华南理工大学

South China University of Technology

专业学位硕士学位论文

深圳梅彩片区城市首层步行空间的立体修补探索

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Exploring the Three-dimensional Repair of Urban Ground Floor in Meicai Area of Shenzhen: An Approach for Pedestrian System

A Dissertation Submitted for the Degree of Master

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摘　要

将“城市首层作为一种项目空间”来自法国的理念“(Ré)aménager les rez-de-chaussée de la ville”（（再）整治城市首层）。倡导该理念的法国著名建筑师-规划师马斯布吉（Ariella Masboungi）女士从城市项目的实践出发，强调城市首层作为项目空间具有实现步行友好，促进经济的可持续和重塑首层空间活力的功能。随着城市的立体化发展，首层空间由单一的地面层转变为连通地上、地面、地下的多层次的立体系统。其中，步行空间是多层次首层系统中上下连通的空间载体，与建筑和城市基础设施可以产生良好的互动，具有促进城市功能复合与社会融合的作用。然而从现实来看，国内城市首层系统的修补缺少项目空间支撑，其中步行空间面临的碎片化问题尤为严重。由此，本次研究将城市首层作为一种项目空间，选择聚焦系统整治的核心环节：步行空间，从而探索对城市首层立体修补的方法路径。研究选择具有高密度环境和新增地铁站建设契机的深圳梅彩片区作为实证研究对象，探索如何立体缝合不同层面的步行空间，促进与公共生活相关的城市功能在不同标高层面展开。

本文首先通过文献综述引入城市首层作为项目空间的理念，并将立体城市理论与步行空间相关理论作为本次工作的基础。而后，深度分析将城市首层作为项目空间的案例经验，归纳出城市首层步行空间修补面临的多重挑战：1）步行空间断裂与地面空间的有限；2）步行生活缺失与空间功能单一；3）公共利益与私人产权协调。在此基础上，提出城市首层步行空间的修补原则与方法。

设计工作的展开首先对梅彩片区进行空间修补的项目契机分析、步行系统的空间分析与片区公共生活的现状调查分析，归纳步行系统的核心问题，并论证空间立体修补的必要性。进而提出梅彩片区城市首层步行空间修补的三大空间方案内容：空间联通、垂直连接与内涵拓展；一大实施策略：公私协作；以及最后运用 ArcGIS 网络分析对方案进行初步的成果验证。

本文将梅彩片区的城市首层作为一个项目空间，探索步行系统的空间修补方法，为城市首层注入新活力，回应城市日常公共生活更复合、更融合的新要求。希望为今后高强度开发城区的步行系统的立体化建设与修补，提供思路和借鉴方法。

关键词：城市首层；步行空间；城市立体化；立体修补

Abstract

"Taking the ground floor of the city as a project space" is a concept translated from French "(ré)aménager les rez-de-chaussée de la ville" which means re-amending the city's ground floor. Ms. Ariella Masboungi, a famous French architect-planner who initiated the concept, emphasized that it has great functional significance in achieving pedestrian-friendly, promoting economic sustainability, and revitalizing the ground floor by the ground floor is taken as a project space in terms of urban projects practice. With three-dimensional development of the city, the ground floor space has turned from a single ground-level to a multi-level three-dimensional system connecting the the space above, on and under the ground. Among them, the pedestrian space is a carrier to connect the above-ground and under-ground space in the multi-level ground floor system, which can interact well with buildings and infrastructures, and has the effect of promoting urban function compound and social integration.

However, in reality, the repair of cities' ground floor in China lacks the backing of project space, in which the pedestrian space faces a particularly serious fragmentation problem. Therefore, this study takes the city's ground floor as a kind of project space, and focuses on the central part of remediation works, that is pedestrian system, so as to explore an approach to three-dimensional repair of the ground floor of the city. The study selects Meicai Area of Shenzhen as the empirical research object, a high-density environment with the opportunity to build new subway stations, and explores how to stitch different levels of pedestrian space in a three-dimensional way, so as to promote the city to fulfil its functions related to public life at different elevation levels.

This study firstly introduces the concept of taking the ground floor as a project space through literature review, and takes the theory of three-dimensional city and the theory related to pedestrian system as the theoretical basis of this study. After that, this study examines the cases of taking the ground floor as a project space, and summarizes the multiple challenges of repairing the pedestrian system: 1) the fracture of pedestrian space and the limited ground space; 2) the lack of pedestrian life and the space's single function; 3) the coordination of

public interest and private property rights.

The research design starts with the analysis of the project opportunity for spatial repair in Meicai Area, the spatial analysis of the pedestrian system and the survey and analysis of the public life in the area, and then the study summarize the core problems of the pedestrian system and to assess the necessity of three-dimensional space repair. Then, this study proposes three major schemes for repairing the pedestrian space of the ground floor in Meicai Area: the first is spatial connectivity, vertical connection and connotation expansion, the second is a public-private collaboration strategy; and the third is to use ArcGIS network analysis to verify the preliminary results of the scheme.

This study takes the ground floor of Meicai Area as a project space, exploring the spatial repair approach for pedestrian system, expecting to inject new vitality into the ground floor of the city and to respond to the new requirements of a more composite and integrated daily public life in the city. It is hoped that it would provide ideas and reference strategy for the construction and repair of the pedestrian system in three dimension in the future high-intensity development of urban areas.

Keywords: The Ground Floor of the City; Pedestrian System; Three-dimensional City; Three-dimensional Repair

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Chapter1 Introduction

1.1 Research Background

1.1.1 Theoretical Background: The Trend of Three-dimensional Ground

For a long time, the issue of spatial resources for urban development has always been closely watched. On the one hand, urban development needs to occupy more land resources as spatial resources. On the other hand, the relative scarcity of land resources has caused the current spatial resource crisis in urban development. For densely populated Asian countries like China and Japan, based on the two realities of high population density and limited land use, they have to choose a more compact and intensive way of urban development. As a result, a large number of practical projects and theories on three-dimensional urban development have emerged, reflecting the advantages of three-dimensional development in terms of saving land resources, resolving space shortages and enhancing urban efficiency.

With the three-dimensional development of the city, the ground floor space of the city develops from a single ground-level to a multi-level three-dimensional structure. In addition to the ground layer, there are different elevations, which have the elements, functions and public activities contained in the original single ground layer, and become a multi-level three-dimensional system connecting the above ground, the ground and the underground.The multi-level urban ground floor maximizes the possibilities of human and material connections, interactions, exchanges, mixing and integration through the integrated development and use of the ground-level, as well as the above and below ground spaces close to the ground-level[1]. The three-dimensional urban ground floor is the basic model for the organization of a three-dimensional urban form, and provides an effective way to address the large demand for transport and public space that arises from the agglomeration of population and functions..

1.1.2 Problem Background: Fragmentation of Pedestrian Space

In high-density cities, the ground space is limited, and the pedestrian life and walking environment gives way to car traffic. A large number of car service lanes are paved with the ground, and the width is much larger than the sidewalks on both sides. The car lane replaces the pedestrian network and becomes the dominant skeleton of the city. In the process of

"car-oriented" urban construction, various urban problems emerge in an endless stream, such as environmental pollution, traffic congestion, contradiction between people and vehicles, lack of vitality in urban central areas, etc.

With the revival of humanism, the concept of pedestrian city began to spread around the world. The demand for pedestrian space brought about by the return of the concept of walking city is contradictory to the current situation that the ground is still dominated by vehicle traffic. On the one hand, the ground pedestrian space is cut by high-grade urban roads and occupied by various facilities, resulting in poor walking experience of citizens. On the other hand, the pedestrian space that gradually develops to multi-level and three-dimensional lacks contact with each other, showing fragmented morphological characteristics. For example, isolated pedestrian spaces within urban buildings, aerial pedestrian corridors between a small number of buildings, separate urban overpasses and underground passages. The fragmentation and non-networking of the pedestrian space have gradually weakened its overall continuity. The deterioration of pedestrian environment leads to the decrease of citizens' willingness to walk and the difficulty of pedestrian life.

1.1.3 Project Background: High-density and New Subway Stations in Meicai Area

Shenzhen Meicai Area (Meilin - Caitian) is located in Futian District of Shenzhen, is one of the 18 key construction areas in Shenzhen, located in the central axis of Shenzhen, only 3.5km away from the central area of Futian, is an important node for the expansion and development of Futian CBD in Shenzhen. The current situation of the area is facing the co-existence of high-density built environment and fragmented renewal projects, as well as the construction opportunity of new subway stations. There are three subway stations in the current situation of the area, and two new subway stations will be added in the future, and the density of subway line network coverage in the area reaches 3.92km/km^2, which is higher than the average value of Futian District and Shenzhen[2]. Moreover, a number of platform areas and sky corridors have been built, with opportunities for spatial repair of the pedestrian system.

In the "Digital China Innovation Competition in 2022", the author used Meicai Area as

the site for design, and carried out a large amount of data collection and site pre-investigation, and found the opportunity of its spatial repair as well as the problems of the pedestrian system, which is in line with the topic of the pedestrian system repair, and therefore chose the Meicai Area of Shenzhen as the empirical research object.

1.2 Research Purpose and Significance

1.2.1 Research Purpose

(1) Introduce the concept of “the ground floor of the city as a project space” and focus on the pedestrian space, which is the core of the ground floor spatial renovation, to explore the approach of three-dimensional repair of the ground floor of the city.

(2) Explore the development of pedestrian system in the context of three-dimensional city, the spatial characteristics of the three-dimensional pedestrian system, and the function of the three-dimensional pedestrian system in the ground floor of the city.

(3) Select cases of using the ground floor of a city as a project space and cases of missing project space, summarize the spatial repair approach and the challenges of pedestrian space repair, and then propose the principles and approach of repairing the pedestrian system on the ground floor of the city.

(4) For the Meicai Area in Shenzhen, which has the opportunity for spatial repair, the current situation is analyzed from the perspective of pedestrian space and public life, and then the problems of the pedestrian system are summarized and the necessity of three-dimensional repair is demonstrated. On this basis, a spatial repair plan for the pedestrian system is proposed.

1.2.2 Research Significance

In the process of rapid urbanization, cities have over-pursued efficiency and neglected the concern for human nature and the pursuit of environmental quality, in which the phenomenon of pedestrian life and pedestrian environment giving way to the vehicular system is the most prominent. Shenzhen, as a typical representative of China’s high-density cities, is caught in the dilemma of increasing demand for pedestrians, increasing conflicts between motor vehicle and pedestrian on the ground, and the lack of vitality in the central area.

Introducing the concept of "the ground floor of the city as a project space" can provide

project support for the repair of the pedestrian system and solve the problem of fragmented development caused by the lack of project support. Seizing the opportunity of the construction of urban transport facilities such as subways and light railways, focusing on the urban pedestrian system, we can explore the approach of three-dimensional repair of the ground floor of the city. The research significance of this study is as follows:

(1) Theoretical significance: providing a theoretical basis for the repair of urban ground floor pedestrian space

At present, the theory of urban ground floor space repair is still in the early stage of exploration, and more project practices are needed to feed the formation of the theory. This study focuses on the core link of urban ground-floor spatial renovation: pedestrian system, and explores the approach of three-dimensional urban ground-floor repair to provide a theoretical basis for the repair of urban ground floor pedestrian space.

(2) Practical significance: realizing fine design of urban ground floor pedestrian space

How to make use of the urban ground floor pedestrian space to form a good interaction with urban infrastructure and architectural space is an important issue in the three-dimensional development of the city. Introducing the concept of using the ground floor of the city as a project space, using the pedestrian system therein as a design boundary, and considering the pedestrian system with the function and property rights of the ground floor as a whole. It will help to reshape the vitality of the pedestrian space, create a convenient and comfortable walking environment, and realize the fine design of urban pedestrian space.

1.3 Concept Definition

1.3.1 The Ground Floor of the City

“The ground floor of the city” is translated from the French “les rez-de-chaussée de la ville” which is a concept advocated by the French famous architect and urban planner Ariella Masboungi in her book *(Ré)aménager Les rez-de chaussée de La ville (2013)* through a large number of practical projects. With the characteristic of compound functions, the ground floor of the city includes three key points: first, the urban ground floor serves as a project space; second, pedestrian friendly environment is one of the essentials for project objectives, and last, collaboration between the public and private sectors is required[3].

"*Le rez-de-chausée est un espace de projet urbain à part entière.*" *The ground floor of the city itself is a space for urban projects.*[3]

As a project space, the ground floor of the city can become the starting point or focal point of urban policies and serves as the foundation of city quality, characteristics, and use value. The richness, diversity, and scalability of the ground floor of the city can be promoted by planning and negotiation, just like the innovative practice of New York that integrates urban renewal at the street level into planning. Michel J.M. (2013) believes that the ground floor of the city systems can establish connections with public spaces, providing them with vision, safety, and vitality, which are closely related to people's daily lives[3]. Kickert C.C. (2016) believes that the ground floor of the city is the key to establishing its quality and experience[4]. It can be shown that taking the ground floor of the city as a project space can solve the problem of poor use of the ground floor and create a place to meet the needs of citizens' lives, activities, and communication. Then, in the public interest, the ground floor space will be constructed.

"Faire la ville par et pour le piéton." The city is built by and for pedestrians.[3]

The primary purpose of designing the ground floor of the city is to establish pedestrian friendly environment and allow the city to be constructed by and for pedestrians. Masboungi A. (2013) believes that functional urban planning has fragmented and frozen the city's ground floor, necessitating a shift to make the ground floor serve pedestrians[3]. Leclercq F. (2013), an architect and urban planner who worked on the La Défense space renewal, believes that it is necessary to understand the city from the perspective of soft mobility (la mobilité douce) and pedestrian (le piéton), so that the city can serve its pedestrians. It can be demonstrated that pedestrian space is the design axis of the project of the ground floor of the city, connecting buildings and public spaces from different spatial levels, alleviating the problem of urban spatial fragmentation.

"Les synergies entre le public et le privé sont indispensables. Cependant le rez-de-chaué e ne peut pas seulement être un pur produit financier."[3]

Collaboration between the public and private sectors is crucial for creating the vitality of the ground floor of the city. The ground floor can't simply be a financial product; it requires long-term investment and attempts to promote its creativity in financing mechanisms to get

suitable diversity and fulfill the economy's and vitality's sustainability[3]. In Birmingham, for example, the operator has retained management rights to the ground floor, while the developer remains the ownership of the ground floor during the operation period in order to intervene in the use of these spaces. Besides, a clear rent equalization policy has been formulated, resulting in the ground floor lives associated with the venue and project. From this, it can be seen that the ground floor of the city is one of the economic sources of the overall project, involving coordination between public and private spaces, which is a sensitive part. The collaboration will be conducive to create a friendly and resilient development, promoting the vitality of the ground floor space.

In China, for the problems of three-dimensional interweaving form and compound functions of urban blocks, Mo Zhejuan et al. (2023) believe that the ground floor of the city is the clue to repair the three-dimensional city, which is a multi-level and three-dimensional system composed of the most common basic bases above ground on and under the ground[5]. Lu Jiwei et al. (2021) proposed that the ground floor of the city has a trend to develop three-dimensional form. The three-dimensional ground floor is designed to avoid crowding phenomenon made by high-density, and it is a method to organizing urban forms by arranging urban elements and functions that were originally only accommodated by the ground surface on the ground base and nearby underground and air bases in a three-dimensional manner to avoid congestion caused by high-density urban development[1]. Therefore, the ground floor space has transformed from a single level to multiple level and finally featured with multi-level spaces.

Based on the analysis above, the study regards the ground floor of the city as a project space with the function of achieving pedestrian friendly purpose, supporting economic sustainability, and reshaping the vitality of the ground floor space. In the context of developing three-dimensional city, the ground floor of the city is a multi-level and three-dimensional system composed of the most common basic bases above ground, ground and underground, with the characteristics of multi-level space and compound function (Figure 1-1).

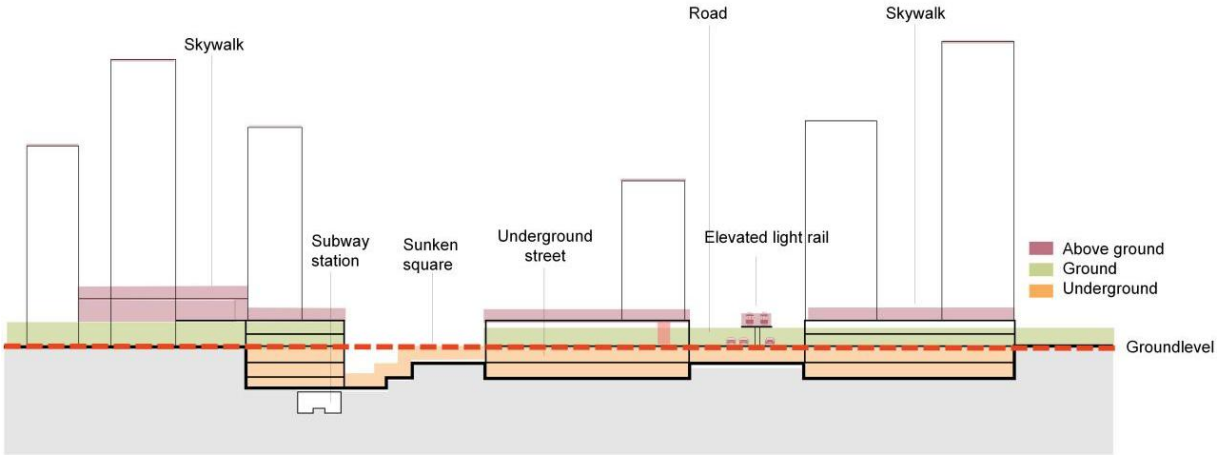


Figure 1-1 The ground floor of the city (Source: redrawn from reference [1])

1.3.2 Three-dimensional City

The concept related to the ground floor of the city is three-dimensional city. From the perspective of the three-dimensional structure of urban space, Professor Han Dongqing of Southeast University proposed in the *Integration of City and Architecture* that the three-dimensional city is the comprehensive development of the three-dimensional ground, ground and underground of the land to form a continuous and flowing space system[6]. From the perspective of three-dimensional urban base, three-dimensional city is the three-dimensional of urban public base, more accurately, the spatial structure of multi-level urban base[7].

Based on the above analysis, combined with the research perspective of this study, the three-dimensional city in this study refers to the three-dimensional public base carrying public activities. The specific performance is the development of the base in the horizontal and vertical directions, forming a continuous and organic complex.

1.3.3 Pedestrian System

Pedestrian system is the key spatial carrier connecting the underground, ground and the air in the multi-level ground floor space, forming a three-dimensional pedestrian system or a multi-level pedestrian network. It includes not only the aerial or underground pedestrian space of different street blocks, but also a variety of spatial components such as rooftop terraces, sunken plazas, shopping mall atrium, etc., which need to satisfy both horizontal and vertical connectivity, and it is a way to alleviate the congestion in high-density urban centers[8, 9].

In this study, pedestrian system refers to the pedestrian space that connects the above ground, ground and underground public bases in a multi-level urban ground floor. It connects the pedestrian space of different elevations together to satisfy the accessibility and openness of horizontal and vertical traffic, and to promote the compound function of the city (Figure 1-2).

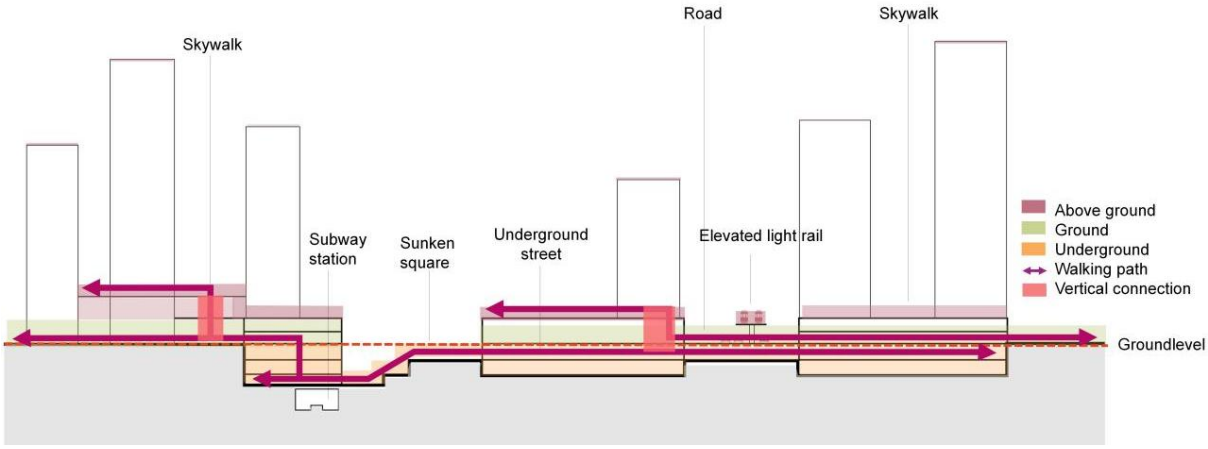


Figure 1-2 Pedestrian system and the ground of the city (Source: the author)

1.4 Review of Relevant Research

1.4.1 Multi-level Ground Floor of the City

The ground floor of the city is very important to the shaping of urban quality and urban experience, and its value was recognized as early as in the 18th century in the Nolly map (1784)[10]. With the three-dimensional development of the city, the connotation of urban ground floor space changes from a single ground layer to multiple ground floors, with the trend of spatial three-dimensionality and functional compound.

In exploring pedestrian space in multi-level urban ground floor, Western countries started earlier, and the initial research was to solve the contradiction between people and vehicles in the industrial era and to establish a traffic system with separated pedestrian and vehicle flows. In the 1920s, Ludwig Hilberseimer's early concept of the three-dimensional city included the idea of a multi-level base[11]. In his proposal, the ground floor was for public services and the upper floors for housing, and a continuous system was created in the air to resolve the human-vehicle conflict in industrial cities. In 1963, Professor Colin Buchanan, in his study Traffic in Towns, introduced the concept of three-dimensional transport In 1963, Professor Colin Buchanan in his study Traffic in Towns proposed the concept of a three-tier traffic

system: the main logistics distribution roads should be built underground; secondary routes and parking should remain at ground-level; and a new environmental area, almost free from all traffic, should be a few feet above the ground-level as a new "artificial ground floor"[12]. At the same time, in the design of the new central area of Naples, Kenzo Tange proposed an absolutization and complication of the traffic overlap based on the logic of separation of pedestrians and vehicles: motor traffic at an elevation of 5 meters and pedestrians at 12 meters. The French scholar Stefan Wewerka proposed the concept of the Boulevard Building[13]. The key to achieving this goal is the construction of an aerial public activity base, which is the key to the construction of an urban complex at the intersection of the city's main roads, to alleviate pedestrian and vehicular conflicts and to organize urban activities and mixed functions.

The concept of landscape urbanism, which has been developed since the 1990s, sees the ground floor of the city as a three-dimensional container that is thick and capable of accommodating a variety of urban functions, referred to as a "thickened ground"[14,15]. In 2004, Koolhaas and the OMA team worked on a competition to transform the marketplace in Les Halles, a representative example of this. Koolhaas wanted the ground floor commercial buildings to vault out of the ground as well. By building a garden on the ground-level, which at the same time serves the underground commercial center, and by extending the garden underground through infrastructure such as walkways, entrances, etc., a good connection is made between the garden on the ground-level and the commercial area on the underground (Figure 1-3). Through the superimposition of elements on all levels, above and below ground, garden and architecture, historical and modern, a holistic landscape form is formed[16].

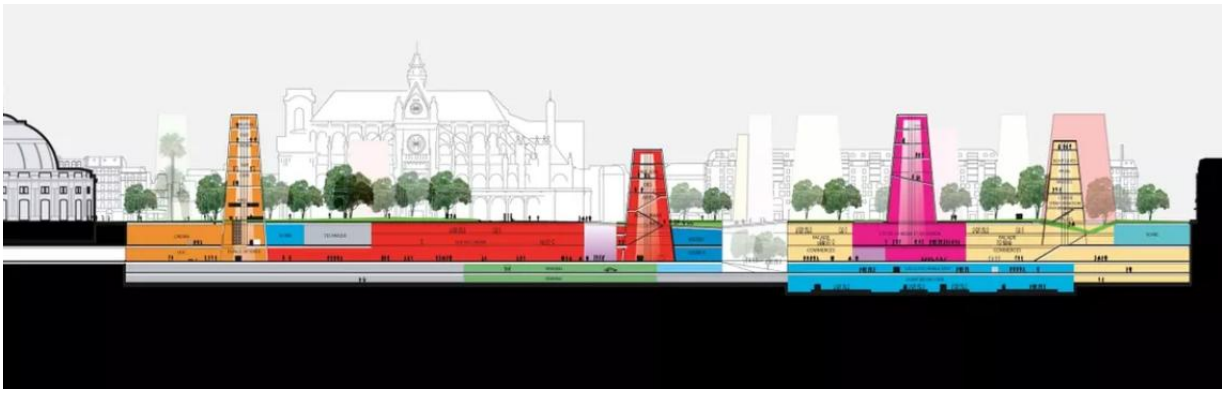


Figure 1-3 Multi-level ground floor space, Les Halles section (Source: Reference [16])

Since the 21st century, with the extensive practice of urban design concepts and strategies in cities, scholars have gradually proposed the ground floor of the city as an object of renovation, and its connotation has also been discussed. In *(Ré)aménager Les rez-de chaussée de La ville*, architects and planners discuss the meaning of "les rez-de-chaussée de la ville" (the ground floor of the city). Masboungi A. (2013) argues that the ground floor of the city is a meeting point between public and architectural space, characterized by a complex of functions, and Michel J.M. (2013) argues, on the basis of the diversity of spatial uses of the ground floor, that the ground floor of the city spans both vertical and horizontal dimensions, involves components of both market and non-market activities, and connects public and private spaces[3]. Mo Zhejuan et al. (2023) believes that the ground floor of the city is the repair clue of the three-dimensional city, emphasizing the up and down connectivity in the ground floor of the city, and believed that the first floor system of the city is composed of the most key bases connecting the sky, the ground and the underground. The "up" and "down" part of the city is the most dynamic in the multi-level urban ground floor, and it is necessary to develop its driving force and adaptability to urban vitality[5]. Lu Jiwei et al. (2021) proposes that the multi-level ground floor is also the basic model of three-dimensional urban form organization, which provides an effective solution to the large demand for transportation and public space caused by the agglomeration of population and function[1].

In summary, in order to avoid the congestion caused by the high-density development of the city, the ground floor of the city changes from a single ground layer to a multi-level three-dimensional system. The urban functions originally accommodated by a single ground layer are expanded on the ground, in the air and underground. Its spatial connotation has also changed from the vertical stratification that originally solved the contradiction between people and vehicles to the consideration of various urban elements, such as transportation, social public activities and natural ecology, forming a multi-level and functional compound system.

1.4.2 Three-dimensional City

During the Renaissance, Leonardo da Vinci proposed the idea of "three-dimensional traffic separation for people and vehicles", i.e. the basement was used for carriages and cars, while the ground was for walking only.

In the first and middle of the 20th century, the exploration of urban three-dimensional development was dominated by the exploration of aerial development, and in the 1920s, Le Corbusier published the concept of the City of Light and the New York Plan, which advocated that the development of large cities should reduce the occupation of the urban ground through the vertical development of buildings, and set up a three-dimensional transportation system of subways, fully pedestrianized ground-level, elevated roads and car parks to solve the conflict between high-density urban environments and traffic[17].The Smiths explored the possibility of transforming the two-dimensional city into a three-dimensional one by introducing public streets in the sky in the design of the Golden Lane settlement (1952) and the de-urbanisation of the center of Berlin (1957), where they argued that three-dimensional networks could enhance urban mobility and connectivity[18].

In the late twentieth century, as traffic patterns changed, the exploration of urban stereoscopic development underground gradually increased, and urban stereoscopic development gradually emphasized the multi-level development of the city above, ground and underground. 1983, the Swedish professor of architecture and urban planning, Asplund H., put forward the famous "Two Town" idea[19]. In 1999, Chinese scholar Han Dongqing proposed that three-dimensionality was the future development trend of urban spatial structure, and in 2010, Dong Hexuan from Tongji University analyzed the practice of urban three-dimensionality, summarized the characteristics of urban public space base systems, and discussed the planning and design methods of different types of three-dimensional urban structures design methods[20].

In recent years, some firms have made bold explorations in three-dimensional cities. For example, MVRDV in Netherlands, in the context of high-density, advocates the development of urban network and base surface up and down to solve the contradictions in urban development, and made a pioneering attempt in the Shenzhen Vanke headquarters plan designed in 2018[21]. Boeree’s Forest City concept demonstrates the possibility of greatly increasing urban greenery, enhancing biodiversity and regulating urban microclimate through green volume three-dimensionality[22]. Groundlab in the UK thinks about cities from the ground up, and in its bid for the urban design of Longgang center in Shenzhen, a transport system and cascading urban public realm, including public events, underground entrances and

exits, and CBD parking facilities, is designed by combining underground space development with river planning.

Moreover, three-dimensional city is one of the forms of urban development, and not all areas have to use this mode[23]. The three-dimensionality of the city is a method of urban form organization in which the city responds to the problems of human-vehicle conflicts and lack of spatial resources by arranging the urban elements and functions three-dimensionally on the above ground, on the ground and underground.

In summary, the three-dimensionality of the city is an urban form organization method that arranges urban elements and functions to the above ground, ground and underground in order to cope with the contradiction between people and vehicles and the shortage of space resources.

1.4.3 Three-dimensional Pedestrian System

With the multi-level and three-dimensional development of the city, the pedestrian space extends to different elevations, connects the public space and buildings at different elevations, and at the same time organically connects with all kinds of transport facilities to create a safe and comfortable public space for social interaction activities, forming a three-dimensional pedestrian system or a multi-level pedestrian network.

