavioral patterns should be considered as complex approach to public space design in particular location in cold climate. Therefore, it is important to supplement and expand theoretical knowledge for other locations for open public space and underground system.

Chapter 3 examines the significance of indoor public pedestrian spaces in winter cities, highlighting their dual role in providing shelter from cold weather and facilitating transit, while also fostering social interaction and enhancing economic activity. The chapter identifies patterns of development and key design features of indoor pedestrian systems, including historical and climatic influences, and evaluates their impact on social interaction and pedestrian behavior. The study focuses on indoor pedestrian systems in cities with cold climates, comparing underground systems in Montreal and Toronto, and skywalk networks in Minneapolis and Calgary, with the system in Sapporo. It also reveals efficient design of these systems across different cultural contexts. The analysis emphasizes that creating a comfortable urban environment in cold climates requires diverse approaches to the design of public spaces. This includes leveraging best practices worldwide in terms of form, location, and functional integration, while achieving a balance between open spaces and indoor public spaces, whether covered, elevated, or underground.

Chapter 4 introduces the urban conditions in Sapporo city, as a case study, including structure, built block parameters and the characteristics of its ground-level pedestrian network space utilization in warm season. Explains behavioral pedestrian patterns in Sapporo downtown in relation to the spatial structure of the city center and its design in a comfortable (September) season, explore features of open public spaces in Sapporo downtown. Case

study was conducting in open public spaces, such as Kita 3 Jo, Odori Park, and the main street linking Sapporo Station to Odori. The analysis of pedestrian flows in Sapporo city center under comfortable conditions was carried out and pedestrians' attraction zones and patterns of pedestrian activity distribution in the city center were identified. Additionally, it reveals the spatial features of the built environment in the city center of Sapporo with the identification of urban heat islands in summer and winter and increased cooling areas (several degrees below than other open spaces) in the studied locations of the pedestrian network.

Chapter 5 explores the relationship between changing climatic conditions, particularly temperature variations, and pedestrian activity within Sapporo's underground pedestrian space. The analysis highlights how the design and functionality of these spaces contribute to maintaining their usability and livability in a cold climate. The influence of temperature on pedestrian behavior is shown to vary significantly depending on location. Observational data reveals a range of temperature thresholds that affect pedestrian activity: from -2 ℃ at points near main transportation station gates and corridors, to +6.8–13.2 ℃ in areas closer to open spaces. These differences underscore the importance of microclimatic considerations in designing pedestrian-friendly environments. A detailed case study of ChiKaHo (Sapporo Underground Pedestrian Space) is presented, including its historical context, design evolution, and functional characteristics. The analysis extends to other underground spaces in Sapporo, focusing on their integration with the broader urban structure. A key finding is the importance of balancing above-ground and below-ground pedestrian networks through seamless connections provided by existing buildings. This integration ensures year-round accessibility and enhances the functionality of the pedestrian system, even in extreme winter conditions. The chapter further identifies critical criteria for forecasting pedestrian flows in underground spaces, which are essential for supporting local business development. These criteria include temperature ranges and the functional design of spaces. For instance, a well-planned mix of amenities and services within underground spaces encourages sustained pedestrian activity. Finally, several hypotheses are proposed regarding the functional and design characteristics of underground public spaces that influence pedestrian behavior. Nowadays, ChiKaHo works as concentrated pedestrian system; however, developing connections with the environment that affects specific areas is preferable.

Chapter 6 presents an approach to the development of a network of public spaces in a winter city, along with design recommendations for both underground and above-ground spaces. The relationship between the design of underground and above-ground public spaces and their integration with the urban structure is shown to have a significant effect on pedestrian flows during winter in cold climates. In addition, periods of decreased or increased pedestrian traffic (temperature range) for a particular location in cold climates are determined by the proximity and variety of accessible functions. These findings contribute to a deeper understanding of how to design resilient and adaptive public spaces in cities with challenging climates, ultimately supporting urban vibrancy and economic activity. The proposed framework distinguishes three scales of intervention based on the design approach and fundamental parameters of public spaces, such as their openness or enclosure. These scales include: systemic (macro), mesoscale, micro scale (local).

- at the macro level (system level): system elements (pedestrian underground or enclosed paths) are recommended to be placed in public areas, bypassing private property if possible. Ease of navigation by organizing perpendicular links (possible duplication under the street network if necessary) and no loops in the spatial configuration. Underground path should be placed in high-density development areas or locations with further development potential for economic feasibility of the project. The presence of pedestrian traffic generators is mandatory.

- at the meso level (superblock/quarter level): creation or presence of a system of attraction nuclei in the form of lobbies or atriums/halls with sources of natural light, they can be shopping, cultural and community centers, offices of companies over 3000 people, super-dense areas in dense locations. It is mandatory to include underground floors of buildings adjacent to the pedestrian corridor and provide free access from the building to the corridor and back.

- at the micro level (local): important attention is paid to interior solutions, finishes with encouragement of natural materials imitations, inclusion of local identity of the place, creation of rest and recreation areas with mobile temporary design of flexible and modular furniture is mandatory, in addition, the creation of work areas, widening of narrow corridors (existing) and creation of corridors at least 30 meters wide for possible organization of additional functions on both sides or at least on one side. In case of core areas of lobby or atrium type, the creation of retention areas is necessary.

This approach will increase the resilience of public underground and open spaces pedestrian network in cold climates and add livability to a compact urban center.