Three-dimensional pedestrian system is a feasible way to alleviate the conflict between pedestrians and vehicles and to provide continuous walking paths[24].In 1983, Prof. Asplund H. of Sweden put forward the idea of "Two Town", in which the ground-level is restored to pedestrian and non-motorized traffic, and a large number of parks and green spaces are set up, while motorized traffic is located in semi-subterranean and underground areas. Motorized traffic is located in the semi underground and underground, and it is believed that the multi-level utilization of space has a great advantage, so that the relationship between people, buildings and traffic in the city can be developed in a coordinated manner. Frampton et al. (2012) tried to explain how a three-dimensional pedestrian network can organize multiple modes of transport located at different levels (ferries, helicopters, subway, buses, etc.) as well as various urban destinations by means of axial-side illustration, using 32 relevant urban neighbourhood clusters, which can greatly improve the connectivity of a city[25]. There is

almost a consensus that three-dimensional pedestrian system can alleviate the human-vehicle conflict in cities more effectively.

In the context of high-density cities facing urban regeneration, in response to the city's human-vehicle conflicts, lack of public vitality, and ecological deterioration, from the perspective of urban design, most of the existing relevant information revolves around the mode of three-dimensional pedestrian system, summarizing the construction experience of other cities, and analyzing its advantages and disadvantages. For example, Zhuang Yu (2017) proposed four feasible multi-level pedestrian system development modes, i.e., connection, pedestrian system tandem, pedestrian system network, and three-dimensional pedestrian system, which can better alleviate the contradiction between people and vehicles and promote the occurrence of public life[26]. Tang Yongjing (2009) studied the construction experience of underground streets in Montreal, Canada[27], Kang Dezhi et al. (2014) studied the construction and revelation of sky corridors in the United States[28] and Xiao Ruiqin (2021) summarized the experience of Hong Kong's fine-tuned construction of sky systems[29]. Jiao Yang (2018) compares pedestrian systems at different spatial levels and analyses their respective characteristics and advantages and disadvantages[30].

Although some researchers have suggested that the three-dimensional pedestrian system affects the street vitality and economic benefits of the ground-level, some scholars have also pointed out that ensuring appropriate population density and convenient vertical connections can eliminate its negative impacts on the street level. Walkability can be improved when the three-dimensional pedestrian network is well connected above and below. Sun Guibo(2019), by constructing a three-dimensional pedestrian network model of Hong Kong, found that pedestrian accessibility and the potential vitality of the space can be improved when the footbridges and underground connections are well connected to the ground-level network[31]. Yosuke Takahashi (2021) in Marunouchi area of Japan called the vertical connection of multi-storey space as "intermediate field", which can be used for a variety of functions by connecting above and below ground and connecting internal and external spaces[32]. Therefore, by rationally designing the up and down parts of the three-dimensional pedestrian system, the connectivity and recognizability of the walking paths can be improved.

It can be seen that there is a relative lack of systematic research on the fine design of the

combination of the ground floor of the city and the pedestrian space. In the current wave of urban renewal and the construction of subway and light rail, the refined design of pedestrian space is very important. The coupling effect of urban rail stations and three-dimensional pedestrian networks has an important impact on the quality of public space[33]. Linking urban pedestrian networks to underground space is potential and should be included in urban planning policies[34]. However, from a practical point of view, some of the built three-dimensional pedestrian space lacks flexible and continuous site design, and lacks a combination of functions and formats that can induce walking behavior and a smooth walking path[35]. The repair of pedestrian system lacks the support of project space. For the three-dimensional repair of urban pedestrian system, "how to build and who should build" requires more detailed consideration.

1.4.4 Summary

Throughout the study of multi-level ground floor of the city, three-dimensional city and three-dimensional pedestrian system, there are the following points:

(1) The ground floor of the city is a project space, which has the function of meeting pedestrian-friendly, promoting economic sustainability and reshaping the vitality of the ground floor space.

(2) With the three-dimensional development of the city, the ground floor space changes from a single ground layer to multiple ground floors, forming a three-dimensional structure. In addition to the multi-level space, it also contains various urban elements and functions, which can adapt to the development of urban three-dimensional development and functional compound development.

(3) The three-dimensional pedestrian system is the spatial carrier connecting the up and down spaces of the ground floor of cities, and it is the core link of the urban ground floor space renovation. It is the foundation of the flexibility and vitality of the ground floor and plays an important role in determining the quality and experience of the city. As the famous French architect-planner Leclercq F. said:

"The goal of the ground floor of the city is pedestrian-friendly, and it is necessary to change the status quo of the city's service for cars, so that the city serves pedestrians and uses

a new way to pass."[3]

Walking, as the most efficient way of human flow docking, can hardly diminish its role in integrating urban systems regardless of the development of dynamic transport[36]. Pedestrian space is an everyday place in the city that significantly accommodates a variety of urban public life[37]. Realistically, however, pedestrian space and pedestrian life give way to vehicular traffic. Pedestrian space has become fragmented as it is cut by high-grade roads and encroached upon by bulky buildings. In the process of three-dimensional development of the ground floor of the city, which provides potential pedestrian spaces in different elevations and brings a new turn to the construction of pedestrian space, the three-dimensional repair of pedestrian space has become an important issue in the development of high-density cities.

Moreover, existing research focuses mostly on transport connectivity and different feasible modes of the pedestrian system itself, while there is a relative lack of research on fine-tuned design that combines multi-level urban ground floors with pedestrian spaces. The repair of pedestrian space lacks the support of project space and faces the problem of spatial fragmentation and difficult implementation. Therefore, this study take the city's ground floor as a project space and focus on the multi-level space carrier of the ground floor of the city that is pedestrian system. So as to explore an approach to three-dimensional repair of pedestrian space at different spatial levels and to promote the city to fulfil its functions related to public life at different elevation levels.

1.5 Research Contents, Methods and Framework

1.5.1 Research Contents

The concept of "the ground floor of the city as a project space" is introduced, and the theory of three-dimensional city and the theory of pedestrian system are the basis of this study. Explore how to repair the pedestrian system in the high-density urban renewal area, stitch the pedestrian system at different levels in a three-dimensional way. Specifically, this study includes the following five contents :

(1) Basic research related to pedestrian system.

(2) Select the ground floor of the city as a project space case to analyze the approach of space repair, and combined with the actual problems faced by the case of missing project

space, summed up the challenges faced by pedestrian system repair.

(3) Combined with the challenges of pedestrian system repair, try to sum up the principle of three-dimensional repair of pedestrian system, the analysis method of the current situation of pedestrian system, and the framework of the three-dimensional repair approach.

(4) Analyze the current situation of the pedestrian system in Shenzhen Meicai Area, summarize the core problems of the pedestrian system and demonstrate the necessity of three-dimensional repair.

(5) Aiming at the problem of pedestrian system in Shenzhen Meicai Area, using the approach of three-dimensional repair, put forward the repair objectives, principles and specific repair scheme.

1.5.2 Research Methods

(1) Literature analysis method

By consulting and summarizing the relevant literature of the ground floor of the city, the three-dimensional city and the three-dimensional pedestrian system, the concept of the ground floor of the city as the project space, the development and concept of the multi-level ground floor of the city are summarized. In-depth understanding of the theory of three-dimensional city and pedestrian system, to lay a solid foundation for the study of pedestrian system repair on the ground floor of the city .

(2) Case analysis method

By selecting the ground floor of the city as a typical case of project space and project space loss, conducting field experience and research, carefully studying the relevant archives and design documents obtained, and based on the context of project background and social conditions, this study summarizes the approach of space repair and the challenges faced by three-dimensional repair of pedestrian system.

(3) PSPL spatial analysis method (Public Space & Public Life Survey)

Jan Gehl, a famous Danish urban planner, founded the PSPL survey method, which is a research method specifically for walking, bicycle traffic and facility space environment[38]. By effectively understanding and mastering the characteristics of people’s activities and behaviors in public space, and combining qualitative and quantitative analysis methods, it

provides a basis for the design and transformation of public space[39]. On the basis of using the existing data of the site, It conducted a field survey of pedestrian space and public life in the Meicai Area of Shenzhen, to obtain the information and data.

1.5.3 Research Framework

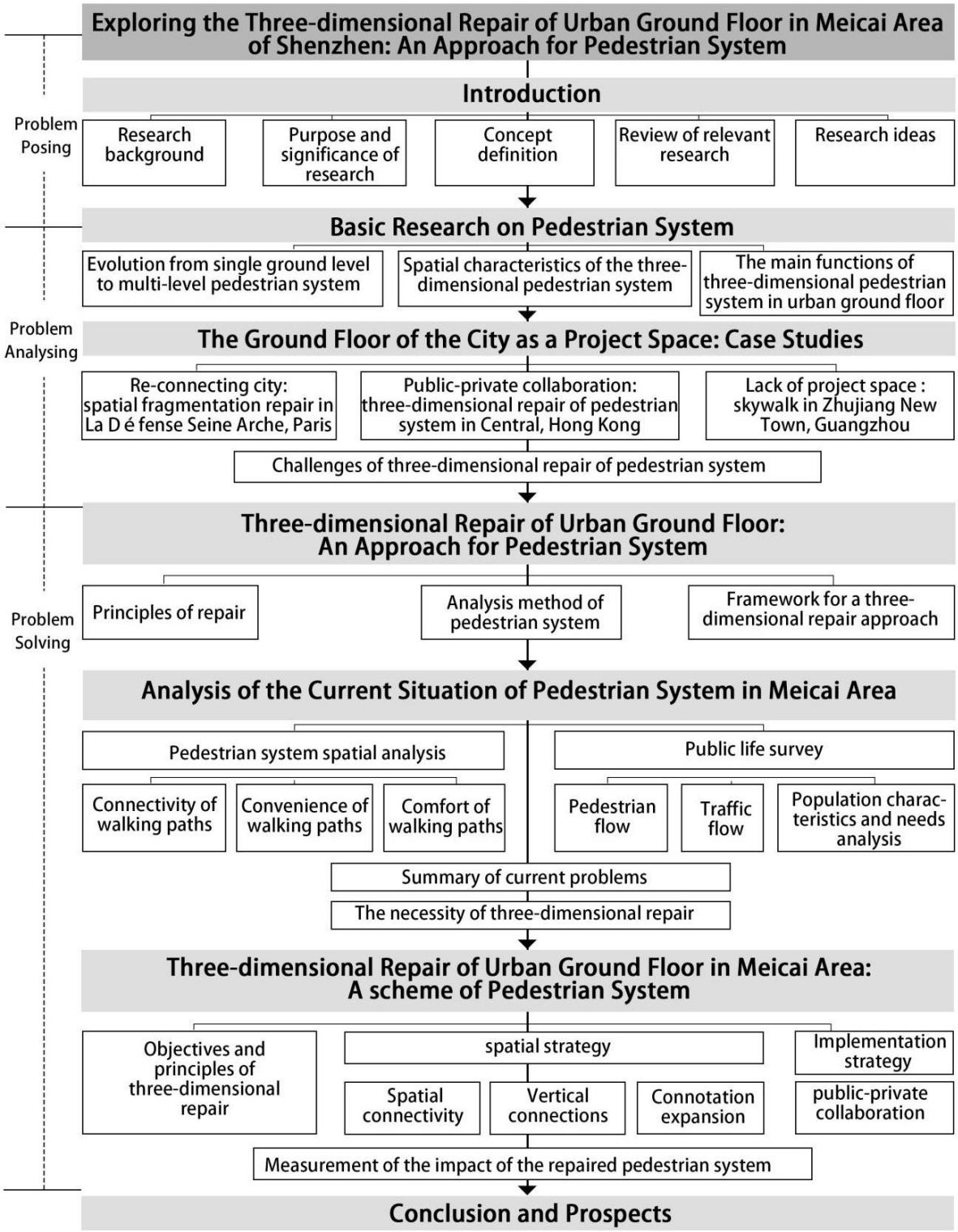


Figure 1-4 Research framework (Source: the author)

Chapter2 Basic Research on Pedestrian System

2.1 Development from Ground-level to Multi-level Pedestrian System

2.1.1 Development Process

The new technologies brought by the industrial revolution at the beginning of the 20th century promoted the development of cities, which led to the increase of motorized traffic and also brought about the problems of traffic congestion and conflicts between people and vehicles. In order to solve the problem of pedestrian-vehicle separation and traffic congestion, a multi-level pedestrian system appeared, and in 1922, Corbusier proposed the development of underground space to solve the traffic problems of cities in *Urbanisme*. Corbusier believed that the contradiction between people and vehicles in the city could be solved by multi-level separation of ground, air and underground.

In 1956, at CIAM's 10th Congress, Group 10 proposed a multi-level city with streets in the air, and applied this vision to the 1972 competition programme for the design of the Golden Lane residential area in London. They argued that the concept of the street should be revived and re-designed to be vibrant, with a multi-level street network connecting buildings and sites, changing an urban situation that at the time did not cater for human interaction. In 1971, Jan Gehl emphasized the importance of walkable space for people in *Life between Buildings*.

In 1983, Professor Asplund H. of Sweden put forward the idea of "Two Town", in which the ground is restored to pedestrian and non-motorized traffic, a large number of parks and green areas are set up, and motorized traffic is placed in the semi-subterranean and underground areas, and he believed that the multi-layered use of urban space has great advantages.

With the rise of the concept of multi-level urban utilization, the development of multi-level pedestrian system has ushered in a new opportunity and embarked on a systematic research path. The consideration of pedestrian system has risen from a purely spatial level to a social, economic and cultural one.

2.1.2 Difference Between Ground-level and Multi-level Pedestrian System

(1) Ground-level pedestrian system

It is mentioned in *Urban Spatial Form* that the pedestrian system is a linear sequence of park trails, squares, pedestrian boulevards, riverfront trails, pavements and footbridges, and plays a continuous organizational role between the city's central business district and the public spaces of other districts. As an important element of urban space, the pedestrian system combines with soft and hard landscapes such as urban parks and recreational spaces to provide places for public interaction and improve the quality of the living environment .And in most studies and urban planning practices, it is common to use the road network rather than the pedestrian network for pedestrian environment analyses, assuming that most of the pavements are those along roads[40].

It can be seen that the ground-level pedestrian system occupies urban land, is based on urban roads, and serves various types of buildings and public spaces.

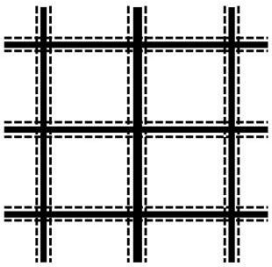
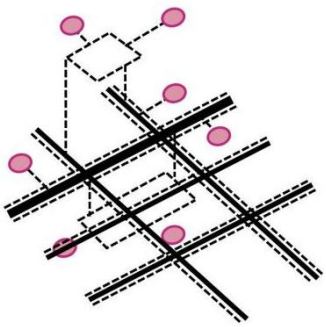
(2) Multi-level pedestrian system

A multi-level pedestrian system is a way of relieving congestion in the core of a high-density city by providing a pedestrian zone independent of vehicular traffic. It is located at different elevations in the city and compiles indoor and outdoor pedestrian spaces together. It includes not only the aerial or underground pedestrian crossing system connecting different street blocks, but also a variety of spatial components such as roof terraces, sunken plazas, and shopping mall atrium that are connected to it [41].

(3) Difference

The main difference between the multi-level pedestrian system and the ground-level pedestrian system is that the multi-level pedestrian system occupies the urban base and compiles buildings of different elevations, urban infrastructure and public spaces together. However, the ground-level pedestrian system occupies the city's land and relies on the city's roads to form a street network that serves the buildings and public spaces. The multi-level pedestrian system contains horizontal and vertical connectivity (Table 2-1).

Table 2-1 Differences between ground-level and multi-level pedestrian system (Source: the author)

	Ground-level pedestrian system	Multi-level pedestrian system
Features	**Occupying urban land,** based on urban roads, serving all types of buildings and public spaces.	**Occupying the urban base**, connecting the different spatial bases of the city and compiling the different indoor and outdoor pedestrian spaces together.
Main forms	Park walks, plazas, pedestrian boulevards, river walks, footpaths and footbridges.	Ground-level pedestrian space, aerial or underground pedestrian system, but also roof terraces, sunken plazas, mall atria and other spatial components connected to them.
Advantages	①Natural light and ventilation, low energy consumption; ②Easy access; ③Easy to attract people flow.	①Weaving a pedestrian network of public transport, buildings and public spaces for high density urban environments; ②Promoting functional compound and social integration; ③Increases pedestrian connectivity.
Disadvantages	①Interference by other traffic; ②Dependent on the city road, often encroached upon by randomly parked vehicles, commercial vendors along the street, temporary buildings, etc.	①Up and down connecting parts, not conducive to the disabled; ②The underground pedestrian environment is prone to a sense of confinement and disorientation; it relies entirely on manual control and cannot be regulated by nature, resulting in high operating costs; ③Aerial pedestrian environment is highly oriented and to a certain extent reduces the economic efficiency of the ground floor.
Diagram	 Ground-level pedestrian system based on city streets	 Multi-level pedestrian system relying on city streets and base

2.2 Spatial Characteristics of Three-dimensional Pedestrian System

2.2.1 Types of Pedestrian Space

The types of pedestrian space of the three-dimensional pedestrian system are various and distributed in different elevations of the ground floor of the city. By analyzing the relevant cases, the types of pedestrian space can be classified according to the space type: walking path, square, atrium space, roof platform, etc. (Table 2-2).

(1) Walking path

Walking path is one of the skeletons that form the pedestrian space of the urban ground floor. Walking path is linear space that provide places for activities where public pedestrian transport is the main mode and content, including the part of the street that is exclusively associated with the pedestrian walkway. Its corresponding spatial entities are pedestrian streets, footbridges, overhead corridors and underground public walkways.

With the three-dimensionalisation of urban space, many cities are using the ground-level public walkways, footbridges and underground public walkways in combination with each other to shape the walking path. For example, the transformation of the Toranomon Hills Area in Tokyo has created a comfortable and convenient urban pedestrian environment through a seamless and continuous pedestrian network linking above and below ground spaces, as well as a variety of commercial, cultural, exhibition and lifestyle services. As a result, walking paths build the backbone of the pedestrian space of the urban ground floor, linking the elements of the ground floor while providing space for public activities.

(2) Square

The square is the node of the pedestrian space of the urban ground floor. As an important public space on the ground floor, the square is mainly characterized by the openness of space and the inclusiveness of behaviour. It is also combined with art installations, plants and water bodies to create a comfortable and pleasant spatial environment. The square can carry the public for various public activities and experience the pleasure of interaction, and has the functions and attributes of the city.

The square is in a node for the transformation and distribution of urban activities. For example, the square can be combined with the first floor corridor of a shopping mall or a

subway station to disperse and converge commercial and traffic flows; the square can also be combined with an underground commercial street, which can provide a suitable place for stopping and resting activities.

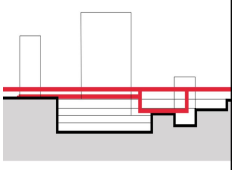
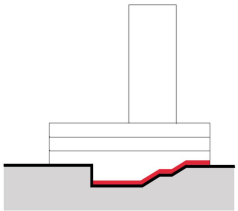
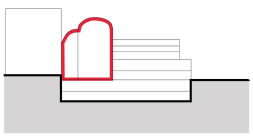
(3) Atrium space

The atrium space is usually located at the intersection of different elevated pedestrian space and serves as a horizontal and vertical link. In order to organize the connections between the different horizontal urban base planes, the atrium space exhibits a certain multi-layered nature in the vertical direction. This is manifested by the simultaneous existence of several different horizontal base planes within a single atrium space. For example, in the Canadian Eaton center, the atrium space is multi-layered in the form of strips, which are located underground, at and in the air, and serve as a link to the city's public transport system. The atrium base thus serves as a link between the horizontal and vertical organization.

(4) Roof platform

Roof platform is urban buildings whose roofs act as urban square, creating a quality artificial terrace environment that is open to the public. In commercial complexes, their rooftop platforms are often developed as urban public activity spaces that are easily linked to the city's air traffic system. For example, in Shanghai Wanxiang City, the first floor is a huge rooftop deck that integrates the mall entrance, offices, hotel and car drop-off areas, outdoor parking and other functions, and through the rooftop deck, introduces people flow to the site.

Table 2-2 Illustration of examples of pedestrian space types (Source: Compiled and drawn by the author)

Type	Walking paths	Plaza spaces	Atrium spaces	Rooftop terraces
Spatial elements	 Toranomon Hills area, Tokyo, Japan	 Wanxiangdi, Suhewan, Shanghai	 Atrium, Eaton center, Canada	 Wanxiang City, Shanghai
	 Multi-level walkway	 Sunken plaza	 Multi-level atrium	 Open Roof

2.2.2 Multi-level Walking Paths

Based on the multi-level nature of the urban ground floor, the walking paths can be divided into: ground-air walking paths, ground-underground walking paths, and underground-ground-air walking paths.

(1) Ground-air walking paths

Ground-air walking paths allow for the functional and formal integration of various urban elements. Where functional integration is the sorting out of relationships between urban activities, formal integration is achieved through formal connections such as buildings, walkways, footbridges and platforms. For example, the Luchtsingel footbridge in Rotterdam, the Netherlands (Figure 2-1), connects fragmented public spaces such as city parks, urban complexes and stations through a 400-metre-long footbridge, creating a three-dimensional ground floor space that belongs to pedestrians.

Figure 2-1 Luchtsingel footbridge in Rotterdam (Source: the author)

The advantage of urban ground-air walking paths is that they are closely linked to urban open spaces and the natural environment, greatly increasing accessibility. Ground-level footpaths make full use of natural light, natural ventilation and facilitate the attraction of pedestrian traffic, while aerial footpaths enrich the landscape hierarchy and help to reorganize urban fragmented spaces in three dimensions and repair urban functions and forms. For example, Kokura Station in Kitakyushu, Fukuoka Prefecture, Japan, serves as an efficient interchange hub with four levels of internal traffic organization (Figure 2-2). The ground-level in front of the station is used to organize the city's ground-level motor traffic flow, the first level platform plaza can be reached by escalators on the ground-level in front of the station, the second level is a two-storey through-height public concourse, and the third level is a Japan Shinkansen platform (Figure 2-3). Of these, the first floor platform extends towards the city and connects to the surrounding public buildings, forming a complete pedestrian system[42].

Through the integration of urban ground-air walking paths, the urban space of Kokura Station is developed in a continuum of sight and behaviour.

Figure 2-2 Kokura station

(Source:Internet)

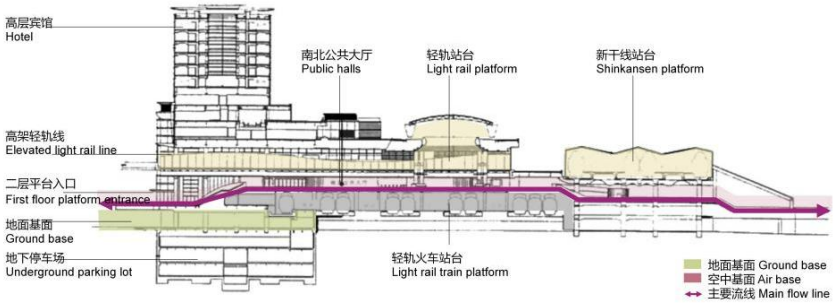


Figure 2-3 Kokura station ground-air walking path

(Source:redrawn from reference [42])

(2) Ground-underground walking paths

Urban ground-underground walking paths link the functional spaces of the city with underground transport. In the city center, it connects offices, residences, etc., making it possible to seamlessly link the adjacent functional areas. In transport hubs, the subway and public spaces are directly linked to make the subway more convenient for people's lives. For example, the Beursplein shopping street in Rotterdam, the Netherlands, is a sunken shopping street extending from the subway station and is 300 meters long. It stitches together the commercial environment on both sides of the city's arterial roads, with fast fashion, beauty, food and beverage and other leisure businesses arranged at the connection between the subway exit and the city's ground-level, creating a three-dimensional street image and a new experience (Figure 2-4).

Figure 2-4 Beursplein shopping street in Rotterdam (Source: the author)

The advantages of urban ground-underground walking paths are that they allow for the separation of pedestrian and vehicular traffic, the integration of urban functions, the bridging of underground and surface environments and the expansion of urban spatial capacity. One of the differences between ground-underground walking paths and ground-air walking paths is

that ground-underground walking paths, can combine underground transport with urban ground activities, so that rail transport can better serve urban activities on the ground. Urban underground walking paths are located underground and consist of underground walkways, underground streets and underground squares. For example, the Xian Drum Tower sunken commercial street is combined with a sunken plaza, which integrates the Bell Tower and Drum Tower through a combination of sunken plaza and steps, and activates underground commerce, enriching urban activities in the historical and cultural district. The Sapporo Station Maedori underground pedestrian space in Japan is an underground pedestrian system connecting Sapporo Station and Odori Station on the Sapporo Station Subway North-South Line, with a total length of 520 meters and a minimum width of 20 meters for internal use[43]. As an empty and diverse space, there are no fixed retail commercial facilities inside, instead there are spaces for short-term rentals, rest areas and places for social groups. One section has been renovated to increase natural light and provide a spacious and comfortable space for urban activities (Figure 2-5). The underground plaza of Sapporo Station has been given a sense of life, providing more spatial resources for public activities (Figure 2-6).

Figure 2-5 Sapporo underground walkway (Source: Internet)

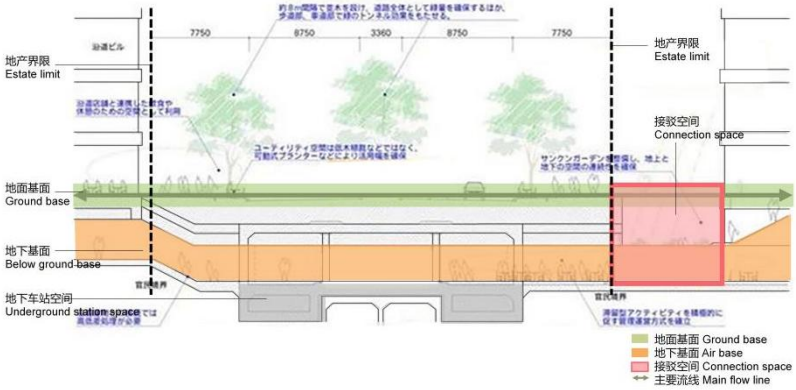


Figure 2-6 Sapporo station ground-underground walking path (Source: redrawn from reference [43])

(3) Underground-ground-air walking paths

The urban underground-ground-air walking path is a more complex system. By overlapping and dislocating horizontally and vertically, functional spaces located in the same horizontal dimension are vertically superimposed in the vertical dimension to form a three-dimensional urban neighbourhood. For example, London's Canary Wharf relies on rail transport to establish four urban bases, and by grooming the flow and setting up traffic joints,

the connections between the bases are strengthened and the efficiency of spatial use is improved[44] (Figures 2-7, 2-8). Specifically, connections between the basal planes are made via escalators, lifts and stairs, with the atrium used to integrate the four bases simultaneously.

Figure 2-7 Aerial view of Canary Wharf
(Source:https://www.vcg.com/creative/808102748)

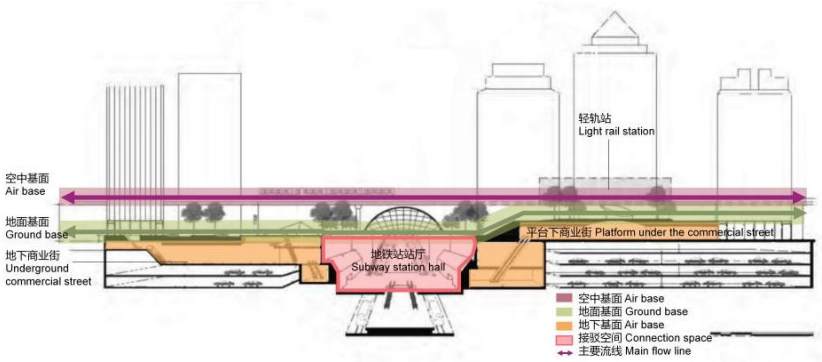


Figure 2-8 Canary Wharf underground-ground-air walking path (Source: redrawn from reference [1])

In summary, multi-level walking paths include ground-air walking paths, ground-underground walking paths and underground-ground-air walking paths. The urban ground-level walking paths correspond to spaces such as ground-level walkways and squares. The underground walking paths correspond to the following spaces: underground walkways, underground streets, sunken squares, etc. The spaces corresponding to the urban sky paths are: pedestrian corridors, platforms, footbridges, roofs, etc. (Figure 2-9). To summarize, multi-level pedestrian paths must have at least two vertically positioned bases with a certain height difference between the public activity base and the ground-level base.

The organization of the flow between the different bases is one of the design priorities for the pedestrian space of the urban ground floor, as excessive separation can lead to a weaker connection between the base planes, which in turn is detrimental to daily use. It is therefore important to have a three-dimensionally accessible traffic system between the different base planes. A three-dimensional system can be created by connecting horizontally and vertically. In the horizontal direction, spaces with multiple paths and nodes are created by expanding, connecting and forming multiple nodes horizontally. In the vertical direction by staggering, overlapping, vertical traffic nuclei and steps, diverse spaces are formed to meet the convenient needs of people’s daily life (Figure 2-10).

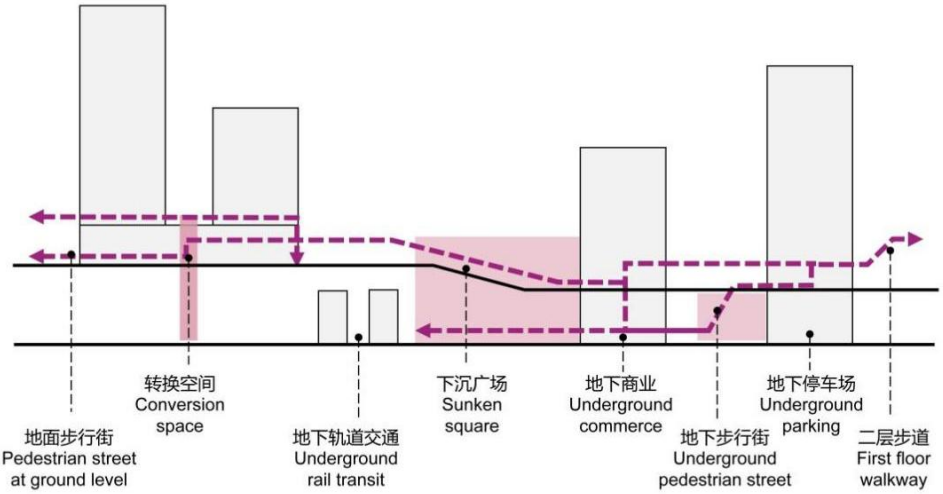


Figure 2-9 The multi-level walking path (Source: the author)

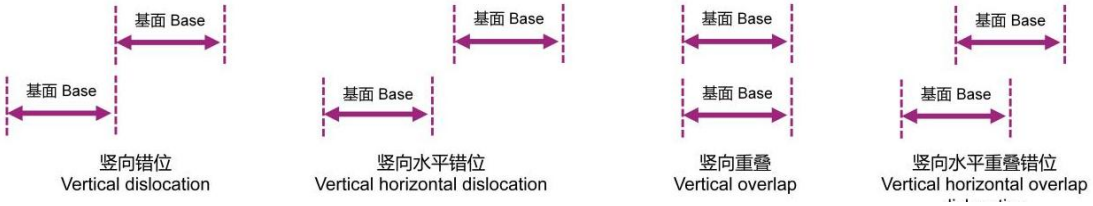


Figure 2-10 Vertical connection of walking paths (Source: the author)

2.3 Main Functions of Three-dimensional Pedestrian System in Urban Ground Floor

2.3.1 Walking Connectivity

The basic function of the three-dimensional pedestrian system on the ground floor of the city is the function of pedestrian connectivity, which realizes the distribution of pedestrian and vehicular traffic through the co-ordination of different modes of transport and the organization of pedestrian flows. From the point of view of traffic connectivity, connectivity rises from a single ground plane to multiple ground and connected spaces, which is expressed in the continuity of horizontal traffic and the conversion of vertical traffic (Figure 2-11).

In terms of horizontal traffic continuity, a three-dimensional pedestrian system is more continuous and can provide pedestrians with a better walking experience, freeing them from the interference of vehicular traffic. A three-dimensional pedestrian system can provide pedestrian space underground, at ground-level and in the air, thus providing continuity of walking paths. A recent study comparing a three-dimensional pedestrian network with a road network in Hong Kong found that the former is twice as long and has eight times the number

of connections[31]. Therefore, a three-dimensional pedestrian network can reduce congestion of ground-level pedestrian flows, alleviate the lack of pedestrian networks brought about by vehicular traffic-oriented urban planning in metropolis, and provide more continuous pedestrian transport.

In terms of vertical transport transition, the three-dimensional pedestrian system can be interconnected with buildings of different elevations and public spaces, providing a pedestrian experience similar to that of the ground floor, and facilitating the distribution and movement of pedestrian flows. Moreover, people can move freely in indoor and outdoor spaces of different elevations through the vertical traffic transfer space, which can provide walkers with continuous pedestrian traffic and convenient traffic transfer. Therefore, the vertical transport transition of the three-dimensional pedestrian system is a key[45]. Neither underground walking nor above ground walking can exist in isolation from the ground space. And the key to the connection lies in the vertical transport links. At the same time, previous studies have found that pedestrians are willing to avoid footbridges and underpasses by walking more, as these features imply extra effort (e.g., getting on and off). These vertical connection facilities tend to be safe in terms of vehicle-pedestrian flow conflicts, but are generally unpopular[46]. So how to improve the accessibility of vertically connected facilities and enhance the connection with the neighbourhood is a topic worth thinking about.

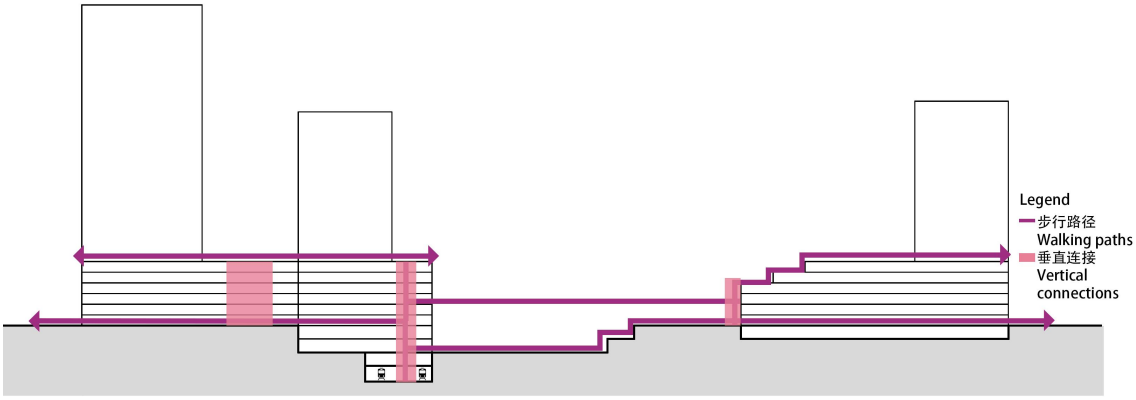


Figure 2-11 Functions of pedestrian connectivity (Source: the author)

2.3.2 Functional Compound and Social Integration

Three-dimensional pedestrian system creates multi-level access points that can link different functions and facilitate the flow of various elements, which in turn promotes functional compound and social integration. Vertical cities create certain safety and social

segregation problems because of spatial layering, and need to emphasize more everyday verticality[47]. The pedestrian system, as a spatial carrier linking different elevations on the ground floor of the city, not only increases the economic value of the mezzanine floor and expands the area dedicated to shopping space, but more importantly, it knits together the functions of different elevations in the city, facilitates the flow of all kinds of elements, and alleviates social segregation in the city (Figures 2-12).

In the project, the three-dimensional pedestrian system not only realize spatial connections, but also promote the compound of various functional elements. The Part-Dieu transport hub in Lyon, France, is a cluster of companies, bank headquarters and shopping centers surrounded by social housing. In the plan to reshape Part-Dieu, the concept of "socle actif" active ground was proposed, using pedestrian flow lines to interconnect the ground floor spaces and implanting functions into the gap buildings such as public facilities and neighbourhood spaces, which converge the community flow with the central district flow, and promote the mixing of social functions[48,49]. In Hong Kong, Subway Plan suggests that public pedestrian routes should penetrate different functions at different levels and converge in a layered urban environment to form a wider, multi-level pedestrian system linked to major transport interchanges and commercial developments[50]. In addition, a wealth of commercial facilities and open spaces with convenient transport interchange facilities are provided in the underground pedestrian paths of the Taipei station. A large number of people entering and leaving the station travelled through the underground commercial streets, which brought great economic benefits to the station (Figures 2-13, 2-12). Along the TOD corridor in Bangkok, Thailand, while achieving physical connectivity, it also integrates related stakeholders such as subway operators, land developers, surrounding communities and land holders, and promotes the prosperity of commerce with mixed urban functions and appreciation of land value[51].

Although it has been argued that elevated pedestrian systems limit or destroy the social and commercial possibilities of surface streets[52]. However, by comparing the aerial pedestrian system from Central to Mid-Levels in Hong Kong with streets in neighbouring districts, it was found that the level of pedestrian activity and concentration of businesses on streets where aerial pedestrian paths existed exceeded the overall level of parallel streets that ran up the slopes. The aerial pedestrian system, combined with ground-level streets and

staircases, collectively contributes to street vitality, facilitates the circulation of people through the streets, and enhances the flow of people through different functional elements[53].

Therefore, the three-dimensional pedestrian system can organize different spatial functions together by combining aerial walking paths, underground walking paths and rooftop platforms, or set up shops, public service facilities, shared spaces, etc. And the underground walking paths can combine with subway station halls, so as to promote the communication and interaction between various elements. It can be seen that the three-dimensional pedestrian system has the function of promoting urban functional compound and social integration.

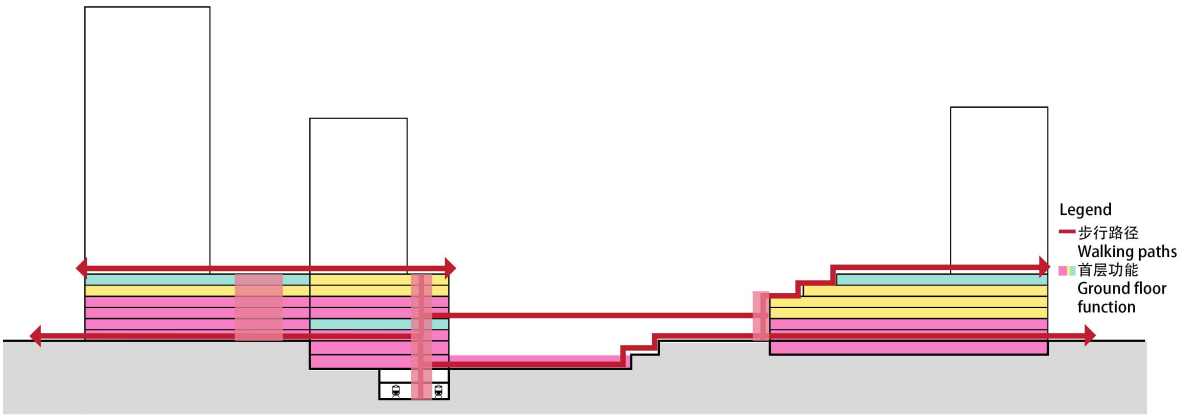


Figure 2-12 Functions of promoting urban functional compound and social integration (Source: the author)

Figure 2-13 Scope of underground street in Taipei Station (Source: the author)

Figure 2-14 Underground street in Taipei station (Source: the author)

2.3.3 Leisure Activities

In high-density cities, which are encroached upon by large volumes of buildings, there is usually little provision of public activity spaces for interaction or rest between users. In addition to its own multi-layer space that can create more rest space, a three-dimensional

pedestrian system can be combined with different levels of green landscape, so as to facilitate the occurrence of leisure and interactive activities.

On the one hand, the walking path itself can enhance the greening rate of the city through the implantation of green plants. For example, the High Line Park in New York has become a vibrant “green belt in the sky” through the reuse of old infrastructure and the implantation of various landscape. On the other hand, the accessibility of the landscape is enhanced by connecting with parks and rooftop gardens in the city through walking paths (Figure 2-15).

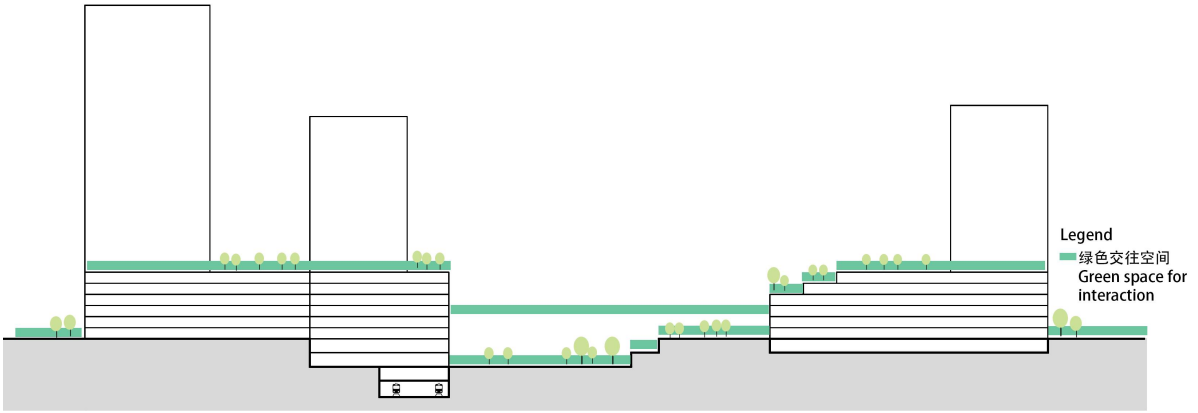


Figure 2-15 Functions to facilitate leisure activities (Source: the author)

2.4 Chapter Summary

This chapter carries out a basic study of pedestrian space.

Firstly, it summarizes and analyses the development of the pedestrian system from a single ground-level to multi-level pedestrian system, outlines the differences between ground-level and multi-level pedestrian system, and points out that the main difference lies in the fact that the ground-level pedestrian system occupies urban land, while the multi-level pedestrian system occupies the urban substrate and serves buildings of different scales, urban infrastructures and public spaces.

Secondly, the spatial characteristics of the three-dimensional pedestrian system are summarized by means of example illustrations. Among them, the types of pedestrian space include walking paths, square, atrium spaces and roof platform. The types of multi-level pedestrian paths include ground-air walking paths, ground-underground walking paths, and underground-ground-air walking paths. It also analyzes their advantages and disadvantages, and summarizes spatial compositions and vertical connections of multi-level pedestrian paths.

Finally, the main functions of the three-dimensional pedestrian system in the urban ground floor are analyzed as walking connectivity, promotion of urban functional compound and social integration, and stimulation of leisure and interaction activities. Among them, walking connectivity refers to horizontal and vertical continuity; functional compound and social integration refers to the creation of multi-level access points, which can connect different functions to each other and promote the flow of various elements, thus promoting functional compound and social integration; and recreational interactions refer to the fact that the pedestrian system can be combined with green landscapes at different levels, thus promoting the occurrence of leisure activities.

Chapter3 The Ground Floor of the City as a Project Space: Case Studies

3.1 Re-connecting City: Spatial Fragmentation Repair in La Défense Seine Arche, Paris

3.1.1 Background

The central business district of La Défense in Paris, built in 1958, is an example of a plan based on the ideas of Corbusier and a representative example of three-dimensional urban planning (Figure 3-1). La Défense has been transformed from an empty roundabout into a new city of tall buildings, with the white iconic Grand Arc echoing the Arc de Triomphe on its east-west historical axis (Figure 3-2, 3-3).

The construction of La Défense brings the concept of pedestrian and vehicle separation and three-dimensional traffic to the fore. Beneath the pedestrian deck is a very complex multi-layered traffic system. After the 1990s, however, the competitiveness of the CBD in La Défense was challenged and the original planning concept was questioned. In this context, the *Schema Directeur de Renouveau de La Défense* was approved by the French government in December 2006. The renewal plan, which positions the La Défense District as the first central business district in Europe and an important part of the "*Le Grand Paris*" plan, was expanded from the existing 160 hm^2 to 500 hm^2 (Figure 3-4). In 2011, the French government commissioned the François Leclercq building agency to renovate the ground floor space. In 2015, the EPADESA (Public Planning Agency of La Défense Seine Arche) launched a public consultation on the 2025 Strategy and published the *LA DÉFENSE SEINE ARCHE STRATEGIE 2025*[54].

This section is mainly based on François Leclercq, a famous French architect and urban planner, who used the ground floor of La Defense as a project space. In view of the current situation that the La Defense three-dimensional platform area is separated from the surrounding environment, the slow-moving system is rectified, and a new way (walking and cycling) is used to pass[55-57].

Figure 3-1 Aerial view of La Défense (Source: reference [54])

Figure 3-2 La Défense walking platform (Source: the author)

Figure 3-3 Grand Arch (Source: the author)

Figure 3-4 Expansion of the La Défense Business District boundaries (Source:redrawn from reference [55])

3.1.2 Repair Objectives and Principles

In response to the fragmentation of La Défense Seine Arch from its surroundings as an "island" in the city and the over-complexity of its internal systems, the famous French architect and planner Leclercq F. has proposed a strategy for the area of the La Défense Seine Arch, which takes into account the special relationship between the national interest and the neighbouring city and includes the following objectives and principles.

(1) Repair Objectives

Firstly, enhance the links with the surrounding cities. Modernise the commercial area and open it up to the surrounding area, changing the unidirectional flow of the current situation in La Défense Seine Arch and creating adequate links with the region. The real goal is not to create a functional mix, but to link polarity, mobility and use in order to connect La Défense

Seine Arch to a more local fabric and to address the fragmentation of the core area from the site's perimeter.

Secondly, increas the attractiveness and slow accessibility of public spaces. Improving the spatial continuity of La Défense Seine Arch, increasing the accessibility and comfort of public spaces, enhancing links to public transport, improving slow-moving (walking, cycling, rollerblading and other non-motorised transport) and increasing the attractiveness and accessibility of public spaces.

Thirdly, improve the ground floor space. Historically, the vertical pattern of development in La Défense Seine Arch has led to a gradual neglect of ground-level issues, starting with the construction of flat slabs. Shifting the past focus on architectural towers and shifting the attention from the sky to the ground floor space, devoting more space to nature and creating human connections, especially through shops to enhance vitality.

(2) Repair Principles

Firstly, slow-moving is given priority. The spatial regeneration of La Défense Seine Arch prioritises slow-moving, providing a structured network of green spaces integrated with the main public spaces and loads.

Secondly, the coherence and accessibility of the historic axis is maintained. The presence of the historic axis in the La Défense Seine Arch is reinforced by the axis.

3.1.3 A Three-dimensional Repair Approach for Reshaping Spatial Connectivity

(1) Identify the center of the site

In order to better connect the surrounding area, Leclercq used the “point-axis” theory to identify the center of the site and establish initial lines of connection. Ongoing and future projects around the site were identified and the location of regional centers of attraction, urban centers, district centers, community commercial centers and markets were identified, along with the location of public transport and public spaces, linking polarity, mobility and use. (Figure 3-5, 3-6, Table 3-1).

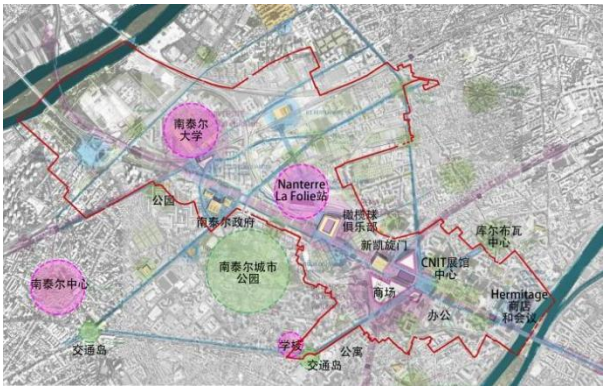


Figure 3-5 Functional analysis of the La Défense (Source: the author)

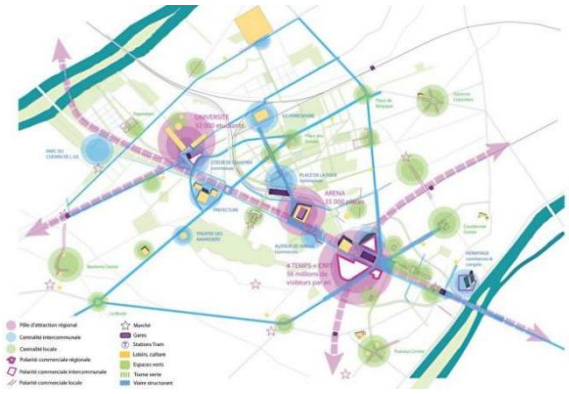


Figure 3-6 Distribution of functional centers in La Défense (Source: reference [55])

Table 3-1 Criteria for judging the center of attraction (Source: compiled by the author from reference [55])

Type	Judgement criteria
Regional center of Attraction	A regional business district made up of large companies and international financial centers, sports arenas, universities, etc. For example, the La Défense business district, the University of Nanterre, the French Rugby Club
Urban centers	The heart of public transport, shopping centers, theatres, public service centers, etc. e.g. station, Nanterre Government, Almond Theatre
District centers	Public open spaces, squares, etc. For example, Grosse Square, Belgium Square, etc.
Community commercial centers and markets	Community center shops, local markets

(2)Diagnose slow-moving problems in terms of connectivity, convenience and comfort

Instead of emphasizing absolute internal stratification of traffic, the view is extended to the connections with the surroundings, diagnosing the problems of the site in terms of connectivity, convenience and comfort, and specifically analyzing the pedestrian paths from the central area of La Défense Seine Arch to the surrounding centers. In Pont de Neuilly, for example, the south-east side is adjacent to the Seine, but the waterfront is occupied by roads, the bridge connecting Paris is a road-rail bridge, which is not passable by pedestrians, and the break in the connection with the historical axis. In the axis comprising Joliot-Curie Street and Arago Street, there is a particular lack of accessible, pleasant pedestrian space and continuity of pedestrian paths. A full understanding of the problem of slow mobility from the core to the peripheral center will provide the basis for sewing up the slow walking break later on.

(3) Connect slow-moving breaks to create a network of structured public spaces

The regeneration plan proposes to “mend” the fragmented urban fabric and integrate La

Défense into the area[58]. On the basis of the existing roads, the city center is interconnected with public transport stations, green spaces and other nodes, creating a structural framework of public space networks. At a finer scale, the land is connected through the continuity of slow-moving, and Leclercq identifies a total of eleven axes (the road equivalent of traditional urban space) that create new links between the otherwise isolated La Défense and the surrounding area, allowing people to quickly identify the space (Figure 3-7).

Moreover, the strength of the connections is determined according to the iconic buildings and planned projects. For example, the RD913-Charras axis, which represented a potential urban continuity between Puteaux, Courbevoie and the commercial area before the construction of the first floor slab and the vertical diversion, could be laid out with the commercial centers of Les 4 Temps and La Coupole on its edge. By reconnecting and adding a reflection on public transport, the slab enhances the links with the surrounding area.

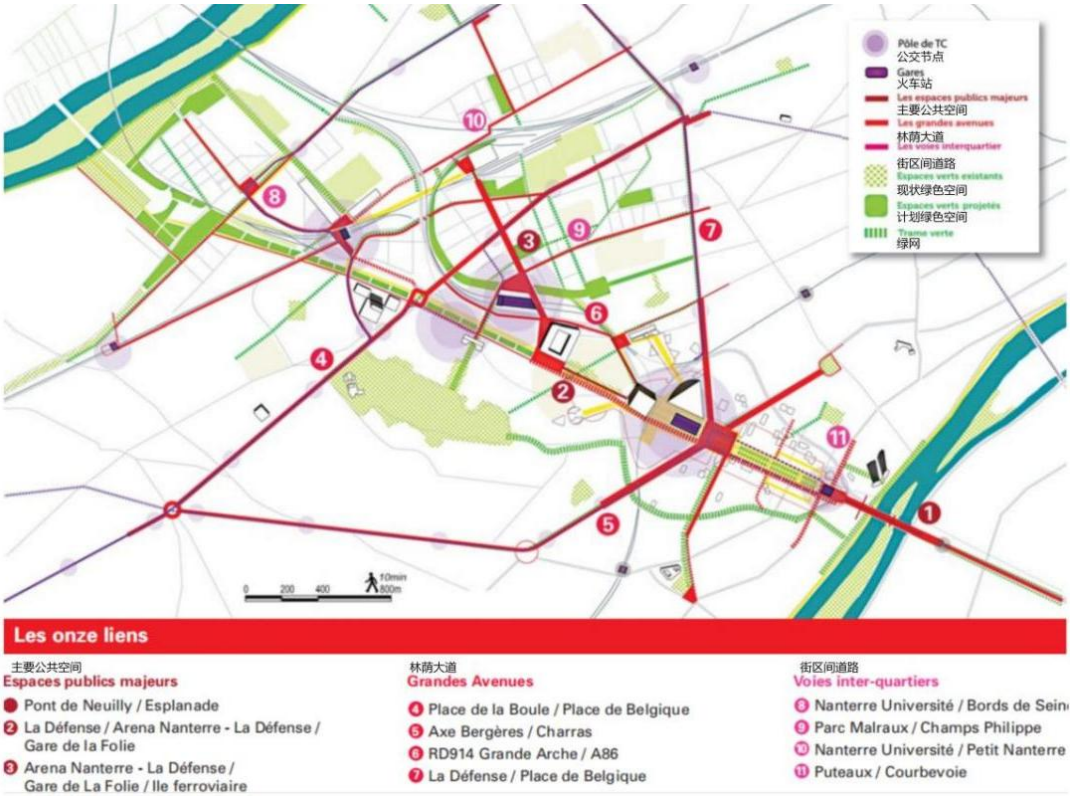


Figure 3-7 François Leclercq proposal: 11 links in La Défense Seine Arche (Source: reference [55])

The linkages established were designed in detail using a three-dimensional repair approach, using techniques such as the design of aerial walkways and the modification of urban overpasses to optimize the slow path. For example, the link between La Défense /

Arena Nanterre and La Défense / Gare de la Folie railway station extends the slab public space of La Défense westwards, linking hotels, stations, services, events and shops through a skywalk, creating new spaces for visitors and residents(Figure 3-8).

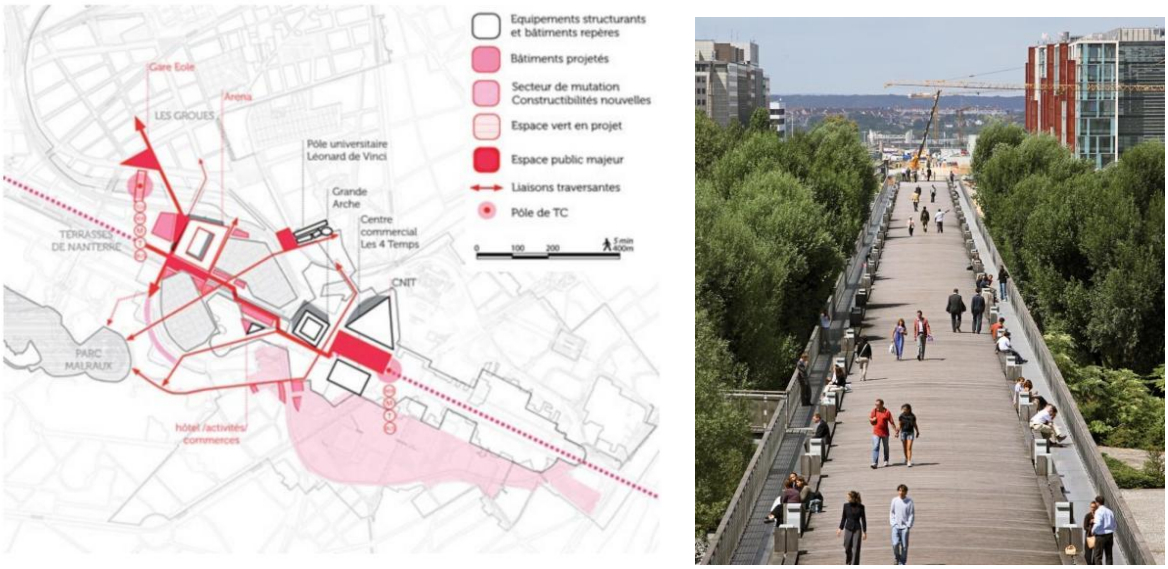


Figure 3-8 Links between Défense / Arena Nanterre and La Défense / Gare de la Folie

(Source: reference [55])

The renovation of the Axe Bergères / Charras, one of the entrances to La Défense, will greatly enhance the connection between La Défense and its surroundings. For the Rose de Cherbourg project on this axis, the designers Arriola et Fiol have transformed the boulevard overpass of the road ring into a suspended promenade. The promenade will provide 500 meters of green space, with the aim of providing more space for slow-moving, ensuring the safety of pedestrian crossings and meeting the needs of walking and sporting activities. Specifically, the project transforms part of the circular avenue into an urban boulevard, including a wide pedestrian path and a cycle path, which will allow everyone to use the new pedestrian path to connect La Défense with Terrasses Boieldieu. on the promenade, various greenery is planted to create an urban linear park; underneath the promenade, play facilities such as a skate park and a climbing area for children are added. The whole forms a composite multi-level public space linking La Défense with the surrounding center (Figure 3-9, 3-10).

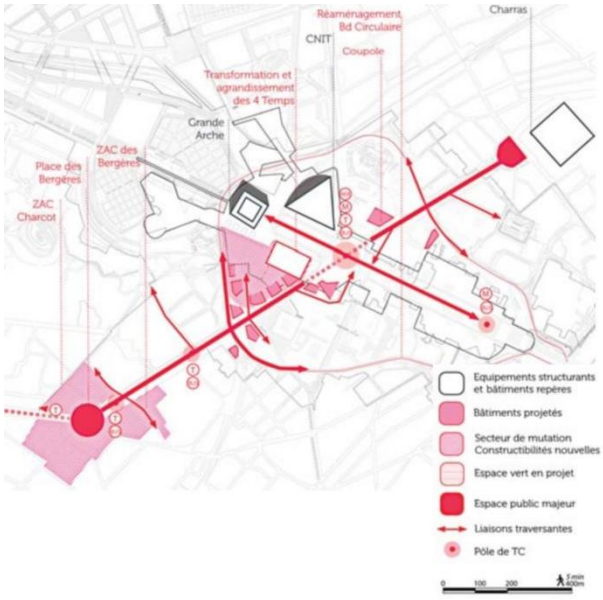


Figure 3-9 Links between Axe Bergères and Charras (Source: reference [55])

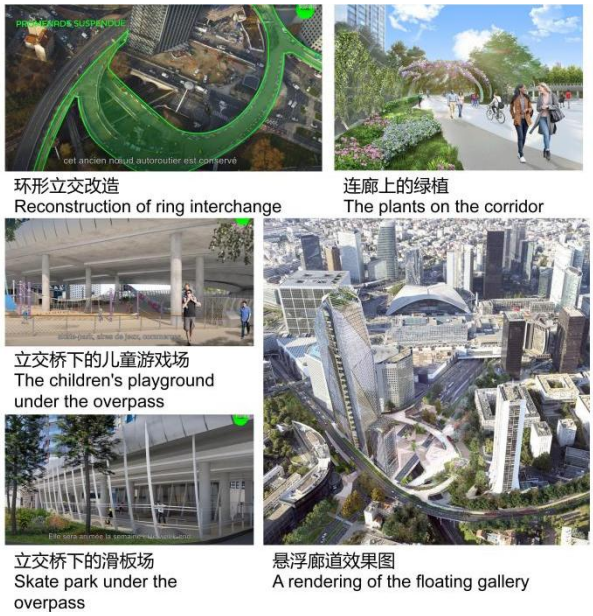


Figure 3-10 Rose de Cherbourg Corridor design (Source: https://parisladefense.com/)

(4) Establish a pedestrian service circle based on the needs of the population

On the slow-moving network, targeted service facilities are provided so that they meet the service needs of the walking circle. In this context, a pedestrian circle is a public service that is available to people within 5, 10 and 30 minutes walking distance.

According to Leclercq's judgement, the main groups of people in the La Défense can be divided into two main categories: families and youth. The services needed by families and youth within a 5-minute, 15-minute and 30-minute walk, respectively, are analyzed in the hope that targeted services can be provided. For example, for youth, a five-minute walk requires services such as subway stations, bus stops, club, markets, cafes, etc. On this basis the pedestrian network is refined to provide services and facilities(Figures 3-11, 3-12).

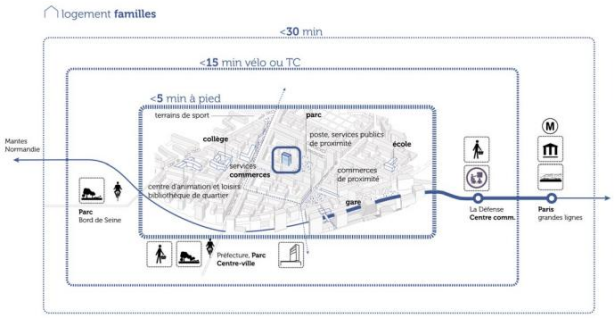


Figure 3-11 Family member pedestrian circle (Source: reference [55])

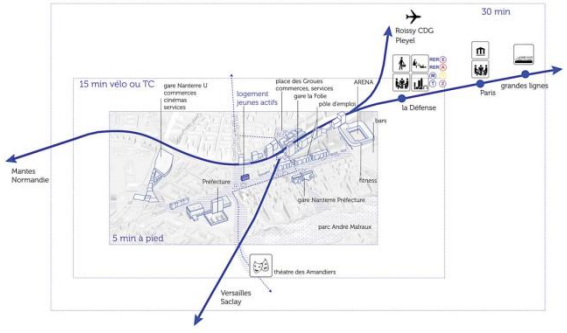


Figure 3-12 Youth pedestrian circle (Source: reference [55])

(5) Renovate the ground floor and implant more green space

On the one hand, La Défense has implanted more green space on the ground floor space, reaching 35% of the pedestrian zone. In conjunction with field research, it has found that it has transformed the spaces on the slab by means of landscape, planting trees, creating new urban parks and sharing gardens (Figure 3-13). The comfort of public spaces is improved, as well as the creation of walking or resting spaces that contribute to the daily physical and mental well-being of citizens.

On the other hand, La Défense opens up and provides easy access to the spaces on the ground floor of the building, increasing the interaction between the building towers and the terrace areas. These new spaces are dedicated to new forms of work, communication and other activities. La Défense advocates the reopening of the ground floor as a result of the changes in current office patterns and economic logic considerations. Due to changes in the way of working, nomadic, coworking and other people without a permanent office are increasingly present. To increase its competitiveness, La Défense, represented by the clustering of office space in towers, needs to strengthen its address effect and provide more convenient services. As a result, the ground floor of La Défense has become a global ecosystem of services for companies, employees and different users, called “QAHNS”, i.e. business districts with a high level of service[59](Figure 3-14).

Figure 3-13 Landscape on the La Défense platform (Source: the author)

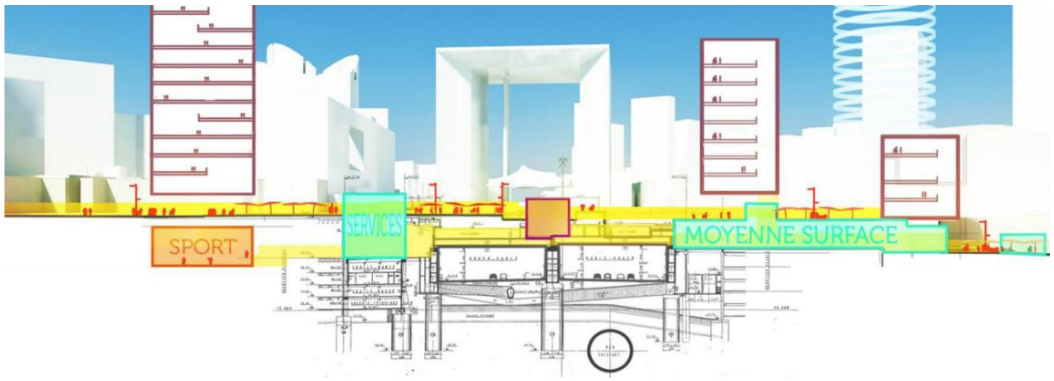


Figure 3-14 La Défense section (Source: reference [59])

3.2 Public-private Collaboration: Three-dimensional Repair of Pedestrian System in Central, Hong Kong

3.2.1 Background

Hong Kong is a dense, compact city with a population of 7.3 million and a built-up area of just 24% of a total area of 1100 sq. The city is a dense, compact city with a population of 7.3 million and a built-up area of only 24% of a total area of 1100 sq. km. Areas designated as "open space" account for only about 2% of the city's area[60]. Open space is particularly valuable in Hong Kong, where the combination of land-use compatibility and flexibility has resulted in the coexistence of a variety of public functions[61]. As a region with a typical skywalk system, Hong Kong has not only achieved accessibility, but has also shaped the city's image as a "vertical city to a three-dimensional city". Hong Kong's 24-hour commuter skywalks are located throughout the city, linking rail stations with major functions and open spaces in an orderly manner, providing a continuous and convenient walking environment for the public. In addition to satisfying the need for continuous pedestrian movement, aerial corridors are also characterized by their diversity and composite nature.

Therefore, this section mainly selects the Hong Kong Central air pedestrian system as an example to analyze the diversity and composite functions of the corridor, and the coordination relationship between public space and private capital. The system is located on the northwest side of Hong Kong and includes Central and Admiralty.

3.2.2 Evolution of Public-private Relations

The elevated pedestrian system in Hong Kong Central has gone through three main stages of development. The role of the government has changed from a spectator to a participant and then to a coordinator (Table 3-2). These changes reflect the evolution of Hong Kong's relationship between the government and private owners over the construction of the pedestrian system in various periods.

Historically, Hong Kong's urban construction is the result of a combination of top-down government planning and bottom-up spontaneous behavior[25]. In 1963, in order to solve the problems of insufficient commercial area in the plot and inconvenient business commuting on

the ground floor, many private owners in Hong Kong took the initiative to establish air corridors between buildings to improve land use efficiency. However, at that time, the "air pedestrian system" was still in its infancy, just a few cross-street corridors scattered everywhere, which did not really constitute a "system", nor did it really solve the problem.

Until 1974, with the promulgation of policy documents such as the *Urban Planning (Amendment and Recognition) Ordinance*, the "Planning Application System" was established. The Hong Kong government gradually clarified its role as a "supervisor" and "guide" in the construction of the air pedestrian system. While coordinating and improving the ground traffic congestion, it vigorously created air public spaces and improved the air pedestrian system.

Table 3-2 Evolution of public-private relationships (Source: collated from reference[62])

Period	Government action	Private owner action	Connected plots	Performance and evaluation of all parties
1963-1973: Scattered construction period	①Approved to build a local small public pedestrian space.	①Hongkong Zhidi designed and built private footbridges.	Commerce	The government's power is weak, and private owners have found the value of aerial walking to promote consumption.
1974-1988: Initial formation period	①The government wholly owned the underground railway company, and began to engage in large-scale real estate; business in the late 1970 s. ②In 1974, the "Planning Application System" was put forward, allowing qualified private owners to carry out construction.	①Hongkong Zhidi launched the "Central Property Redevelopment Programme". ②Allow footbridges to pass through the atrium of private properties and connect to other properties.	Commerce, Subway Station, Bus	Moving from private to public construction, the government's role is not that of a "manager" but that of an "opener" who also joins the "capital for profit".
1989-2003: Boom period	①With the construction of Hong Kong Station and Central Station, the public space between the properties is opened up. ②Puts forward guiding principles for the construction of footbridges.	①Hongkong Zhidi continues to build pedestrian system in conjunction with other properties.	Commerce, Subway Station, Bus, Wharf, Green Space	The government formulates guidelines to guide the construction of the pedestrian system, and consciously organizes private owners to plan uniformly.

3.2.3 A Three-dimensional Repair Approach for Public-private Collaboration

(1) Enhancement of public functions along the line: air pedestrian paths connecting various city-level functions

The air pedestrian system in Central connects a variety of urban functions along its route, mainly commercial, public facilities, public spaces, cultural facilities and other public attributes, and is characterized by the diversity of connected functions. 29 buildings in different blocks are linked by 40 corridors, with the Central Station (public transport) as the core, directly linking the Hong Kong-Macau Ferry Terminal, the International Finance center (major commercial) and the Central Ferry Terminal. Emphasis is placed on the connections between the railways and the major transport distribution points, which take on the function of gathering and dispersing people in the city (Figure 3-15).

The functional space of the Central air pedestrian system includes traffic space, commercial space, landscape space, rest and entertainment space. Among them, in the commercial space, the continuous flow of people in the air pedestrian path contains huge commercial potential. The pedestrian path passes through the commercial space and the first-floor entrance hall of the office, with shops, coffee shops, restaurants and so on on both sides, which improves the commercial migration and commuting efficiency, and stimulates the regional commercial vitality. It is one of the manifestations of Hong Kong’s embrace of consumerism. The pedestrian path and the building are interspersed and combined in a variety of ways, blurring the spatial boundaries between each other, and the boundaries between public and private have become blurred. In the rest and entertainment space, the air pedestrian path provides the activity space for daily communication (Figure 3-16).

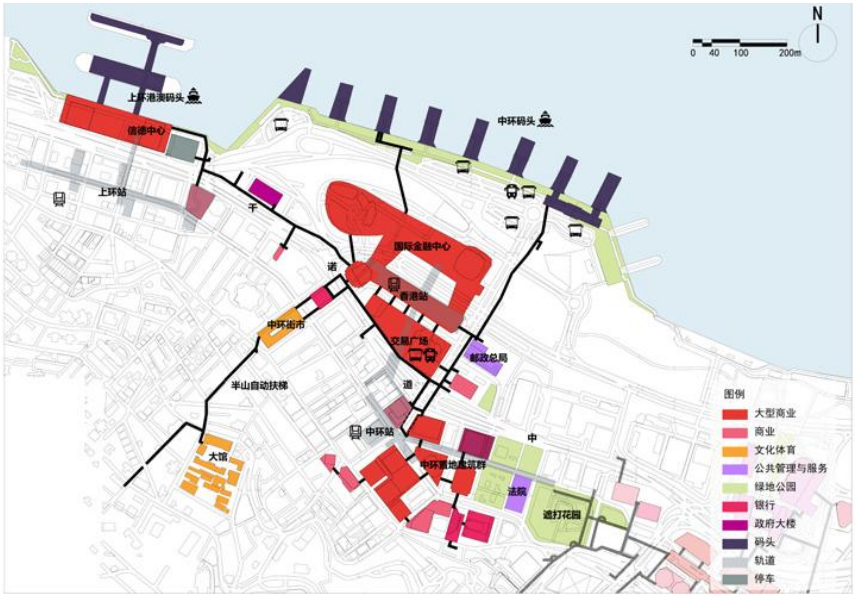


Figure 3-15 Functional analysis of the Central air pedestrian system in Hong Kong (Source: reference[29])

Figure 3-16 The diverse functions of footbridges (Source: the author)

(2) Flexible function of statutory plans: promoting the coexistence of multiple functions of air pedestrian system

The flexible function setting of Hong Kong statutory plans has brought design redundancy to the construction of the air pedestrian system, and further laid the foundation for the coexistence of various public functions of the air pedestrian system[29]. In the *Hong Kong Planning Standards and Guidelines*, it is stipulated that the land use at the bottom of the overpass and pedestrian overpass is divided into acceptable, conditional acceptance and unacceptable(Table 3-3). In consideration of land use, structure, fire safety, traffic, environment, landscape and other relevant factors are accepted, can be arranged in the pedestrian system. Moreover, urban design guidelines specify the need for convenient pedestrian networks in ground, underground, and platform areas within commercial land[63]. The three-dimensional pedestrian system combines commercial facilities, roof gardens, public squares and other facilities to form a variety of complex functional places.

Table 3-3 Classification of uses in footbridge systems (Source: compiled from the *Hong Kong Planning Standards and Guidelines*)

Classification of uses	Specific details
Acceptable uses	Amenity, fine art, commercial displays, government facilities, public information kiosks, vending machines, open flower points, newspaper and magazine kiosks, offices of non-government bodies and associations providing convenient public services
Conditionally Accepted Uses	Indoor recreational facilities, static open space, library

(3) Good coordination of multi-agent development : privately owned public space strategy to improve the quality of public space

The symbiotic relationship between public space and private capital in Hong Kong began in 1962 with the introduction by the Hong Kong government of New York's incentive zoning system, the concept of POPS (Privately Owned Public Space), in which developers create urban spaces for public use in exchange for additional development space or special exemptions. This type of public space is known in Hong Kong as POSPD: Public Open Space in Private Developments[64,65]. The provision of public open space in private developments is overseen by the relevant government departments, with the developer being responsible for its management and maintenance after completion, and granting free access and use to the public. The strategy of using private public space to increase the stock of urban public space, enhance its quality and stimulate urban vitality.

As an innovative product under the management mechanism that stimulates urban vitality and balances public and private benefits, privately owned public space has the threshold characteristics between "public" and "private", which gives it more possibilities. For example, K11 Art Mall has created a relatively free public life under the balance of publicity and consumerism. In the context of spatial justice, private public space, as an intermediary benefit to alleviate urban injustice, faces the transition interval between private sphere and public sphere, and reserves a kind of adjustability for public life. It helps to achieve the optimal allocation of public space and alleviate social injustice[66].

(4) The government improve public-private partnerships: FAR bonus policy and property management system

On the one hand, through the Floor Area Ratio (FAR) bonus policy to improve the enthusiasm of developers for the construction of public channels. Hong Kong's volume

incentive measures refer to the land development management department rewarding developers with a certain building area on the premise that developers provide certain public space or public welfare facilities in order to obtain the cooperation of developers. The development subject of the air pedestrian system has shifted from a single government department to multi-party coordination, which has greatly improved the enthusiasm of developers for the construction of the pedestrian system.

On the other hand, the *Building Management Regulations* also provide a statutory basis for the operation and management of the air pedestrian system. The document mentions: *"Government departments can supervise and manage the operation of air pedestrian system such as corridors, corridors, stairs, and gardens in property management independent of developers."* In addition, the inspections of the General Administration of Lands and the Buildings Department have played a good supervisory role in the construction of the air pedestrian system.

3.3 Lack of Project Space : Skywalk in Zhujiang New Town, Guangzhou

3.3.1 Background

Zhujiang New Town is the main part of Guangzhou Tianhe CBD. It is located in Tianhe District, Guangzhou, bounded by Huangpu Avenue in the north and the Zhujiang in the south. It is located on the central axis of the new city. The area contains dozens of landmark buildings and is the most concentrated business office area in Guangzhou. In order to closely connect the important buildings in the area and alleviate the contradiction between people and vehicles, in the *GCBD21-Zhujiang New Town Planning Review* and *Zhujiang New Town Central Square Design* completed in 2002 and 2004 respectively, the idea of building a air pedestrian system for the core area of the Zhujiang New Town was proposed[67]. In 2007, the *Implementation Plan of the* skywalk *in the Core Area of Zhujiang New Town and along Xingsheng Road in Guangzhou* was compiled (hereinafter referred to as "Implementation Plan"). At present, the construction of the air pedestrian system in the Zhujiang New Town is still in progress, and its implementation effect is controversial[68].

The construction of the skywalk in the Zhujiang New Town lacks project space, and does

not consider the integrity of the pedestrian space and the function of the ground floor of the city, resulting in a fragmented form of the status quo.

Therefore, this section mainly analyzes the skywalk of Zhujiang New Town in Guangzhou from the implementation effect of the lack of project space.

3.3.2 Current Situation

This situation analysis mainly compares the skywalk that have been built with the "Implementation Plan", focusing on its implementation completion, spatial connectivity, spatial function, spatial convenience and comfort.The meaning of each indicator is explained in detail below.

Implementation completion degree: Comparing the goal of *Implementation Plan* with the current skywalk, the implementation of skywalk and vertical transportation facilities planned and constructed is analyzed.

Spatial connectivity: Analyze whether the connection of the built skywalk has achieved the expected results, including the skywalk connectivity between different plots, the connection between buildings and skywalk, and the vertical connectivity of skywalk with different spatial layers.

Spatial function: Analyze the actual use function of the built skywalk and the spatial function connected to it.

Spatial convenience and comfort: Analyze the connection facilities between the built skywalk and the ground and bus systems, as well as the use experience and visual identity design of the skywalk.

(1) Implementation completion degree

By comparing the current skywalk with the long-term objectives of the *Implementation Plan*, the current level of completion of the skywalk system in the core area of Zhujiang New Town is less than half. There is only good connectivity along the already in-use commercial pedestrian streets of Gaode Spring Plaza, Summer Plaza and Xingsheng Road. Meanwhile, the skywalk at the four intersections of Jinsui Road and Huacheng Avenue underneath Huacheng Plaza has been completed and is in use, with the remainder still under construction (Figure 3-17, 3-18).

Figure 3-17 2009 Implementation Plan for Zhujiang New Town Core Area Skywalk Plan

(Source: reference[67])

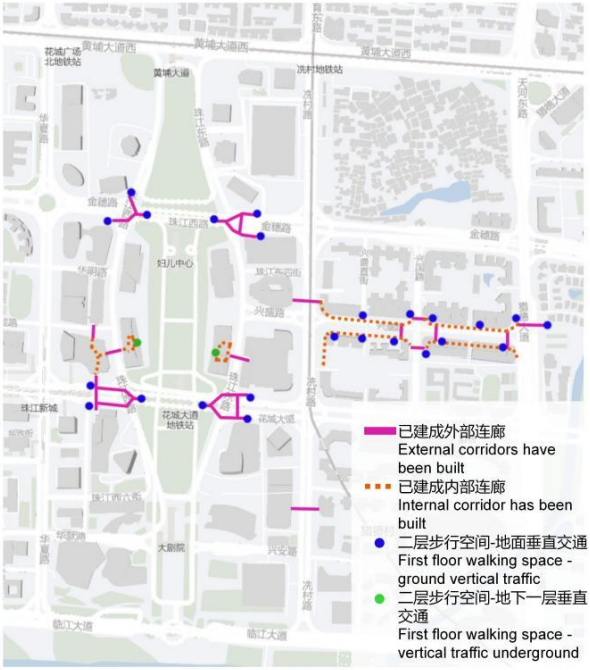


Figure 3-18 Current status of skywalk in the Core Area of Zhujiang New Town

(Source: the author)

(2) Spatial connectivity

The continuity of the skywalk in the core area of Zhujiang New Town is poor, and the walk is easily interrupted during the process of walking on the skywalk, and the phenomenon of insufficient connectivity is manifested as follows:

Firstly, the skywalk between the less public commercial office buildings are “not connected”. Not only is it impossible for people to pass between the two buildings, but the corridor also lacks direct access to the outside and cannot be used as a passageway for pedestrians. For example, the skywalk from the Bank of Communications building to the W Hotel is not in use, and the building corridor between the Gaodezhidi and the Global Crossing building is unused.

Secondly, the skywalk is not well connected to the ground and underground pedestrian system. Most of the building corridors are connected to the ground-level by steps and escalators, with insufficient consideration given to barrier-free design and rough connections. At the same time, in terms of the connection with the underground pedestrian system, except for the vertical transportation facilities inside the building, the outdoor part of the sky corridor

has not established a direct and convenient connection with the underground pedestrian system, so the connection with the subway station is also relatively weak.

Thirdly, the connectivity of the public pedestrian corridors within the building is weak. When the skywalk is connected to the building, it is directly connected in series, and there is no independent main skywalk. Although this can save construction costs, it is difficult to guarantee the implementation effect in the later period, and it is highly dependent on the reservation of public channels by connected buildings. In addition to the construction of internal public channels in Gaodezhidi Spring Square and Summer Square, the rest of the buildings have not realized the interaction between internal and external corridors, and the goal of seamless connection between buildings (Figure 3-19).

Corridor between Bank and W Hotel　Corridor dependent on mall opening hours　Vertical connection

Figure 3-19 Skywalk view of the Zhujiang New Town core area (Source: the author)

(3) Spatial function

The function of the skywalk in the core area of the Zhujiang New Town is single, and the design can only be used for walking, and the practicability is low. The skywalk lacks green plants, leisure facilities, communication and staying space, and has become a “cold” transportation structure. The main functions connected to the air trail are shopping malls, office buildings, and catering functions, lacking a variety of city-level functions. The combination of skywalk and urban public space is weak (Figure 3-20).

Figure 3-20 Skywalk in the Zhujiang New Town core area (Source: the author)

(4) Spatial convenience and comfort

In terms of spatial convenience, the vertical connection of different elevations is weak.

At present, there is no direct conversion from the skywalk to the underground pedestrian system. It must be connected through the outdoor or take a vertical elevator to the inside of the building. For example, from Gaodezhidi Summer Square to underground space, it is necessary to enter the outdoor space of the central axis, and then enter the underground space by an independent vertical traffic core or step.

In terms of connection with the public transport system, within the planning scope of the air pedestrian system in the core area of the Zhujiang New Town, there are multiple rail stations, such as : Zhujiang New Town Station, Liede Station, APM Huangpu Avenue Station, Women and Children's Center Station, Huacheng Avenue Station and Grand Theatre Station, as well as dense bus stations. Through the investigation of the current situation, it is found that the connection between the skywalk and public transportation is not close. For example, the connection with the subway is weak in the area of Xingsheng Road.

In terms of space comfort, from the perspective of climate and environment, Guangzhou is hot and humid in summer, cold and dry in winter, and has higher requirements for shading, rain blocking and ventilation of outdoor walking paths. Most of the skywalks in the Zhujiang New Town have not been built with ceilings, sun and rain, and walking comfort is general. At the same time, the pedestrian identification system has poor guidance to the flow of people. The walking distance is long, and some corridor paths are interspersed indoors and outdoors, which is easy to get lost. For example, although there are elevators in the area of Xingsheng Road, the indication system is weak and not easy to find.

3.3.3 Summary of Problems

(1) The lack of project space in skywalk construction leads to fragmented development

The construction of the skywalk in the core area of the Zhujiang New Town is still in progress, and the scattered construction has not yet formed a complete system. Since the construction was proposed, the completion rate has been less than half, and the construction and development of the aerial pedestrian system has been slow. At the same time, the design is basically in series, and the trunk of the skywalk is not set. This connection method has high requirements for the openness of the internal space of the series building and is suitable for buildings with high publicity. Moreover, this method is easy to cause inconvenience in use

and management, such as the inability to unify the opening time.

(2) The weak continuity of the skywalk causes horizontal and vertical fractures

At present, the skywalk in the core area of the Zhujiang New Town has not yet formed a network, and the connection with the surrounding area is not strong. Pedestrians cannot directly reach more destinations through the skywalk, and vertical traffic has not formed a system, and the vertical connection of the three bases of the ground, ground and underground is not close enough. The vertical connection method adopted lacks humanized design, basically steps and escalators.

(3) The lack of humane consideration

The skywalk has a single function and lacks facilities for resting and viewing, making it difficult for activities such as rest and recreation. The lack of landscape design and greenery makes the skywalk a “cold” traffic structure. Moreover, most of the walkways are not suitable for Guangzhou’s climate, making the walking experience poor.

3.4 Challenges of Three-dimensional Repair of the Pedestrian System

3.4.1 The Fracture of Pedestrian Space and the Limitation of Ground Space

The repair of pedestrian system faces the challenge of pedestrian space fracture and limited ground space. On the one hand, the urban pedestrian space is cut by high-level roads, and the problem of becoming a space island needs to be solved. On the other hand, the urban ground space is limited. In order to accommodate more urban elements, functions and behaviors, various contradictions and even conflicts have arisen. Through the analysis of the skywalk in Guangzhou Zhujiang New Town, it is found that the domestic pedestrian path presents obvious “connection” characteristics in design, but most of them are “continuous” on the same horizontal plane. In the actual construction, it presents a fragmentary form, and there are more horizontal and vertical walking break points. In particular, there is a lack of vertical connection facilities, and it is impossible to naturally transition and connect with the urban environment at multiple levels of urban life.

Specifically, at the horizontal level, pedestrian space is cut by urban roads and large-scale buildings. For example, the crystal island in the central area of Futian in Shenzhen has severely fragmented the walking path, resulting in the central area being divided into two

areas, the north and the south. At the vertical level, the walking paths at different levels have less consideration for the vertical connection facilities closely connected to the ground, and lack the natural transition and integration with the urban environment. For example, the huge platform in the central area of Futian in Shenzhen is separated from the surrounding texture, and the three-dimensional connection facilities are extremely lacking. The underground, ground and air are isolated from each other, forming an “urban island”.

3.4.2 The Lack of Pedestrian Life and the Single Function of Space

In a high-density environment, pedestrian life gives way to vehicle traffic, and the repair of pedestrian space faces the challenge of lack of pedestrian life and single space function. The architect-planner Leclercq F., in the repair of the spatial fragmentation of La Défense Seine Arche, clearly proposed to think about the city from the perspective of walking and to use another way to pass (circuler autrement). The pedestrian space of the ground floor of the city should be changed from “car-oriented” to “human-oriented”, so that it can meet the diverse needs of human-oriented scale. Combined with the actual situation in China, the functions of the existing air corridor and underground pedestrian space are mainly pedestrian traffic, lacking the supplement of other functions and the expansion of spatial connotation, and also lacking the combination of functions and formats that can induce walking behavior. The response to the needs of diverse groups is insufficient.

3.4.3 The Coordination of Public Interest and Private Property Rights

The repair of the pedestrian space needs to coordinate the relationship between the public interest and the owners of different property rights, and faces the challenge of coordinating the public interest and private property rights. The construction and repair of pedestrian space requires a lot of capital investment and coordination of the interests of relevant owners, and later needs operation and management to promote economic sustainability and the vitality of pedestrian space. If the relationship between public interest and private property rights is not coordinated and symbiotic, the repair of pedestrian space is difficult to implement and sustainable development, such as the Huaxia Road skywalk in the Zhujiang New Town, because the developer refuses to connect, making the entire skywalk a dead end road.

3.5 Chapter Summary

This chapter analyses the La Défense Seine Arch and Hong Kong's Central pedestrian system, which use the ground floor of the city as a project space. It analyses the repair approach of spatial fragmentation in La Défense and the three-dimensional repair approach under public-private collaboration in Hong Kong respectively. As well as the problems of the skywalk in Zhujiang New Town, Guangzhou, which lacks project space, and then the challenges of three-dimensional repair of pedestrian system are summarized.

In the programme to repair the spatial fragmentation of the La Défense Seine Arch, Leclercq used the ground floor of the city as a project space to repair the fragmentation of the platform area and the city. The approach consists of: 1) Identify the center of the site and establishing initial lines of connection; 2) Diagnose the slow-moving problems in terms of connectivity, accessibility and comfort; 3) Link the slow-moving breakpoints to create a structured network of public spaces; 4) Provide targeted services to create a walking life circle; 5) Renovate the ground floor space and implant more green spaces.

In the three-dimensional repair of the pedestrian system in Hong Kong Central under public-private collaboration, the evolution of the relationship between the Hong Kong government and the private sector and the three-dimensional repair are analyzed. The approach consists of: 1) Strengthen public functions along the lines; 2) The elastic function of the statutory plan promotes the coexistence of multiple functions of pedestrian space; 3) Privately owned public space strategy to improve the quality of space ; 4) FAR Bonus policy and property management system, improve public-private partnerships.

In the skywalk of Zhujiang New Town in Guangzhou, which lacks project space, the core problems of its current situation are analyzed: 1) The pedestrian system lacks project space and does not set up an independent skywalk trunk; 2) Walking path continuity is weak, horizontal and vertical fracture; 3) Lack of humane consideration.

Finally, the three major challenges faced by the three-dimensional repair of the pedestrian system are summarized: 1)The fracture of the pedestrian space and the limitation of the ground space; 2)Lack of pedestrian life and single space function; 3)Public interest and private property rights coordination.

Chapter4 Three-dimensional Repair of Urban Ground Floor: An Approach for Pedestrian System

4.1 Repair Principles

4.1.1 From Fracture of Pedestrian Space to Horizontal and Vertical Continuity

The primary principle of space repair of pedestrian system is continuity, from the fracture of pedestrian space to the continuity of horizontal and vertical(Figure 4-1). When the architect-planner Leclercq repaired the pedestrian system in the La Défense Seine Arch, he improved the separation between the platform area and the surrounding environment from the perspective of walking connectivity, and proposed 11 different forms of connection lines, forming a continuous walking network and walking life circle. Therefore, for the space repair of the pedestrian system, it is necessary to first meet the connectivity of walking, find the fracture area of the pedestrian space, strengthen the connection with other planning systems such as open space, street space, public facilities, residential land, transportation facilities and natural transition in horizontal and vertical, seamlessly connect multiple levels of urban life, and jointly form a daily life circle.

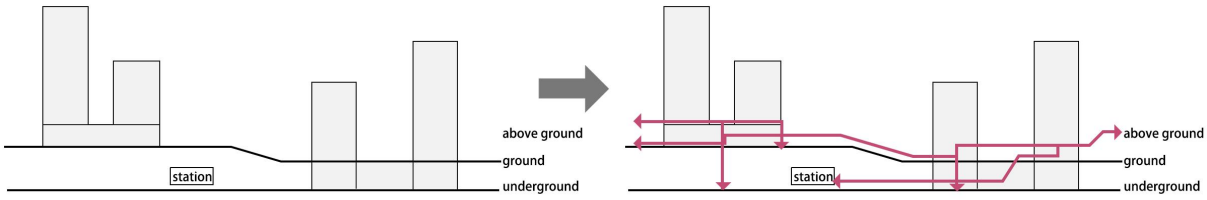


Figure 4-1 Horizontal and vertical continuity of pedestrian system (Source: the author)

4.1.2 From Single Function and Activity to Expansion of Spatial Connotation

The space repair of the pedestrian system needs to shift from the single function and activity to the expansion of space connotation. Pedestrian space can carry a wealth of public life, with the attributes of public product (Figure 4-2). The pedestrian space should be evolved into a high-quality public space, and then a high-concentration life scene should appear,

which gives a new connotation to the pedestrian system. Through the affinity scale to create a sense of spatial belonging, establish a positive interaction between people and space, stimulate the potential public attributes of space, and create more possibilities. For example, the pedestrian system in Hong Kong's Central has made pedestrian spaces a container of public life by bridging diverse city-level functions, complex functional spaces and the elastic functional settings of statutory plans. Therefore, the spatial repair of the pedestrian system needs to expand its spatial connotation, meet people's walking needs, adapt to a variety of traffic modes and urban functions, promote the interaction of people between various elements of the city, and make it a living place for gathering various public activities.

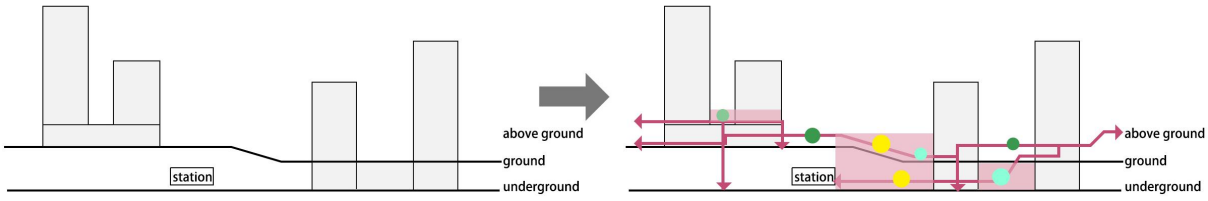


Figure 4-2 Spatial connotation expansion of pedestrian system (Source: the author)

4.1.3 From Government-led to Public-private Collaboration

The spatial repair of the pedestrian system needs to be led by the government and turned to the construction and operation of public-private collaboration (Figure 4-3). Through the creation of friendly, flexible public-private partnerships, the interaction between public space and architectural space is established, and the vitality of the pedestrian system is promoted. The construction and operation of public-private collaboration can create high-quality pedestrian space and promote the occurrence of pedestrian life while taking into account the public interest and economic sustainability.

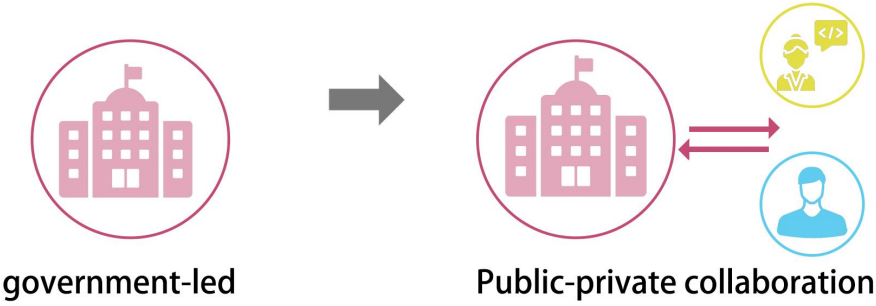


Figure 4-3 Public-private collaboration for pedestrian system repair (Source: the author)

4.2 Analysis Approach of Pedestrian System

4.2.1 Technical Route

It is necessary to clarify the generation and necessity of three-dimensional repair of the pedestrian system. The three-dimensional repair of pedestrian space on the ground floor of the city is affected by both objective and subjective factors. The objective factors mainly refer to environmental factors, and the subjective factors mainly refer to people's public life. Therefore, the analysis of the pedestrian system can be divided into three parts: spatial analysis, public life survey, and summary. It needs to clarify the problems of the pedestrian system and the areas that need to be repaired (Figure 4-4).

The first step is the pedestrian system spatial analysis. It is carried out in the context of the three principles of connectivity, convenience and comfort proposed by the French architect-planner Leclercq in his diagnosis of the La Défense Sainte-Arche.

The second step is the public life survey. The pedestrian flow statistics, pedestrian streamline and the traffic flow were used to identify the pedestrian break areas. This is combined with public interviews to understand people's walking needs and their evaluation of pedestrian space.

The third step is to summarize the problems of the pedestrian system and then justify the necessity for three-dimensional repair.

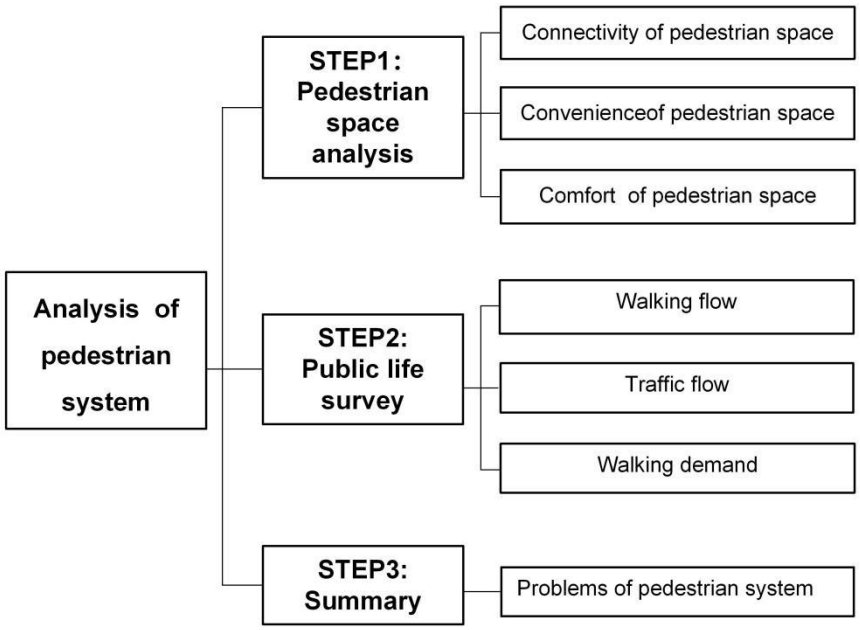


Figure 4-4 Technical route for analysis and evaluation of pedestrian system (Source: the author)

4.2.2 Indicators for Pedestrian System Spatial Analysis

(1) Connectivity of pedestrian space

The connectivity of the pedestrian space refers to that the pedestrian space is continuous and unobstructed, and is not interrupted by motor vehicles and other modes of transportation. It can ensure that pedestrians of different ages and different physical health conditions can walk freely in the city with dignity. It should be ensured that pedestrians can reach their destinations in the shortest walking distance and the most direct walking route. Then it can be considered that this block has good pedestrian network continuity. At the same time, the pedestrian space should also have sufficient width and continuous stability from the impact of motor vehicles and non-motor vehicles to ensure that pedestrians have a relatively loose and free space in the pedestrian network. Streets should be set up with a special walkway, and the width of the walkway should match the level of the street and the number of pedestrians.

This study analyses the connectivity of pedestrian space in the area based on the measurement of pedestrian rights of way and pedestrian space encroachment.

(2) Convenience of pedestrian space

The convenience of the pedestrian space refers to the degree of perfection of the facilities on the pedestrian space, the accessibility of the pedestrian space, and the possibility of transforming the pedestrian space into other modes of transportation. When people can walk smoothly to their destination, the level of facilities on the walking path will further affect the convenience experience of pedestrians, which will also have an impact on the willingness to walk.

This study measures the density and richness of daily service facilities, as well as the density of bus stations, the connection of public transportation modes, and the distribution of shortest paths to reflect the convenience of pedestrian space in the area.

(3) Comfort of pedestrian space

The comfort of the pedestrian space refers to walkers can experience urban pedestrian space in depth in terms of touch, smell and hearing. A comfortable and appropriate pedestrian space can attract people to participate in walking activities. From the perspective of the physical nature of the space, the comfort of the space is influenced by the scale of the passage

such as height and width; from the perspective of the spatial environment, the crowdedness of the pedestrian flow, the enclosed nature of the space, the green landscape, shading facilities, paving, etc. also affect the comfort of the pedestrian.

This study uses measures of shading facilities, staying space, and the positivity of interfaces to reflect the comfort of pedestrian space.

Therefore, a framework for the analysis and evaluation of pedestrian space is formed in the three dimensions of connectivity, convenience and comfort (Table 4-1).

Table 4-1 Pedestrian space analysis and evaluation indicators (Source: the author)

Analysis dimensions	Indicators	Calculation method	Data sources
Connectivity of pedestrian space	Pedestrian rights of way	Percentage of the width of the walkway	Site survey
	Pedestrian space encroachment	Whether there are obstacles occupying the pedestrian space	Site survey
Convenience of pedestrian space	Density and variety of POI	Density and type of POI for both public and commercial facilities	Baidu POI
	Public transport connections	Number of bus stops within a 10-minute walk of subway stations	Baidu Map
	Distribution of the shortest walking paths	Distribution of shortest paths from subway stations to offices, parks, residences and from residences to offices	OSM data, Baidu POI
Comfort of pedestrian space	Shade facilities	Whether shade is provided by street trees, covered walkways, etc.	Site survey, Street View Map
	Rest spaces	Stopping space can be covered within a 5-minute walk	Site survey
	Positivity of interfaces (Transparency)	Whether the interface along the street is active	Site survey, Street View Map

4.2.3 Indicators for Public Life Survey

According to Jane Jacobs, the most fundamental feature of cities is human activity, and it is the public life of people as subjects that makes public spaces such as streets the most powerful urban organ of cities[72]. However, statistical data and empirical analysis are generally lacking for the behavioural patterns of pedestrians. Therefore, a combination of activity observation and following survey is used for different time periods. Among them, the activity observation refers to the video shooting of pedestrian flow at the survey point during the peak hours of weekdays and non-workdays in 2-minute intervals, and then counting the

number of pedestrians by using intelligent recognition or manual counting, so as to obtain data on the distribution and the spatial-temporal changes of the pedestrian flow. Following survey refers to randomly selecting walkers near the survey point during peak hours on weekdays and non-weekdays, and recording the walkers' activity paths on the map, so as to obtain the walking flow line (Table 4-2).

Table 4-2 Public life survey indicators (Source: the author)

Analysis dimensions	Indicators	Calculation method	Data sources
Pedestrian flow	Distribution of pedestrian flow	Distribution and number of statistical walkers	Activity observation
	Space-time variation of pedestrian flow	Characteristics and distribution patterns of walking in different time periods	Activity observation
	Vertical distribution of walking	Statistics on the distribution of walkers around subway stations	Activity observation
	Walking streamline	Recording of the walker’s movement, distance, path choice	Following survey
Traffic flow	Peak period road traffic conditions	Road saturation and level of service	Site survey
Pedestrian demands	Walking demand interviews	Select a representative group of people to interview and summarise their walking needs	Public interviews

4.3 Framework of a Three-dimensional Repair Approach

4.3.1 Repair Context

First of all, the three-dimensional repair of pedestrian system is a approach of design and is not the goal of design. The application of its approach is based on the actual problems faced by urban pedestrian space, such as the contradiction between pedestrians and vehicles and the congestion of ground space. Although there are some controversies about whether the three-dimensionalization of pedestrian space will destroy the vitality of streets, for high-density cities, the three-dimensional repair of pedestrian system can reduce the congestion of ground traffic and alleviate the lack of pedestrian network caused by vehicle traffic-oriented urban planning.

Second, the three-dimensionalization of pedestrian system emerges with the three-dimensionalization of urban traffic patterns and the complexity of urban functions. With the development of urban transportation facilities to the air and underground levels, walking

activities extend up and down with them, bringing the need for three-dimensionalization of pedestrian space. The complexity of urban functions makes the three-dimensionalization of pedestrian space a feasible solution to the demand for public space brought about by the three-dimensional interweaving of urban space and the agglomeration of population and functions. For example, by building multiple pedestrian bases, optimizing the accessibility of non-ground level, and adding multi-level commercial and service entrances to enhance the efficiency of space use.

Therefore, this study considers the application of three-dimensional repair approach as a design method based on the background of three-dimensional and functionally complex transportation facilities in high-density cities to alleviate the problems of pedestrian-vehicle conflicts, broken walking paths, and fragmentation of pedestrian space, which requires accurate finding of the problems of the pedestrian system and identification of the areas that need three-dimensional repair.

4.3.2 Selection Criteria for Repair Site

With the compounding of urban functions and the three-dimensional development of urban traffic patterns, the pedestrian system has transformed to a three-dimensional pedestrian system with different bases underground, on the ground and above ground. The three-dimensional pedestrian system can adapt to a variety of urban traffic patterns, better integrate the spatial resources of different base surfaces of the city, and solve the problems in walking. However, the development of pedestrian system in three dimensions requires a lot of construction cost and management of later operation. Therefore, the following conditions should be satisfied for the site selection of three-dimensional repair of pedestrian system in urban ground floor.

(1) The core of a high-density city

The core of high-density cities is the area in the central area of high-density cities, which refers to the urban environment in a state of high volume, dense high-rise buildings and low coverage of open space.

In a high-density urban form, the reliance on a single surface level to solve traffic problems is no longer applicable, and the scarcity of land and space has led to a move towards

the use of space in the air and underground. The pedestrian system is characterized by this urban form and has the conditions for a gradual move towards three-dimensionality, with underground and aerial pedestrian spaces being developed.

(2) Functional composite area

In the area with complex urban functions, diverse and dynamic public life has been produced. The three-dimensional pedestrian system has the characteristics of space richness, which can provide various spaces such as air squares, ground parks, and underground commercial streets to meet the diverse needs of different groups of people. The three-dimensional pedestrian system can meet the needs of the crowd and create a composite space as a living place for gathering various public activities in the functional composite area.

(3) Three-dimensional transport infrastructure

The development of the three-dimensional urban transport infrastructure is an important factor in promoting the development of a three-dimensional urban pedestrian system. Areas with three-dimensional transport infrastructure, i.e. vertically developed transport facilities, such as subway stations, light rail stations and elevated urban roads, have the potential to develop a three-dimensional pedestrian system. Relying on transport infrastructure, the development of a suitable three-dimensional pedestrian system will guide commuters as well as shoppers and recreationists to their destinations, increasing the convenience of commuting and interchanging while triggering service businesses and daily consumption.

4.3.3 Workflow of Three-dimensional Repair of Pedestrian System

The three-dimensional repair workflow of the pedestrian system can be divided into three main steps as a whole. First, Analyze the current conditions of the pedestrian system (find problems); second, propose a three-dimensional repair strategy (solve problems); third, verify the results after repair (result verification) (Figure 4-5).

The first step is to analyze the current situation of the pedestrian system in the area, find the problems of the pedestrian system from the two aspects of pedestrian space analysis and public life survey, and then summarize the necessity of three-dimensional repair.

In the second step, on the basis of the current problems and the necessity of repair, the objectives and principles of repair, as well as the corresponding design strategies and

implementation strategies are put forward. Among them, the design strategy needs to include pedestrian connectivity at the horizontal level, vertical indirectness at the vertical level, pedestrian nodes, scene construction, etc. In the implementation strategy, it is necessary to clarify the main body of construction and design guidelines, and establish a flexible development framework for public and private sector collaboration.

In the third step, ArcGIS was used to verify the preliminary results of the repaired pedestrian system and to check the effectiveness of the repair of the pedestrian system.

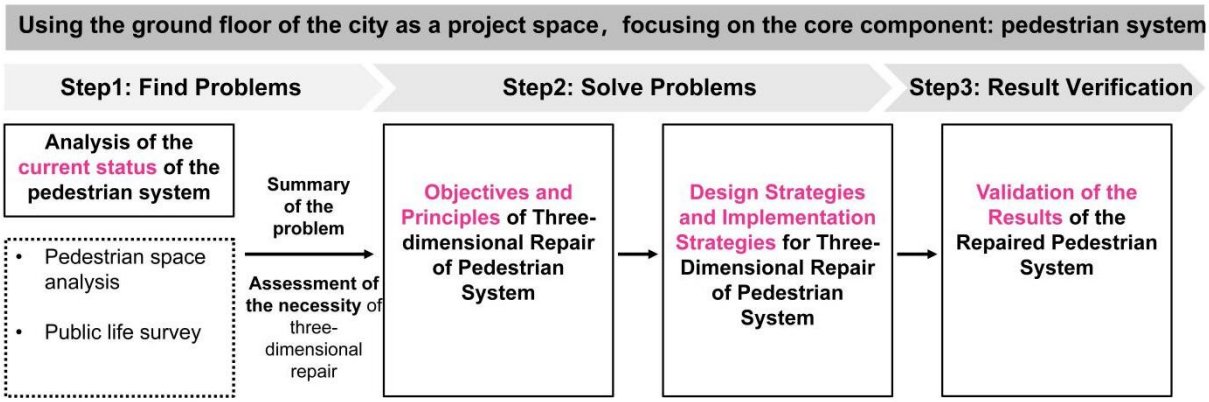


Figure 4-5 Workflow of the three-dimensional repair approach (Source: the author)

4.4 Chapter Summary

This chapter presents a preliminary approach to three-dimensional repair of pedestrian system based on the challenges of spatial repair of pedestrian system.

First of all, the three-dimensional repair of the pedestrian system needs to meet three main principles: from the fracture of the walking path to the horizontal and vertical continuity; from the single function and activity to the expansion of space connotation; from government-led construction to the construction and operation of public-private collaboration.

Secondly, it is proposed that the analysis of the current situation of the pedestrian system can be divided into the spatial analysis of the pedestrian system and the investigation of public life. Combined with the actual situation in China, the indicators of the analysis are refined.

Finally, the application background of the three-dimensional repair approach, the selection criteria of the repair site and the workflow of the repair approach are summarized. It is pointed out that the stereo repair of the pedestrian system needs to accurately identify the stereo repair area, and a targeted repair scheme is proposed.

Chapter5 Analysis of the Current Situation of Pedestrian System in Meicai Area

5.1 The Opportunity of Three-dimensional Repair of Pedestrian System in Meicai Area

5.1.1 High-density Environment and Dynamic Renewal

Shenzhen's urban spatial development is characterized by high-density, the spatial development of Shenzhen's core urban area shows a trend of ultra-high density[69,70]. In this regard, Shenzhen has carried out 18 key construction areas and many three-dimensional urban practices. These key construction areas are themselves high-density cores[71]. Among them, Meicai Area (Meilin-Caitian) was approved as one of the key construction areas in the city in 2016. It faces a situation of high-density construction environment and dynamic renewal. There is a complex situation of coexistence of completed, unfinished and to be updated.

In terms of location, Meicai Area is located in the northern part of Futian District, Shenzhen, in the central development axis of Shenzhen, only 3.5km away from Futian Central District. Meicai Area can reach Shenzhen North Railway Station, Longhua New City and other areas to the north, and can reach Futian Port to the south, with obvious location advantages (Figure 5-1). In terms of development positioning, the future positioning of Meicai Area is to create a high-end industrial agglomeration area, which is an important part of Shenzhen's central axis upgrading strategy, and an important link for the integration and development of Futian and Longhua Districts. Therefore, the area needs to take over a large number of commuters and ease the pressure brought by the high volume of pedestrian traffic.

Reviewing the planning process of Meicai Area, it is divided into two main stages. In 2017, the *Meilin-Caitian Area Urban Renewal Co-ordination Spatial Planning* (hereinafter referred to as the Coordinated Plan) was compiled. In 2019, the *Futian District Key Area Quality Development and Construction Implementation Rules (Meilin-Caitian Area)* was compiled to support the economic structure optimization and industrial transformation and upgrading of Futian Central District. Nowadays, there is a dynamic renewal of completed high-density office buildings, to be completed and to be renewed within the Meicai Area.

Figure 5-1 Meicai Area location analysis (Source: the author)

5.1.2 Construction of New Subway Stations and Platforms

There are three subway stations in Meicai Area, and two subway stations will be added in the future. There will be five subway stations within the range of 1.48k/km^2 in the area. The coverage of the planned subway network is high, with a density of 3.92 km/km^2, which is higher than that of Futian District 1.752 km/km^2 and Shenzhen 1.21 km/km^2 [2] (Figure 5-2).

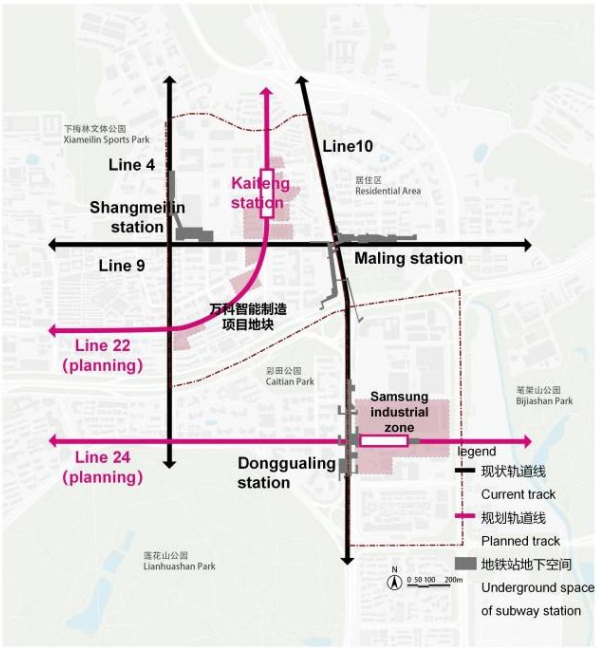


Figure 5-2 Distribution of subway lines

(Source: redrawn from references[2])

With the development of the subway station, the integration of the subway station hall layer and the surrounding urban functions to form a three-dimensional pedestrian system is conducive to easing the contradiction between people and vehicles in the area and creating a good walking environment. At the same time, Meicai Area has many built aerial platforms. The

consolidation of regeneration projects with the help of the platform is conducive to the formation of a continuous and vibrant pedestrian environment. Therefore, with the construction of new subway stations and aerial platforms, Meicai Area has the opportunity to repair pedestrian system.

5.1.3 Large-scale Development Increment and High Traffic Pressure

The current situation in the area is that there are high-end office areas and inefficient old industrial buildings, old office areas, and old neighborhoods. According to the *Coordinated Planning Scheme*, a large number of inefficient industrial parks will be demolished and turned into intensive and efficient industrial office buildings to accommodate high-end and innovative industries. The amount of new construction will put enormous pressure on the already overburdened transport infrastructure of the area. Therefore, urban renewal projects provide the opportunity for pedestrian space repair, and facing the high traffic pressure provides the necessity for pedestrian system repair.

5.1.4 Research Scope

The research scope is the area of Meilin-Caitian, that is an area bounded by Meiao Road, Zhongkang Road, Beihuan Avenue, Caitian Road, Sungang Road, Huanggang North Road, Beihuan Avenue, Caitian Road, with a total area of about 1.48 square kilometers (Figure 5-3).

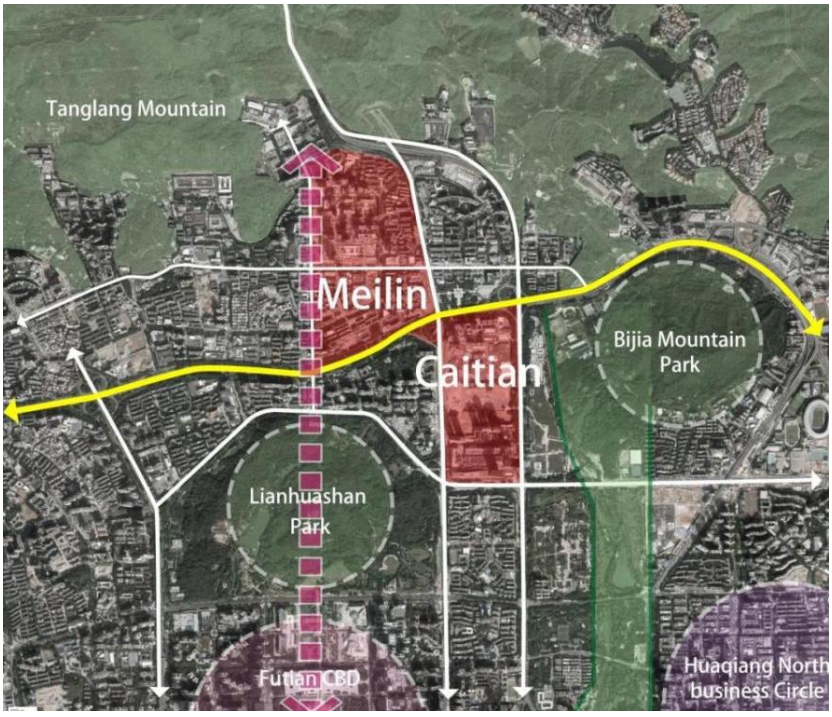


Figure 5-3 Research scope (Source: the author)

5.2 Spatial Analysis of Pedestrian System

5.2.1 Construction of Pedestrian System

The pedestrian system consists of ground-level pedestrian space, aerial pedestrian space, underground pedestrian space. Therefore, this section will investigates and analyses these three components.

(1) Ground-level pedestrian space

The ground-level pedestrian space is the basis of the pedestrian system and is the intermediate link between the air pedestrian system and the underground pedestrian system. The Meicai Area is divided by four major traffic arteries, of which Beihuan Avenue is an important expressway linking Shenzhen from east to west, creating a north-south barrier to the Meicai Area. There is a high level of vehicular access at ground-level, but pedestrian access is not easy. From a pedestrian perspective, the large volume of commercial complexes, commercial shopping traffic, office commuting traffic and motor vehicle traffic around the subway station tend to cause ground-level traffic conflicts (Figure 5-4). Moreover, there are gated communities and schools in the area, which are weakly connected to the surrounding buildings and roads.

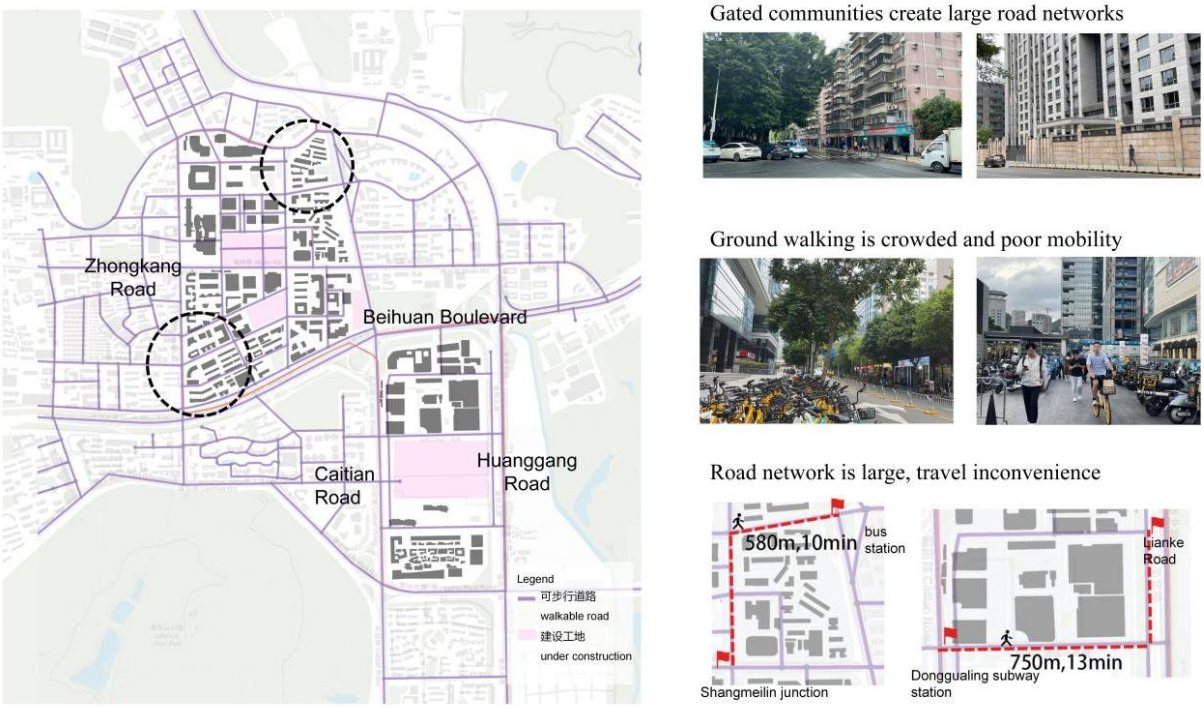


Figure 5-4 Ground-level pedestrian space (Source: the author)

(2) Aerial pedestrian space

Aerial pedestrian space usually include aerial platforms, elevated footbridges and air corridors. The aerial pedestrian space in the Meicai Area is arranged in a dotted pattern, with a single shape and a rather rigid integration with the urban space.

Specifically, in terms of the distribution of aerial platforms, there are two completed platforms in the Meicai Area. They are located in the New Generation Information Technology Industrial Park in the north and in the shopping mall of Shenyeshangcheng in the south. The ground floor is the internal space of the shopping mall, while the first floor is an outdoor commercial street integrated with the platform, and the connecting corridors on the east and west sides connect Lotus Hill Park and the Futian River, making the construction relatively complete. In terms of the distribution of elevated footbridges, there are two elevated footbridges mainly on Beihuan Avenue, but it still does not solve the problem of the lack of connection between the north and south sides. The design of the elevated footbridges is rigid and lacks integration with the surrounding buildings. In terms of the distribution of air corridor, the office buildings in the Meicai Area are partially linked by corridors, but they are not open to the public and it is difficult for the public to use the air corridors (Figure 5-5).

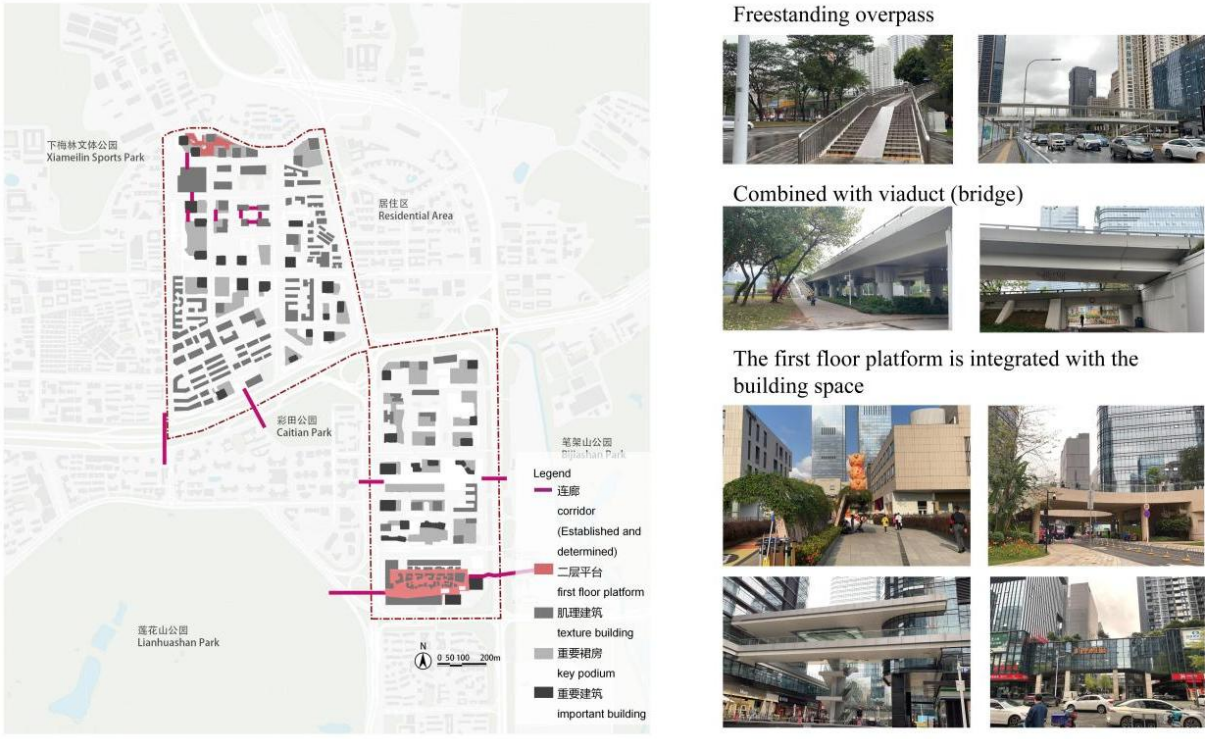


Figure 5-5 Aerial pedestrian space (Source: the author)

(3) Underground pedestrian space

The underground pedestrian space integrate the main walking nodes within the underground space, are clearly defined and oriented, and are the main carrying surface for underground walking activities. The underground walking in the Meicai Area is centered on the subway station concourse, namely Shangmeilin Station, Maling Station and Donggualing Station. Among them, the Shangmeilin Station achieves a better connection with the underground street of the surrounding INJOY shopping mall, which allows walkers to pass continuously between subway stations and the mall through the sunken plaza and the passage on the negative first floor of the mall. However, the connection between the subway station concourse at Dongguailing and the underground space of the shopping mall at UpperHills is relatively poor and requires a longer walk to reach (Figure 5-6).

Overall, the underground pedestrian space in the Meicai Area is poorly constructed and has greater potential for development. The underground pedestrian space can be established to take up the commuter flow brought by the subway and ease the contradiction between people and vehicles on the ground. It will strengthen the connection of the subway city's architectural space and promote the development of the business district and the city's vitality.

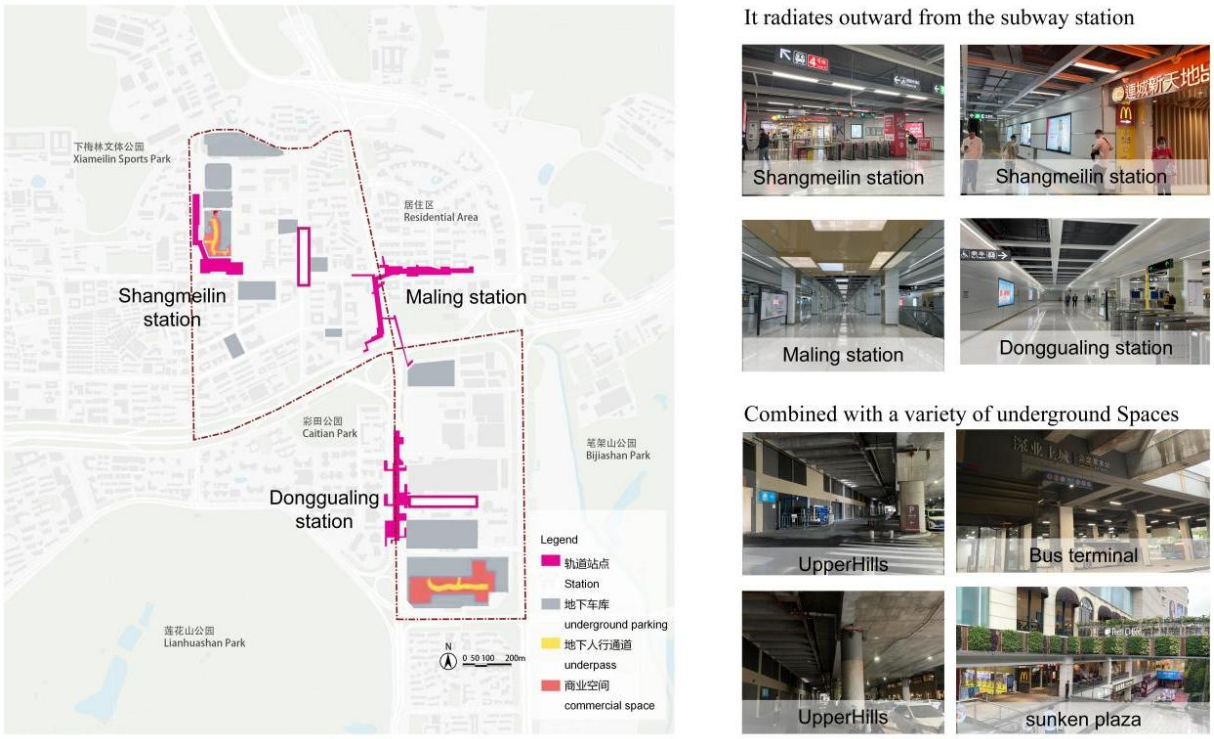


Figure 5-6 Underground pedestrian space (Source: the author)

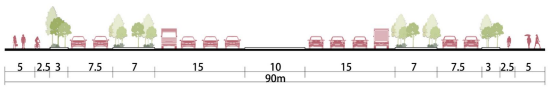
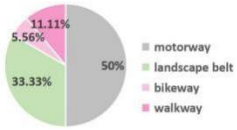
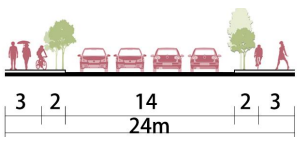
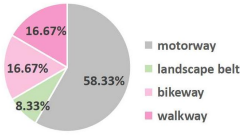
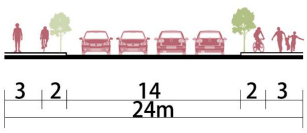
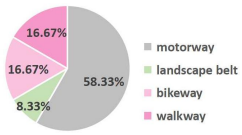
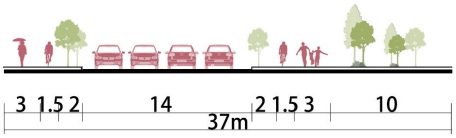
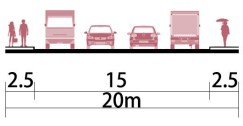
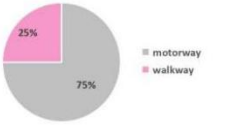
5.2.2 Connectivity of Pedestrian Space

(1) Pedestrian rights of way

The analysis of road cross-sections shows that the pedestrian paths in the Meicai Area are all at least 2 meters wide. However, pedestrian space problems are more prominent in Zhongkang Road, Meilin Road, Meikang Road and Lianke 2nd Road.

Specifically, Zhongkang Road is dominated by commerce and there are 2 subway stations with a high walking demand. But the slow-moving space is only 5 meters wide and cannot carry a large amount of commuter traffic. Meikang Road has many bicycle parking on one side of the walking path, while on the other side are the functions of food and shop, making the already only 5meters wide walking path even more crowded. Lianke 2nd Road has poor conditions with 2.5 meters wide of the pavement. The Beihuan Avenue cuts off both sides of the Meicai Area, requiring pedestrians to cross the north and south plots via the path under the viaduct or the footbridge. Walking paths are heavily influenced by motor vehicles and the right of way for walking needs to be further improved (Table 5-1).

Table 5-1 Analysis of pedestrian rights-of-way on major roads (Source: the author)

Road name	Photos	Road cross-sections	Right-of-way share
Beihuan Avenue			
Zhongkang Road			
Meilin Road			
Kaifeng Road			
Lianke 2nd Road			

(2) Pedestrian space encroachment

The pedestrian paths in the Meicai Area appear to be encroached upon by motorized and non-motorized traffic, showing a clear mix of pedestrian and vehicular traffic. There are two main reasons for the occurrence of mixed pedestrian and vehicular traffic and the impairment of pedestrian rights of way.

On the one hand, it lies in the fact that the pedestrian path of the site does not take into account the needs of non-motorized travel such as electric vehicles, and the site is various in food and beverage outlets with a high demand for takeaway deliveries. However, the narrower pedestrian paths are flooded with fast-moving electric vehicles, resulting in artificially fragmented pedestrian spaces. The lack of parking facilities and the lack of road management in the main urban area make the encroachment of motorized vehicles on the pedestrian space unscrupulous.

On the other hand, the disorderly encroachment on the pedestrian space has led to a situation where pedestrians do not confine themselves to the pedestrian paths, resulting in a mix of pedestrians and vehicles. The safety of pedestrians is not guaranteed and the normal flow of vehicular activity is greatly affected (Figure 5-7).

Figure 5-7 Analysis of impairment of pedestrian rights-of-way (Source: the author)

5.2.3 Convenience of Pedestrian Space

(1) Density and variety of POI

It is generally believed that residents around areas with a good diversity of POI numbers and the convenience of pedestrian space is better. The type and number of business POI and their distribution in space around the Meicai Area (Meilin street, Huafu street and Lianhua street) have an important influence and role in the convenience of pedestrian space. This section analyses the POI of commercial facilities and public services facilities that are closely related to daily life by crawling the data of Baidu Map POI in 2022.

In terms of the spatial distribution of the overall POI, the site is located at the edge of the main catchment area for commercial facilities and the catchment area for public services (Figures 5-8, 5-9). Specifically, in terms of commercial facilities, the overall distribution shows a high degree of agglomeration, with businesses mainly concentrated in the Shangmeilin area and the Xiameilin area. As a result, the commercial accessibility of the pedestrian spaces in these two areas is high and can provide better commercial services for walkers. However, the southern part of the Meicai Area, namely the Caitian Area, has a lower commercial density, with fewer commercial facilities along the pedestrian spaces, and commercial convenience needs to be improved.In terms of public service facilities, they are mainly located in the Xiameilin area and the Lotus area. The public service facilities on the pedestrian spaces in the Meicai Area are less in comparison to the surrounding areas as a whole. The number of public service facilities points in the Meicai Area can be appropriately increased to improve walking convenience.

Figure 5-8 Commercial facility POI kernel density analysis (Source: the author, Data: Baidu Map)

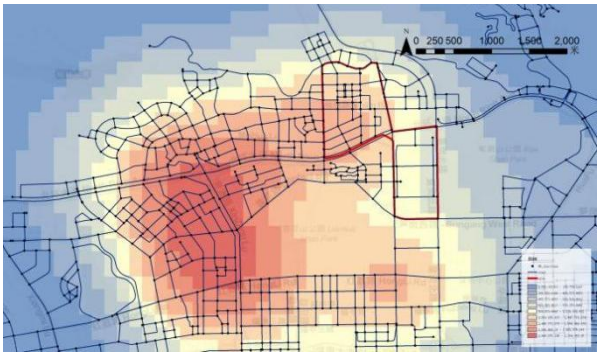


Figure 5-9 Public service facility POI kernel density analysis (Source: the author, Data: Baidu Map)

In terms of the number and types of commercial service facilities, the main forms of commercial support around the Meicai Area are mainly shopping malls and department stores, accounting for 18.32% and 7.27% of Futian District respectively, but there are relatively few forms of commercial pedestrian streets (Figure 5-10).

In terms of the distribution of specific types of commercial businesses, living services, retail and food and beverage are the main commercial formats. The living services category accounted for 25.31% of the total, retail accounted for 24.99% and food and beverage accounted for 17.6%. The sports and fitness category accounted for the least, with only 2.66%. The five types of education and training, leisure and entertainment, finance and insurance, beauty and wellness and vehicle services were not very different in number, accounting for between 4% and 8% (Figure 5-11). Overall, the types of business are relatively ecumenical, lacking in site characteristics and not sufficiently responsive to the needs of a diverse population.

In terms of the number and types of public service facilities, the current situation has adequate educational facilities, with facilities such as hospitals, health services and community cultural centers. Moreover, it is planned that an international sports exchange center will be built in the Meicai Area, and a shared service center and other facilities will be built in the Caitian area.

Therefore, there is still a lack of public service support facilities for R&D-oriented micro and small enterprises. Moreover, the connection between the community and the enterprise space is insufficient.

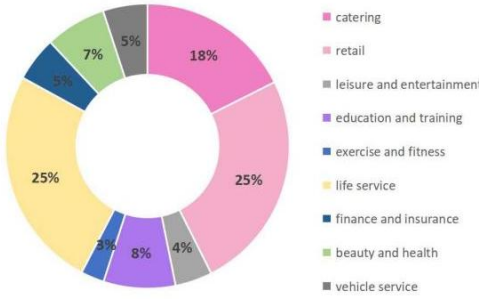


Figure 5-10 Distribution of commerce types

(Source: the author, Data: Baidu Map)

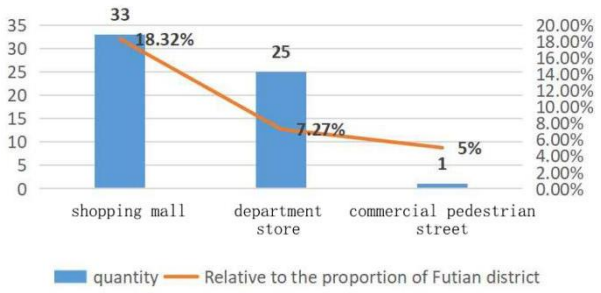


Figure 5-11 Distribution of the number of commerce

(Source: the author, Data: Baidu Map)

(2) Public transport connections

There are currently three subway stations in the Meicai Area, namely Shangmeilin Station, Maling Station and Donggualing Station. The network analysis by ArcGIS shows that the area that can be covered within a 5-minute and 10-minute walk from the subway stations is limited, and 44.8% of the bus stops are distributed within a 10-minute walk of the subway stations (Figure 5-12).

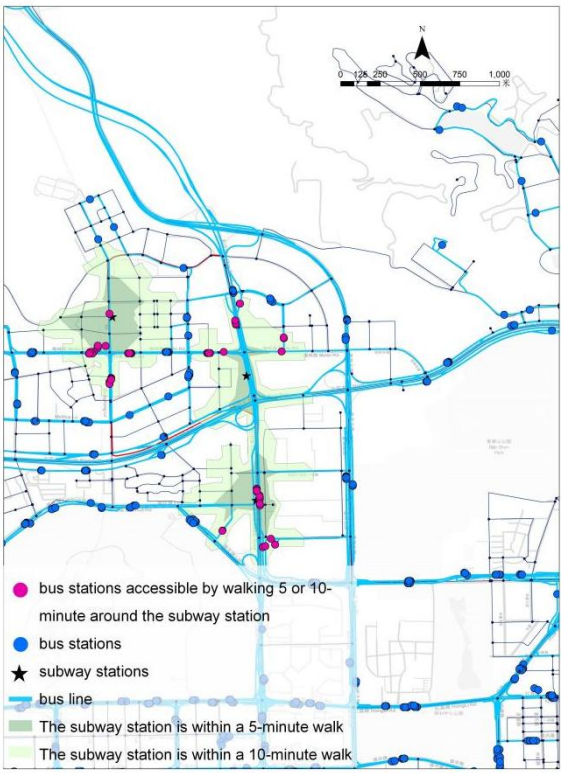


Figure 5-12 Distribution of transport stations within a 10-minute walk of subway stations

(Source: the author)

There is room for further improvement in the accessibility of public transport, and connections between public transport can be optimized by refining the pedestrian network. It is also possible to set up bicycle lanes in areas with more than 10 minutes of walking, develop a variety of slow-moving traffic mixing modes such as cycling, and facilitate people to achieve rapid conversion of public transportation modes.

(3) Distribution of the shortest walking paths

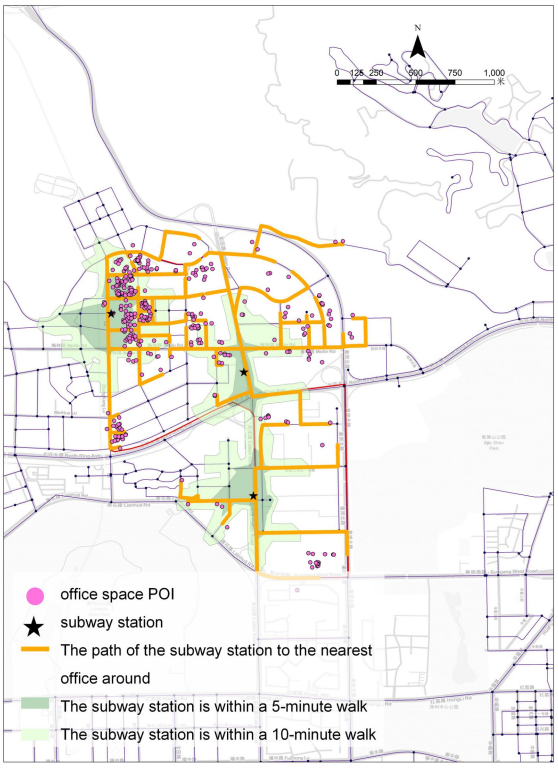
As walkers tend to choose the shortest and most energy-efficient walking paths, the distribution of the shortest path reflects the path selection of pedestrians to a certain extent, and the length of the path indirectly reflects the convenience of walking. This section examines the topology of walking paths and intersection interruptions by filtering out urban roads and POI. Network analysis with ArcGIS was used to analyse the shortest paths from subway stations to offices, parks and residences, and from offices to residences, respectively.

In terms of spatial distribution, the shortest path from the subway station to the office point is mainly distributed in the northern part of the Meicai Area. In addition, the shortest path from the subway station to the park needs to cross the urban expressway and the main

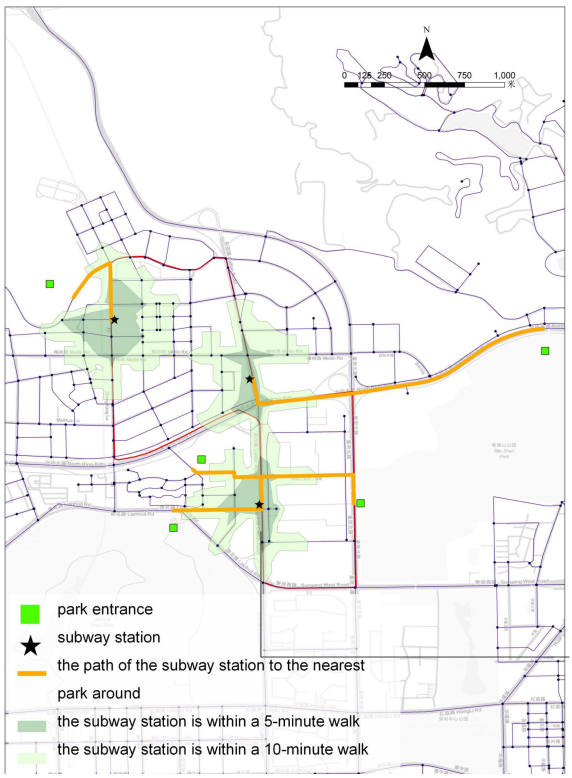
road, and the convenience needs to be improved. And the shortest path from the subway station to the residential point is mainly distributed in the northern part of the Meicai Area. While the shortest path from the office point to the residential point is in the periphery of the Meicai Area, such as Zhongkang Road and Lianhua Road. Therefore, the northern part of the Meicai Area is the area where the distribution of the shortest paths between the facilities points is more concentrated, however, the southern part has less path distribution, its current construction level is relatively low and there are relatively few facilities points.

In terms of the length of the walking paths, the paths between the subway stations and the office points and between the residential points are relatively short. While, the paths between subway stations and parks, and between office points and residential points are relatively long.

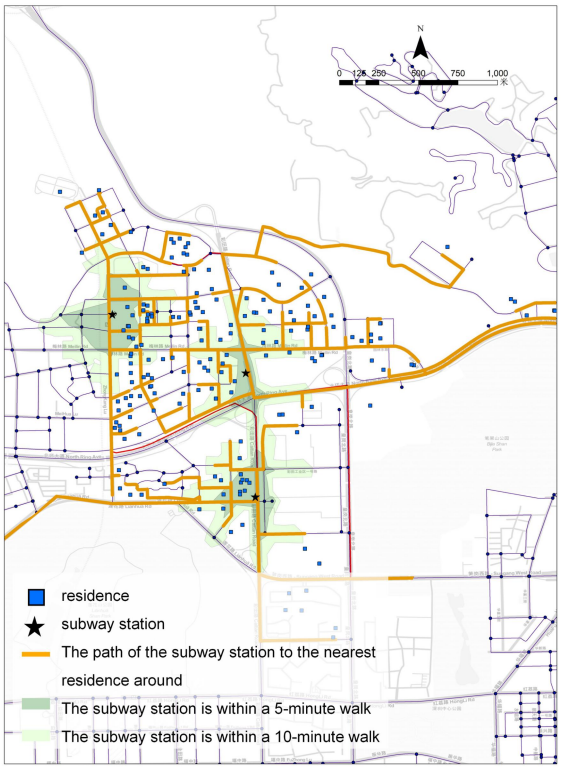
Therefore, from the perspective of reducing walking time, walking connections between subway stations and parks, and between office points and residential points should be enhanced to reduce detours and walking time. To a certain extent, the convenience of the walking experience can be enhanced and the willingness of walkers to travel on foot can be increased (Figure 5-13).



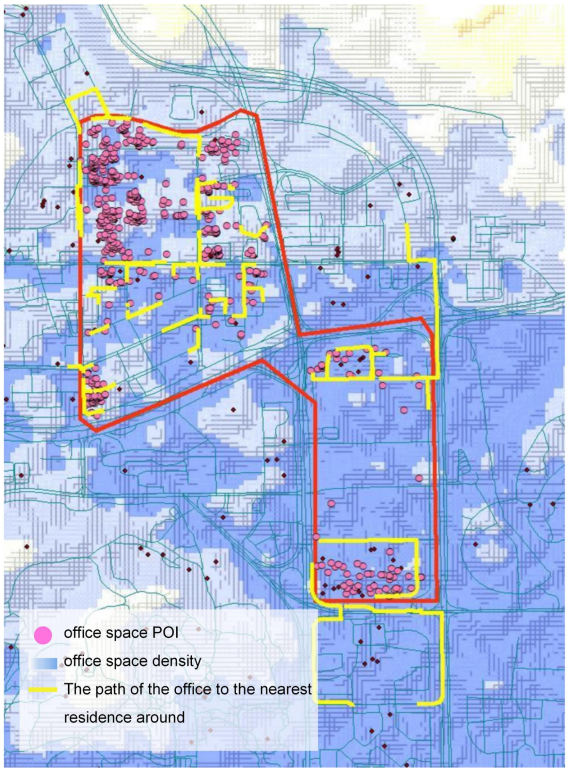
The shortest paths from the subway station to the office



The shortest paths from the subway station to the park



The shortest paths from the subway station to the residence



The shortest paths from the office to the residences

Figure 5-13 Distribution of shortest paths between major nodes

(Source: the author)

5.2.4 Comfort of Pedestrian Space

(1) Shade facilities

Shenzhen is located in the south of Guangdong Province, south of the Tropic of Cancer, and has a subtropical maritime climate. The climate is characterized by southeasterly winds in summer, with high temperatures and rainfall, and northeasterly monsoons in the same season, with dry weather, mild climate and long sunshine hours. In such a subtropical climate, the physical environment of the pedestrian spaces should meet the sunlight standards based on reducing direct sunlight and ensuring the ventilation of the environment. Therefore, shading facilities on pedestrian spaces, such as street greenery and covered corridors, have a greater impact on the walking comfort of pedestrians.

In terms of the distribution of pedestrian shading facilities, approximately half of the pedestrian spaces have street trees that provide shade. Specifically, continuous street trees are found on Kaifeng Road, Meihua Road, Huanggang Road, Beihuan Avenue and Lianhua Road; sparse street trees are found on Meilin Road and Zhongkang Road; and there are no shade

trees on other pedestrian spaces. In terms of the distribution of covered linkages, three of the street crossings in the Meicai Area are in the form of covered linkages and the rest are uncovered (Figure 5-14).

Overall, the pedestrian shading facilities in the area need to be improved. For Shenzhen's long sunshine hours all year round and hot summer weather, if there are cool and comfortable pedestrian spaces,it can enhance walkers' willingness to walk.

(2) Rest spaces

The pedestrian rest spaces in the Meicai Area are mainly in the form of park squares and linear green areas. In terms of spatial distribution, they are mainly located on Zhongkang Road, Kaifeng Road and Caitian Road. According to the *Implementation Rules for Quality Development and Construction of Key Areas in Futian District (Meilin-Caitian Area)*, public open space should be reached in 5 minutes on foot[69]. However, the quantity and distribution of public open space in the current situation in the Meicai Area cannot meet the requirements of the guidelines (Figure 5-15).

In addition, after specifically analyzing the environmental quality of the current stay space, it is found that the stay space lacks integration with the surrounding environment. Although there are service facilities inside, such as seating, street lights and fitness equipment, there is still a shortage in meeting the diverse needs of different age groups, such as children, young and middle-aged people and the elderly (Table 5-2). For example, in the plaza of the Xinhao Industrial Park, the landscape vignettes are simple, lacking in sheltered space settings and facilities that can provide suitable for quiet rest. Moreover, it is not integrated with the surrounding businesses to provide a comfortable and professional outdoor service space, which is not conducive to attracting pedestrian flow.

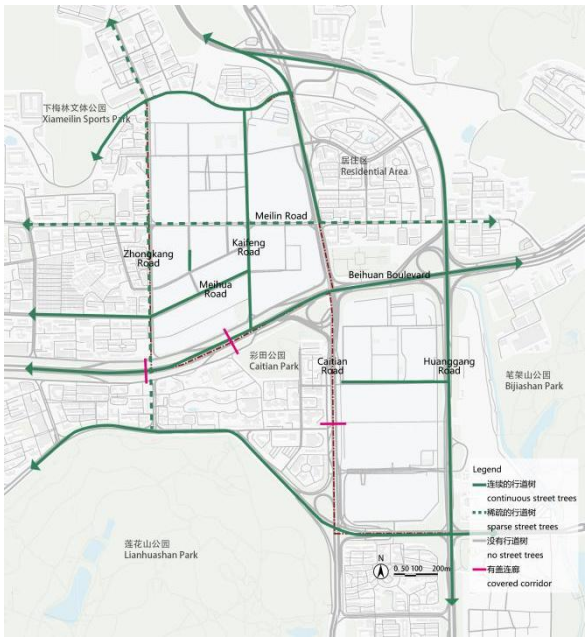


Figure 5-14 Distribution of shading facilities

(Source: the author)

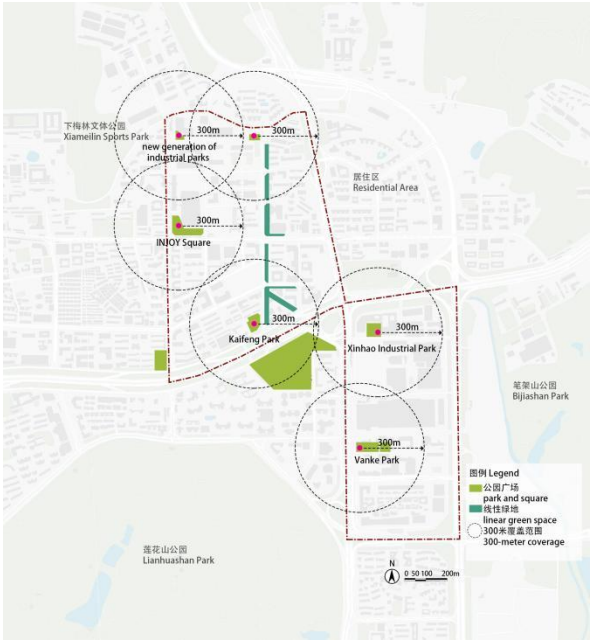


Figure 5-15 Distribution of resting spaces

(Source: the author)

Table 5-2 Analysis of resting space types (Source: the author)

Type	Location	Description	Photos
Park Square	New Generation Industrial Park	①Lack of private space for relaxation, fitness and walking ②Monochromatic landscape elements ③Lack of sensory stimulation and fitness space ④Low comfort level of amenities	
	Xinhao Industrial Park	①The site is empty, functional and uninteresting ②Simple landscape features, lack of sheltered space and facilities for quiet relaxation ③Not integrated with surrounding businesses to provide a comfortable outdoor service space	
	Kaifeng Community Park	①Small area and lack of plaza to gather people ②Single facilities, with only seating for sitting and a few fitness facilities to meet the needs of a diverse population	
Linear green space	Green space in front of Anjuyuan	①Lack of function, the current situation is a linear park in the form of a green belt ②The site is underlain by the Fotan River culvert, which is difficult to use	

(3) Positivity of interfaces

The positivity or physical transparency of an interface has a greater impact on the comfort of the pedestrian space. When the interface is positive and transparent, where the interior can be seen from the outside or where features are open to walkers, walkers will have a better sensory experience when walking. There are four main types of pedestrian interfaces in the Meicai Area, namely building facades, green landscape, barrier railings and open spaces to be built. The current interface types in the Meicai Area are mainly building facades and green landscapes (Figure 5-16, Table 5-3).

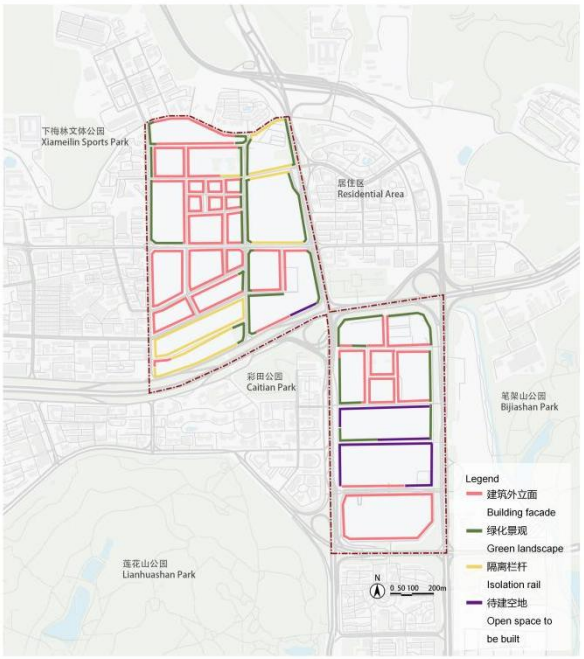


Figure 5-16 Distribution of interface types

(Source: the author)

Among them, the ground floor of the New Generation Industrial Park and Xinhao Industrial Park are overly dense building densities and more closed interfaces, with a small amount of commercial but limited vitality. For pedestrians, it is difficult to stay while walking through them. At the same time, some areas have enclosed railings that limit the pedestrian paths, such as the Dingye Building and closed communities, and the space lacks integration with urban functions. Moreover, there are open spaces under construction, enclosed by blank walls, which are relatively poor in terms of physical transparency, functional permeability and perceived enthusiasm.

Overall, the ground floor interface in the Meicai Area has a variety of interface types, but the positivity of the interface and its permeability with urban functions needs to be improved. More precisely, the interface transparency is low in the pedestrian paths of Kaifeng Road, Zhongkang Road and Caitian Road. The relatively dull, closed, or oppressive ground floor interfaces cannot provide a comfortable psychological environment for walkers and are not conducive to the formation of a flexible and diverse pedestrian system.

Table 5-3 Analysis of interface types (Source: the author)

Type	Location	Description	Photos
Building facade	New Generation Industrial Park, Ideal Apartments	①Overly dense high-rise towers create a sense of oppression and closed building interfaces create a sense of exclusion	
	Xinhao Industrial Park	①The ground floor interface is partly commercial and partly office lobby, with limited vitality	
Green landscape	Front Square of INJOY Mall	①Bicycle and electric vehicle parking occupies part of the square space. ②The square has a single facility and lacks artistic landscape facilities	
Barrier railing	Dingye Building	①Closed barrier railings, poor openness, poor walking experience and difficulty in staying ②Lack of shared facilities with the city	
Open space to be built	Samsung Industrial Zone	①Part of the current land has been levelled and surrounded by a barrier	

5.3 Public Life Survey

5.3.1 Pedestrian Flow

Walking is the most direct way for users to experience and perceive urban public space. The pedestrian flow statistics for different time periods can provide an intuitive grasp of the pedestrian travel pattern in the study area and provide a basis for the optimal design of the pedestrian system in the Meicai Area at a later stage. Therefore, the pedestrian flow in the Meicai Area is monitored at different times of the day. The method of roadside artificial observation is adopted, which is carried out in fractions throughout the day. In this way, the distribution of pedestrian activity in different areas and time periods is obtained. And the

segmentation of the north-south area by the Beihuan Avenue and the connectivity of the north-south walking are evaluated. The intensity of pedestrian flow, the spatial and temporal distribution of walking, the vertical distribution, and the pedestrian streamline were specifically analyzed. An approach to the measurement and analysis is divided into the following steps:

The first step is to identify measurement points. Typical intersections and important public space nodes are selected for on-site observation. Short road section bisection points, long road short quarter points, entrances and exits of bus and subway station, large public buildings, park green spaces, etc. need to be far away from the intersection, and the average distance between control points is no more than 200 meters (Figure 5-17).

The second step is to conduct on-site research in different time periods. The survey was conducted on a working day with good weather, June 5, 2023 (Monday). The times were morning peak (7:00-9:00), afternoon peak (11:30-13:30) and evening peak (17:30-19:30), each time period was 2 minutes as a unit, and the number of people and activity time patterns were observed at each measurement point and the data obtained were recorded.

The third step is to analyse the human activity. Distinguish between passers-by and stayers, count the number of pedestrians and record the PPU (Passing People Unit) distribution values on the map. Analyse the distribution of people’s activities, compare and analyse the hot spots and non-hot spots of people’s activities, and argue for the connectivity, convenience and comfort of the pedestrian space.

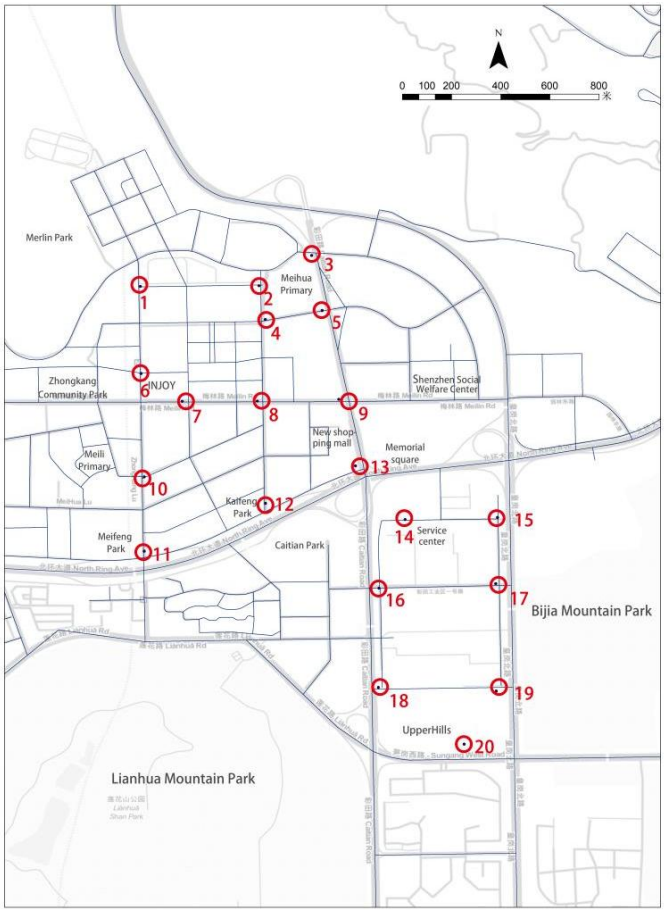


Figure 5-17 Pedestrian flow observation points (Source: the author)

(1) Distribution of pedestrian flow

The pedestrian flow distribution map (Figure 5-18) was obtained by counting pedestrians in the Meicai Area by time of day and recording the number of walkers per 2min at the observation points on the map.

Overall, the Beihuan Boulevard creates a serious fragmentation of walking, causing the Meicai Area to form two north-south zones. Pedestrian traffic is concentrated in the Shangmeilin subway Station and the New Generation Information Technology Industrial Park in the north, and in the UpperHills Shopping Mall and Caitian Road in the south. The overall distribution is characterized by high pedestrian traffic on the peripheral roads and low pedestrian traffic inside the site.

A specific analysis of the reasons for the sharp decline in pedestrian flow reveals that the spatial functions within the site are not sufficiently attractive to pedestrians. Although the preliminary spatial analysis of walking shows that Kaifeng Road is a section with good landscape conditions in the Meicai Area, the ground floor of the buildings on both sides have

a single function, office and residential, which is hardly attractive to the walking activities of the public. The intersection of Beihuan Avenue, Kaifeng Road and Caitian Road is a low point for pedestrian traffic, and the nearby Kaifeng Park and Caitian Park make it difficult to create a concentration of pedestrian traffic, and there is a need to improve the pedestrian connectivity between the north and south sides and enhance the quality of public space.

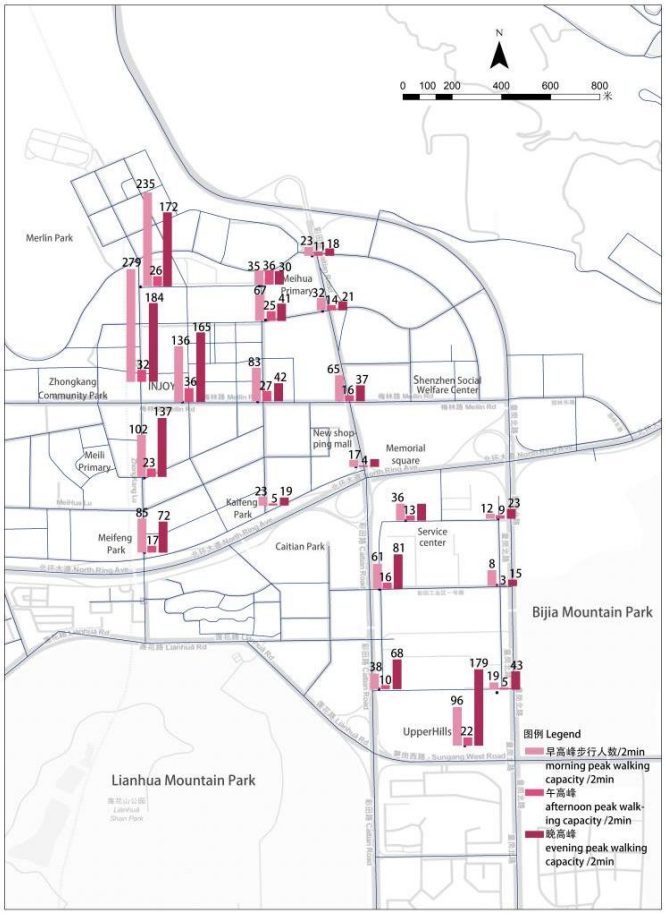


Figure 5-18 Distribution of pedestrian flow (Source: the author)

(2) Space-time variation of pedestrian flow

Looking at the data for each peak time period on weekdays (Figure 5-19), the number of walkers at each observation point peaks during the morning peak and evening peak rather than during the day.

Specifically, during the morning peak hours, the number of walkers is higher in the vicinity of New Generation Industrial Park, Shangmeilin Station and UpperHills center. In the north, there are more walkers on Zhongkang Road, 279 walkers/2min near Shangmeilin subway Station, 235 walkers/2min near New Generation Information Industrial Park and 102 walkers/2min at the intersection of Zhongkang Road and Guangkang Road, and there are

more primary school students going to school on Meilin Road with 83 walkers/2min. In the south, the number of walkers was 96 walkers /2min in the vicinity of UpperHills and 57 walkers /2min in the vicinity of Dongguailing subway Station.

During the afternoon peak hours, the number of walkers in the Meicai Area was relatively low due to the hot weather, with the highest number of walkers being in the front square of INJOY Shopping Mall with 36walkers /2min and the lowest number of walkers being in the intersection of Beihuan Avenue and Caitian Road with 4walkers /2min.

During the evening peak hours, the number of pedestrians walking along the northern section of Zhongkang Road was relatively large, with 184 walkers per 2min near the Shangmeilin station, and there were more pedestrians crossing the pedestrian bridge over Beihuan Avenue, with 72 walkers per 2min. The number of walkers near UpperHills Mall and Dongguailing subway Station was higher than the morning peak, with 179 walkers/2min and 81 walkers/2min respectively.

Overall, the points with higher pedestrian traffic are near the subway stations, shopping malls and industrial parks; the points with lower pedestrian traffic are at the intersection of Beihuan Avenue and Caitian Road and along Huanggang Road. Moreover, the peak periods occur during the morning and evening peak hours, and people are more inclined to travel in the morning and evening due to the influence of high temperature in summer. Therefore, the design of the pedestrian system in the Meicai Area should take into account the public's needs for morning and evening travel activities.

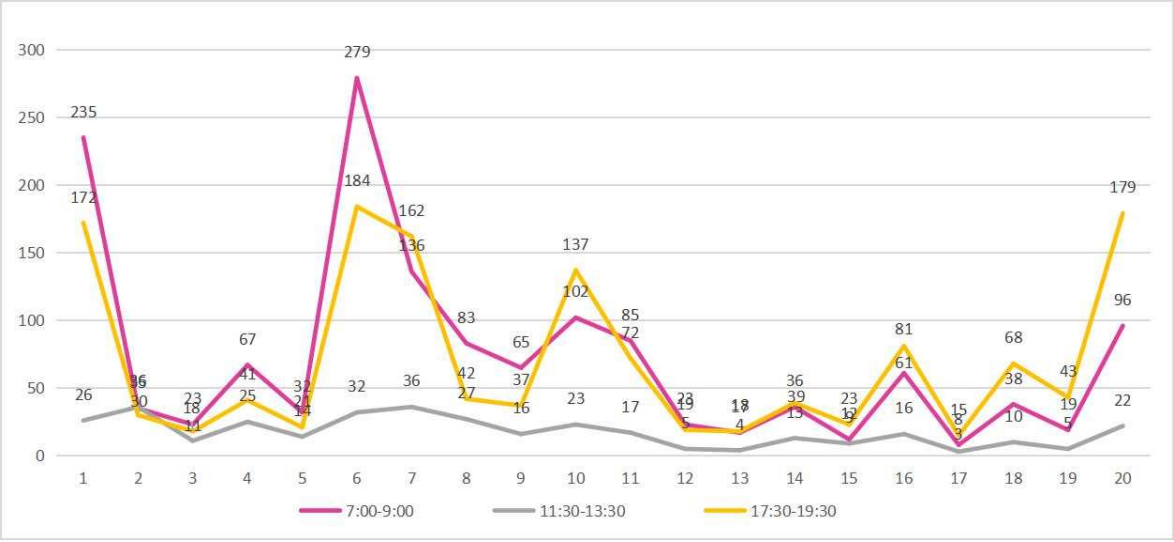


Figure 5-19 Change in the number of pedestrians on a working day (Source: the author)

(3) Vertical distribution of walking

Due to the hot weather in summer, the spatial vertical distribution of pedestrian flow in the Meicai Area varies greatly. Taking the Shangmeilin Station-New Generation Information Technology Industrial Park and Dongguailing Station-UpperHills Mall as examples, the pedestrian flow during the lunchtime peak was investigated in 2min time periods, and it was found that the pedestrian flow was mainly concentrated in the underground space.

In particular, 62.2% of the total pedestrian flow in the underground space of the Shangmeilin Station-New Generation Industrial Park , with relatively less pedestrian flow on the ground (Figure 5-20). In the Dongguailing Station-UpperHills Mall, underground flow of people accounted for 47.3% of the total flow of people in the area, with some walkers on the aerial walking path connecting Lianhuashan Park and Futian River (Figure 5-21).

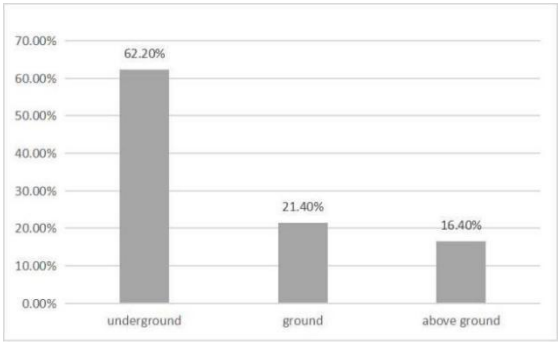


Figure 5-20 Shangmeilin Station - New Generation Industrial Park pedestrian flow distribution

(Source: the author)

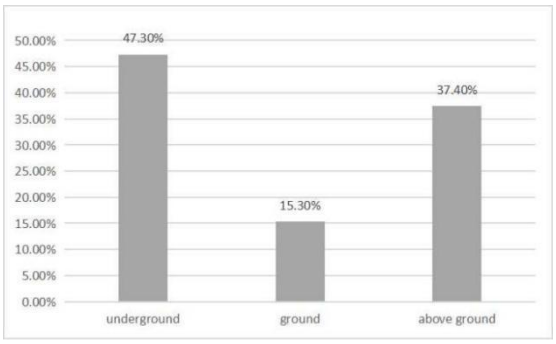


Figure 5-21 Donguoling Station -UpperHills Mall pedestrian flow distribution

(Source: the author)

(4) Walking streamline

The trajectory tracking method was used to record people's behavioural activity process in the Meicai Area, recording in detail the movement trajectory, distance, walking time, route choice, etc., so as to analyse the walking streamline characteristics. The data collected by observation can reflect the complexity and richness in the actual walking environment[73]. A sunny day on 7 June 2023 (Wednesday) was selected to track the movement trajectories of randomly selected walkers in the vicinity of the subway station during three periods: 7:00-9:00 am in the morning peak, 11:30-13:00 pm in the afternoon peak, and 17:30-19:30 pm in the evening peak. A total of 32 walking trajectories were collected and their walking processes were aggregated to create a behavior map.

From the pedestrian streamline map around the metro station (Figure 5-22) shows that the pedestrian streamlin is mainly distributed along the northern section of Zhongkang Road, Meilin Road, Kaifeng Road and Caitian Road. Among them, walkers from the Shangmeilin subway Station basically walk along the pavement of Zhongkang Road, with a few going to the front plaza of the building. During peak hours, the walking path is crowded with people and the walking speed is slow. The majority of the walkers from Maling Station have their walking destinations across Beihuan Avenue and Caitian Road. However, the tracking trajectory revealed that people travelling to work in the Caitian area had to cross the two main roads, Beiluan Avenue and Caitian Road, after departing from the Ma Ling Station. The walking process requires passing through the pedestrian bridge first, crossing two culverts underneath and then passing through the pedestrian bridge to reach their destination, making the walking path very unfriendly to walkers.

There are also a large number of shared bicycles parked under the bridge, taking up most of the walking space. Most of the walkers from Dongguailing Station walk along the pavement of Caitian Road. For destinations that require crossing the street, people generally choose the pedestrian bridge over the road to cross the street.

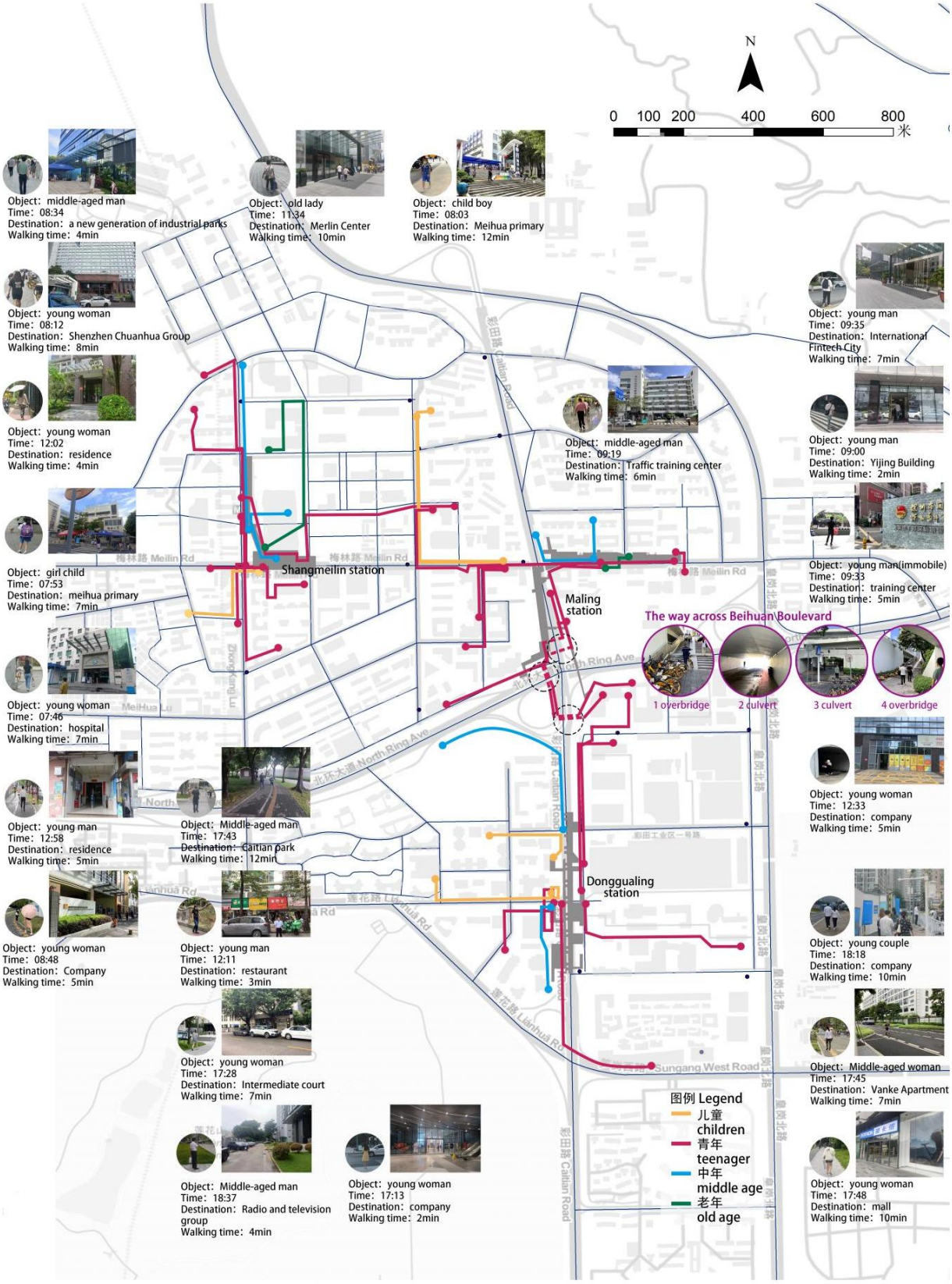


Figure 5-22 Pedestrian streamline and behaviour map around the subway stations (Source: the author)

An analysis of the characteristics of the 32 walking streamlines revealed that the walking streamlines were basically destination-based trips with very little stopping activity occurring during the walk. The types of people and walking destinations were diverse, with the majority of walks lasting less than 10min (Figure 5-23).

Specifically, in terms of crowd type, young people dominate, followed by middle-aged people, with a small number of children and older people present. In terms of walking time, 47% and 44% walked for less than 5min and 5-10min respectively, with only 9% of the population walking for more than 10min. In terms of whether stopping activity occurred during walking, only 9% of walkers stopped to engage in activity during walking, such as resting or talking on the phone. There was a lack of space on the walking path to stop and promote activity, and walkers did not stop during the walk. In terms of walking destinations, the highest proportion of destination places were company, home and business respectively. Some walkers also have school and public services as their destinations.

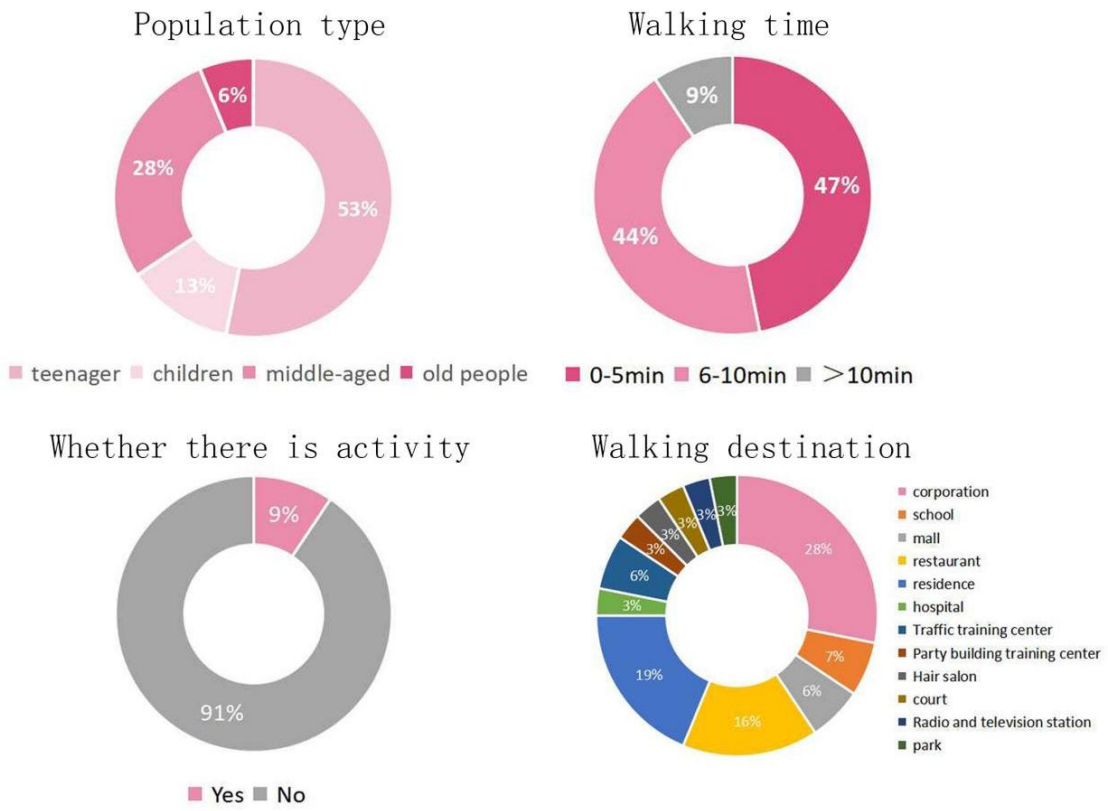


Figure 5-23 Pedestrian streamline characteristics (Source: the author)

5.3.2 Traffic Flow

The degree of right-of-way occupation between pedestrian and vehicular traffic is the most prominent point of conflict in the practice of pedestrian systems, where pedestrian walking activities are affected by the volume of traffic. The PCU (Passenger Car Unit) of the peak period traffic flow is measured on selected major road sections to analyse the traffic operation of the road.

The current situation in the Meicai Area is characterized by high motor traffic flows, overlapping arrival and departure traffic and transit traffic during peak periods, and congestion at some intersections. The motor traffic road network tends to be saturated, which directly leads to problems such as long waiting times for crossing the street and far crossing the street. Due to the division of roads several tens of meters wide, the functional areas are difficult to connect and less interactive, and the continuity of pedestrian activity is greatly affected. In terms of the current state of road operations, the service level of Beihuan Avenue, Huanggang Road, Caitian Road and Xinzhou Road reaches Level E during the evening peak hours, with traffic volumes reaching the maximum road capacity, traffic operations are sensitive to disruptions and are prone to congestion (Figure 5-24, Table 5-4). Their pedestrian paths are affected by the flow of motor vehicle traffic and the walking paths are broken, which is not conducive to continuous and smooth pedestrian movement.

Projections of future traffic operations based on bottom-line thinking. Under the situation of large-scale development increment, the carrying capacity of the road network will be even more overwhelmed in the future. In the 2030 road intersection traffic operation map of the Meicai Area (Figure 5-25), the traffic operation of Huanggang Road, Beihuan Avenue and Caitian Road is unstable, with traffic flow reaching the maximum capacity of the road and more congested. In terms of road intersections, the road service level of the intersection of Zhongkang Road and Meilin Road is E. The service level of the intersection of Meilin Road - Meicun Road and Mehua Road - Meicun Road is D. The road intersection is more congested with increased traffic flow.

In summary, on the red sections, such as Beihuan Avenue, Huanggang Road, Caitian Road and Zhongkang Road North, road congestion is serious and the intersection of

pedestrian and vehicular traffic should be avoided as far as possible, and if there is a genuine need to cross the road, it can be directed to a suitable section or a three-dimensional intersection can be used. On orange sections, such as Meidong 2nd Road and Lianke 2nd Road , congestion can exist within the road section, but the congestion is light and short-lived, and crossing-type pedestrian traffic can be planned according to the through traffic demand.

Figure 5-24 Road traffic operations in 2020

(Source: reference[2])

Figure 5-25 Road traffic operations in 2030

(Source: reference[2])

Table 5-4 Urban road service level division standard (Source: *Technical Standards for Highway Engineering (JTGB01-2014)*)

Service Level	Saturation	Description of operation
A	V/C<0.27	High stability of traffic operation and low sensitivity to disturbances
B	0.27≤V/C<0.57	High potential for access and high stability of traffic operations
C	0.57≤V/C<0.70	Traffic operations are still largely in a stable state
D	0.70≤V/C<0.85	Traffic volumes have not yet exceeded the maximum capacity of the road. It is still acceptable during the peak hour
E	0.85≤V/C≤1.00	Traffic volumes reach the maximum capacity of the road. Traffic operations are sensitive to disruptions and are prone to congestion
F	V/C>1.00	Traffic flow is erratic, with frequent traffic jams caused by excessive traffic volumes

5.3.3 Population Characteristics and Demand Analysis

(1) Population characteristics

The resident population of the Meicai Area is about 34,000, mainly distributed in the Meilin area, and the employed population is 43,000, evenly distributed in two plots. The population structure is characterized by youthfulness, high education and high consumption.

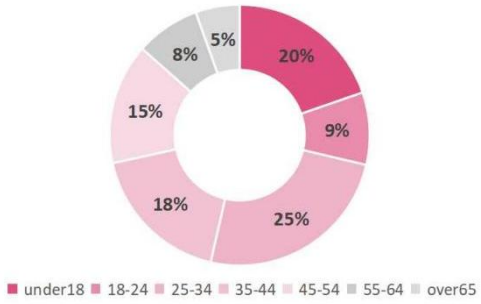


Figure 5-26 Population structure in Meilin (Data source: The Seventh Population Census, Futian District Bureau of Statistics)

Specifically, in terms of age structure, 52% of the population of Meilin street is between 18 and 45, more than half. Meaning, the population of Meilin is younger in age overall (Figure 5-26). In terms of education level, the Meicai Area has about 47% of the population with tertiary education or above, while Shenzhen has about 36% of the population with tertiary education or above. The education level of the Meicai Area is characterized by a high level of education, which is higher than the average level in Shenzhen (Figure 5-27). In terms of consumption level, the high consumption share of Meicai Area is about 47%, which is higher than the high consumption share of Futian District and the average of Shenzhen (Figure 5-28). Overall, the population of the Meicai Area is dominated by the youth group, with a higher level of education and consumption.

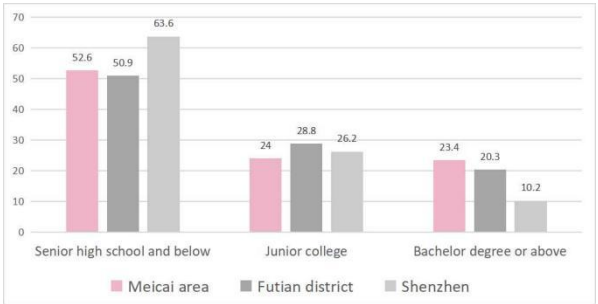


Figure 5-27 Education level of the population (Source: redrawn from reference[2])

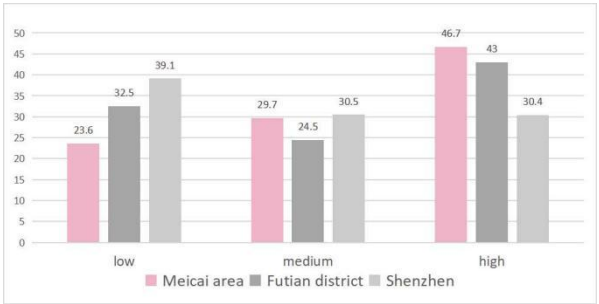


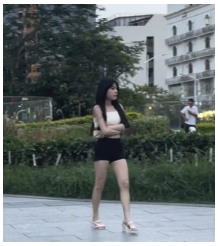
Figure 5-28 Consumption level of the population (Source: redrawn from reference[2])

(2) Analysis of the demand of the population

The population structure and occupational types of Meicai District are diverse. In order to better understand the walking needs of the people in the area and their evaluation of the

walking space, different groups of people were selected for free interviews, including primary school students, university students, youth R&D groups, white-collar workers and neighborhood residents, etc. A representative group of each type of people was selected for analysis below (Table 5-5).

Table 5-5 Population needs interview analysis (Source: the author)

Subject 1: Primary school student, male, 10 years old	Subject 2: University student, female, 21 years old	Subject 3: Middle-aged, male, 43 years old
I take subway to school, and there are many people on the way to school, sometimes I have to **wait a long time at the traffic lights**, so I need to walk faster to not be late.	Usually I come here to eat with friends and visit the mall, and I rarely walk on the street, but if there are **more interesting activities and shade** I will be more tempted to walk.	It is very **inconvenient** to come here by subway, as it is very **confusing to find the entrance and exit of the subway station** and to cross the road many times after coming out.
		
Subject 4: Householder, female, 67 years old	Subject 5: White collar, male, 31 years old	Subject 6: White collar, female, 29 years old
I take my grandson out for a play in the afternoon and talk with my neighbors. I think the environment is good relatively , but it would be better if there are **more children's playground facilities.**	It's a 20 minute walk to home and the **streets are basically boring** with nothing worth stopping for. It would be more interesting if there was space to interact and bring a bit of our group's culture.	I often walk downstairs during my lunch break to get a coffee. But it takes me ten minutes to walk to the nearest park square, so I wish I had **more natural space** to breathe in my life.
		

After the character interviews, it was found that at the level of pedestrian path connectivity, the public perceives the pedestrian paths to be crowded due to high pedestrian traffic during peak commuting hours. The parking of electric bikes and bicycles, especially shared bikes, leads to the encroachment of pavement space and poor walking continuity. At the facilities level, young white-collar workers generally report a lack of space to interact and

stay. Some people feel that there are fewer interesting spaces and children's playground facilities. Moreover, the commercial businesses on the streets are homogeneous and can only meet the basic needs of life. Moreover, the signage system in the underground space is confusing, and for people with a poor sense of direction, it basically depends on repeated trial and error to know where the correct path is. In terms of walking comfort, people generally report a lack of shade facilities along the walking path, making the walking experience poor. At the same time, there is not enough space to stay, and it takes more than 10 minutes to walk to a square, which is not a various spatial experience.

5.4 Summary of Current Problems

The three-dimensional repair conditions of the pedestrian system in the Meicai Area were analyzed and evaluated in terms of both pedestrian space and public life. In terms of pedestrian space, the analysis focused on the connectivity, convenience and comfort of the pedestrian spaces; in terms of public life, the analysis included pedestrian flow, traffic flow and interviews with people. In a comprehensive analysis, the following problems were found in the pedestrian system of the Meicai Area.

5.4.1 Broken Pedestrian Paths and Fragmented Spatial Functions

The analysis of the current situation and connectivity of the pedestrian space in the Meicai Area, combined with the distribution of pedestrian and vehicular traffic, reveals that the Meicai Area suffers from broken pedestrian paths and fragmented spatial functions.

At the horizontal level, the Meicai Area is divided into "spatial islands" by four major traffic arteries, of which Beihuan Avenue is an important expressway linking the east and west of Shenzhen, creating a north-south barrier to the Meicai Area. Pedestrians need to cross the site from north to south via an under-viaduct path or footbridge. The pedestrian paths on the site are narrow and the pedestrian life and walking environment gives way to vehicular traffic. The width of the footpaths is relatively cramped for the congested pedestrian flows and the pedestrian rights of way could be further improved. The overall character of the site is characterized by a high level of vehicular access at ground-level, but not easy access for pedestrians. In addition, there is conflict between non-motor parking and movement and pedestrian streamlines in some sections, creating artificial fragmentation of pedestrian paths.

At the vertical level, there is a lack of humane vertical connections. The current three-dimensional spaces are mainly the air platforms of the industrial parks, the roof gardens of the commercial complexes, and some of the air corridors and overpasses. However, they are not connected to each other and most of the vertical connections are made by stairs, with relatively little consideration given to accessibility. During the pedestrian streamline survey, it was found that the signage in the underground space of the station was confusing and that some walkers had to ask for directions and make detours to reach their destinations at ground-level. In the later stages of design optimization, it is necessary to improve the vertical connections and enhance the vertical connections and transitions between the ground, underground and air levels to create a truly accessible walking environment.

5.4.2 Mismatch of Pedestrian Demand and Poor Quality of Pedestrian Space

The study combined with the pedestrian flow and pedestrian streamline found that there is a mismatch of people's needs and poor quality of pedestrian space at the level of convenience and comfort of the pedestrian space.

In terms of the distribution of facilities, there is a certain mismatch of facilities. The current pedestrian flow and streamline is concentrated on the outer roads of the Meicai Area, with relatively little pedestrian flow on the internal walking paths. However, Kaifeng Road and the center of the Caitian Area, located within the site, are sections of the Meicai Area with a relatively good pedestrian environment, with continuous shade and linear parkland, but are less frequented by walkers.

In terms of facility types, the industrial and service facilities are relatively universal and lack site characteristics, and are not sufficiently responsive to the needs of a diverse population. The high-density industrial space lacks composite functional support and integration with the urban environment, bringing about a loss of warmth in the first floor interface, a lack of street vitality and a certain fragmentation with the surrounding communities. The current walking behaviour is mostly destination-based and lacks spontaneous walking behaviour. People largely do not linger during the walking process, in relation to the attractiveness and quantity of the spatial facilities themselves. For example,

character interviews revealed that neighbourhood residents would like to see more facilities for children's activities and corner parks to enrich their daily lives; young white-collar workers would like to see more spaces to stay on foot, to provide a window to breathe for their busy work and to raise the temperature of the space to promote interaction activities. In turn, it will improve the sense of wandering and coldness of working in Shenzhen and enhance the sense of belonging to the space. The design of the pedestrian system should take full account of the needs of the population and provide a specific response to guide the localization and dailyization of the pedestrian space.

In terms of climate adaptation, the pedestrian paths in the Meicai Area are not sufficiently adapted to the climate and the quality of the pedestrian space is poor. Shenzhen has a high level of sunshine throughout the year and is hot and rainy in the summer, yet the current pedestrian space lacks shading facilities and is of poor quality. The spatial and temporal variation in pedestrian flows shows that people tend to travel during the morning and evening peak periods and less during the day, which is related to the hot weather in the area. Weatherproofing facilities should be added to the design of the pedestrian system to create all-weather weather-protected pedestrian paths.

5.5 The Necessity of Three-dimensional Repair

5.5.1 Pedestrian-vehicle Conflict

Firstly, there is a high volume of vehicular traffic in the Meicai Area. The Meicai Area is only 3.5km away from the central area of Futian and is the fourth employment center in Futian with a high traffic flow. As a pain point for the development of the area, there are already many problems with traffic: during peak hours, external traffic is inconvenient and almost all major arterial roads are congested; at the same time, the internal feeder roads in the Meicai Area are simple which cannot share the traffic flow of the main roads better. The current transport infrastructure is unable to carry the increasing traffic flow.

Secondly, the development of subway lines bring high volume of pedestrian traffic. In the current situation of the site, there are three subway stations,of which the Shangmeilin Station and the Maling Station are among the important interchange subway stations in Futian District, providing access to popular destinations such as Futian Port, Civic center and

Shenzhen Bay Park. Two more subway stations will be added in the future to bring more people to the area. The construction of a multi-level pedestrian system will relieve the congestion and discomfort caused by the high volume of pedestrian traffic.

Moreover, the site is densely populated. The current resident population is about 34,000 and the employed population is about 43,000. After urban regeneration, a large number of new high-end industrial R&D and commercial office sites have been added. With the significant increase in the number of jobs, there will be more and more competition between people and vehicles for roads.

5.5.2 Fragmentation and Lack of Vibrancy of Pedestrian Space

The Futian Central District will be transformed from a CBD to a CAZ in the future and will expand to the north. The connection between the the north area of Futian is particularly crucial, but due to the separation of the current expressways and trunk roads, there are many bottlenecks in the conventional ground road connections. In particular, the Beihuan Avenue separates the Meilin Area from the Caitian Area, and the site is divided into “spatial islands” by the city’s main roads. Moreover, the site has been upgraded through industrial upgrading and industrial up-grading to enhance the overall image of the area, but it has also brought about the problem of fragmentation of pedestrian space and lack of vitality. The regenerated site is full of tall buildings, and some of the sites are built in the form of “first floor podiums with office towers”, which lacks connection with the surroundings and is not vibrant. For example, the pursuit of high rents has led to the high-endisation of office buildings; the excessive pursuit of efficiency has led to a lack of adequate social space.

At the same time, the high-density of industrial space lacks integration with the surrounding community, bringing about a loss of warmth on the ground floor interface and a lack of street vitality. There is less actual stay and activity occurring in the space. There is a lack of consideration and response to the specific needs of a diverse population and the need for increased high quality urban living and social interaction. A three-dimensional pedestrian system can interconnect complex spatial functions, create spaces for various activities, enhance communication between people, revitalize the urban ground floor space and promote innovation and connections between industry and the community. It can also support the

northward expansion of the central Futian District and promote the integrated development of the Futian north region.

5.5.3 Lack of Pedestrian Space

In a high-density construction environment, pedestrian life and the pedestrian environment give way to vehicular traffic. Specifically, after analyzing the pedestrian environment of the site in terms of connectivity, convenience and comfort of walking, it was found that: there are many pedestrian break points and some of the pedestrian space is crowded by commercial facilities; lack of effective and humane vertical connections; some of the pedestrian spaces lack shade and greenery, and comfort needs to be improved; the current public space is monotonous and difficult to meet the diverse needs of people. As an important supplement to high-density urban public space, the three-dimensional pedestrian system can effectively enhance the capacity of urban space, not only to meet the function of pedestrian transportation, but also as a carrier of urban public life.

5.6 Chapter Summary

This chapter makes a comprehensive analysis of the current situation of the pedestrian system in Meicai Area from two aspects: pedestrian space analysis and public life investigation. It is found that there are two main problems in the site : 1)walking path fracture, space function fragmentation; 2)crowd demand mismatch, poor space quality.

On this basis, it is summarized that the necessity of three-dimensional repair of the pedestrian system in Meicai Area has the following three points.

Firstly, there is the problem of contradiction between pedestrians and vehicles in the area, and the three-dimensional pedestrian system can ease the high flow of commuters.

Secondly, the northward expansion of Futian central area has increased the necessity of north-south integration of Meicai Area. However, it is more difficult to connect on the ground, and the feasibility of three-dimensional connection is higher.

Thirdly, in the high-density construction environment, the pedestrian space in the Meicai Area is scarce, which is difficult to meet the various needs of multiple groups of people. It needs to be improved in terms of suitability of spatial scale, diversity of space, and facilities.

Chapter 6 Three-dimensional Repair of Urban Ground Floor in Meicai Area: A Scheme of Pedestrian System

6.1 Objectives and Principles of Three-dimensional Repair

6.1.1 Objectives of Three-dimensional Repair

The overall goal of the three-dimensional repair of the pedestrian system in the Mecai area is to use three-dimensional repair to create the same pedestrian space as on the ground. Creating an organic and efficient spatial network through the optimization of two types of elements, paths and nodes, so as to make it consistent with the demand for walking and to promote the mixing of urban functions. According to the overall goal, it can be refined into two objectives: the establishment of a continuous and systematic pedestrian network and the creation of a varied pedestrian space.

(1) Establishment of a continuous and systematic pedestrian network

A continuous and systematic pedestrian network is created by linking pedestrian breaks on the basis of urban roads and regional centers. The development of a multi-level pedestrian base is integrated, extending the pedestrian space into the air, underground and inside buildings. Through the rational optimization of pedestrian paths, spatial connectivity is recreated. At the same time, pedestrian links are established between industrial spaces and community centers to promote a mix of urban functions.

(2) Creation of a varied pedestrian space

Create a various level of pedestrian space which can carry the diverse activities of the public demand. In high-density cities, there is a lack of public activity space. As an important supplement to urban public activity space, the pedestrian system not only carries the basic walking needs, but also is a living place that brings together all kinds of public activities. Through the three-dimensional repair of the pedestrian system, the lack of ground public space is alleviated, and the occurrence of pedestrian life is stimulated.

6.1.2 Principles of Three-dimensional Repair

Based on the analysis of the three-dimensional repair conditions of the pedestrian system in the Meicai Area, three repair principles are proposed.

(1) Horizontal and vertical continuity

The repair of the pedestrian system must first satisfy the continuity of the path. Due to the priority given to vehicular continuity in road network planning, the overall continuity of the pedestrian system, which coexists with the vehicular system, is not easy to achieve, and problems such as broken and missing pedestrian paths arise. Therefore, it is important to co-ordinate the relationship between the pedestrian systems at different levels of elevation and to establish a continuous pedestrian path.

(2) Comfort of pedestrian space

The comfort of pedestrian space focuses on the scale of pedestrian path, shading and temperature control facilities and rest space, which usually directly affect the quality of walking experience. Pedestrian system need to meet the needs for appropriate spatial scale, thermal comfort and resting space, so that walkers can experience the urban pedestrian space in depth and from multiple perspectives.

(3) Satisfaction of diverse needs

The satisfaction of diverse needs means that the pedestrian system should meet people's diverse needs as much as possible in the process of repair. In *Life between Buildings*, Jan Gehl suggests that people have three levels of activity in public space, namely, necessary, optional and social activities[74] (Table 6-1). In current urban life, the transport function of pedestrian space is only one of many functions, and people also put forward diverse needs in terms of continuity, diversity, selectivity and recognisability in their walking activities. Therefore, the three activities of people in public space should be fully considered in the design process of the pedestrian system, so that the pedestrian system can span multiple levels of needs and become a container for public life.

Table 6-1 Classification of public activities (Source: Compiled from reference [74])

Necessary activities	Optional activities	Social activities
Necessary activities include compulsory everyday activities, such as going to school, shopping or waiting for the bus; they are generally only marginally influenced by the physical aspects of the space.	Optional activities involve the voluntary activities that people engage only if they wish to and if the time and place allow, such as strolling, sitting and sunbathing; they are dependent on both spatial and weather conditions.	Social activities include those that depend on the presence of other people in the space, such as children at play, conversations and communal gatherings; they occur spontaneously.

6.2 Spatial Connectivity: Continuous and Convenient Pedestrian Network

6.2.1 Identifying Pedestrian Breaks and Reshaping Spatial Connectivity

Firstly, combined with the previous analysis, the pedestrian flow, pedestrian flow, traffic flow and functional center of the area are superimposed and analyzed, and the area of pedestrian break is identified, that is, the break area of pedestrian space and the break area of human activity (Figure 6-1).

In terms of pedestrian spatial breaks, they mainly refer to areas with poor spatial accessibility and areas where pedestrian movement is discontinuous due to the influence of motor vehicle traffic. The breaks in the pedestrian space of the Meicai Area are mainly located around the first floor platform and the underground station, as well as around the high-grade roads. The first floor platform area is weakly connected to the urban surroundings, and the subway station is not well connected to the ground-level. Combined with the analysis of traffic flow, the Meicai Area is divided into “spatial islands” by the peripheral expressways and the congested traffic flow on the main roads, and there are spatial breaks in the weak north-south connections.

In terms of the breaks of people's activities, it refers to the areas with low pedestrian flow and less pedestrian circulation, mainly in the internal areas adjacent to the industrial and community spaces such as Kaifeng Road and Meilin Road. Specifically, the intensity of pedestrian flow on the peripheral roads of the Meicai Area is higher than that of the interior of the site, indicating that the pedestrian paths within the site are insufficient. Pedestrian flows are largely located around the subway station and the periphery of the site, with less distribution within. At the same time, after superimposing the distribution of the urban center, block center and community center of the site, it is found that the connection between each functional center is weak. In fact, fewer pedestrians travel to and from multiple functional centers, mostly for destination travel. There has been a problem of industrial space isolation caused by the one-sided emphasis on functional compounding, the lack of integration of industrial space and the surrounding environment, and the fragmentation of people's activities in industrial space and community space.

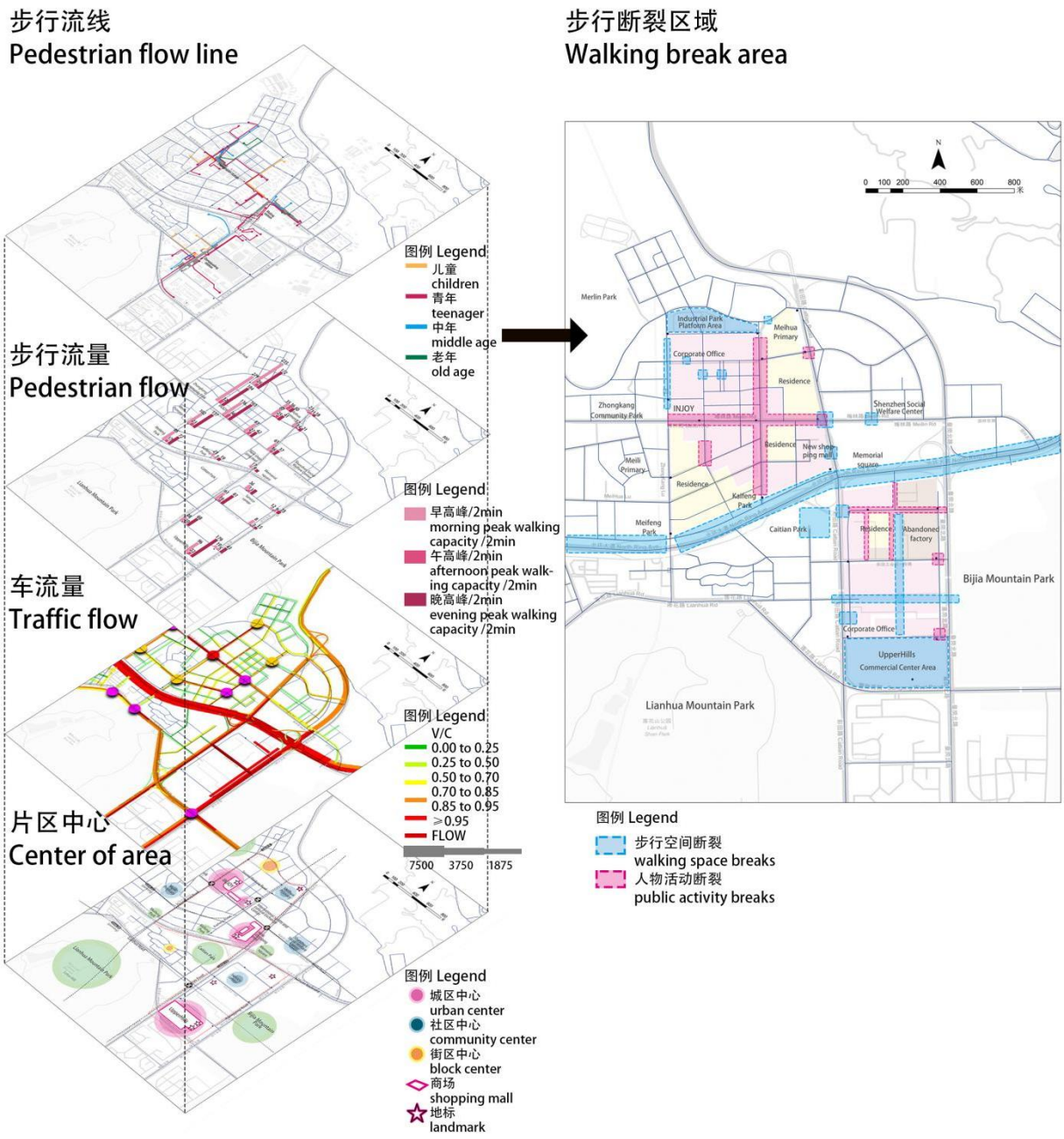


Figure 6-1 Identifying walking break areas (Source: the author)

Secondly, relying on urban roads, the area of pedestrian breaks are connected with the urban greenway system to determine the overall public space structure (Figure 6-2). A new composite corridor is added within the site, linking the functional center to the north and south, the subway station and the pedestrian fracture, creating a reconnection between work, life and leisure. Four new community greenways are added to interconnect with the urban greenway system, enhancing links with the surrounding mountains, parks and other natural

landscapes, and promoting the interchange between walking and cycling.

Overall, the program strengthens the connection between the north and the south, enhances the connection between the area and nature, the connection between industry and community, and promotes the free flow of elements.

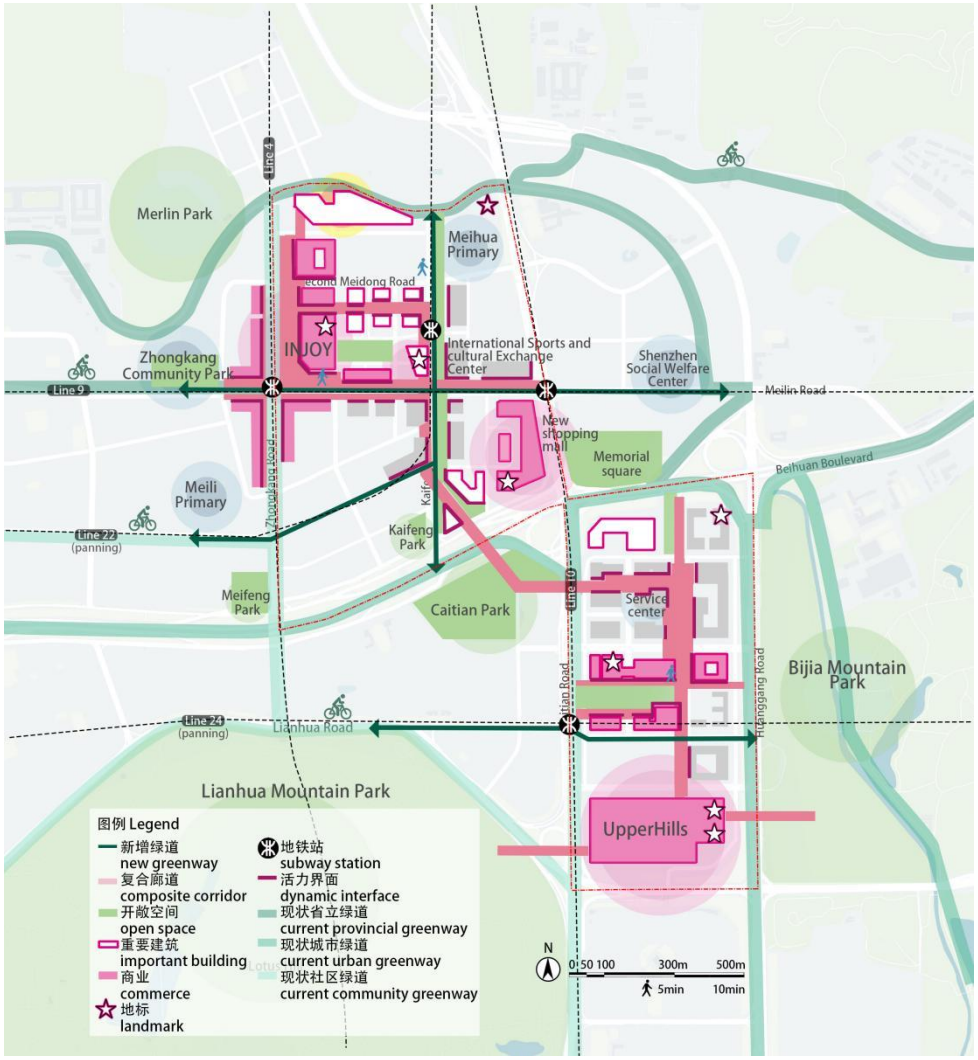


Figure 6-2 Public space structure (Source: the author)

(1) Ground-level pedestrian paths

The ground-level pedestrian paths are the basis for the pedestrian space in the urban ground floor, while the elevated pedestrian paths are an extension of the ground-level pedestrian space. Therefore the ground floor should create more space for pedestrian to use and provide high-quality open space for the public. Optimise connections with public transport to improve the efficiency of ground-level walking trips (Figure 6-3).

On the one hand, more ground-level pedestrian space should be released. In view of the

problem that motor vehicle and non-motor vehicle parking occupy the ground pedestrian space, we should make rational use of the unbuilt renewal projects, guide them to build underground parking lots and release more ground pedestrian space. At the urban cycling road and important nodes, new bicycle parking points are added to standardize bicycle parking.

On the other hand, optimise the connection with public transport. Improve road connectivity by encrypting the urban road network, for example by adding new urban bypasses, opening up closed blocks, and opening up cut-off roads. In particular, increasing the density of the road network around stations will facilitate micro-circulation of pedestrian flow. For areas where the station cannot be reached by walking in 10 minutes, the community greenway is added, which can quickly reach the station by bike. This promotes the mutual conversion of various modes of transportation and improves the efficiency of ground travel.

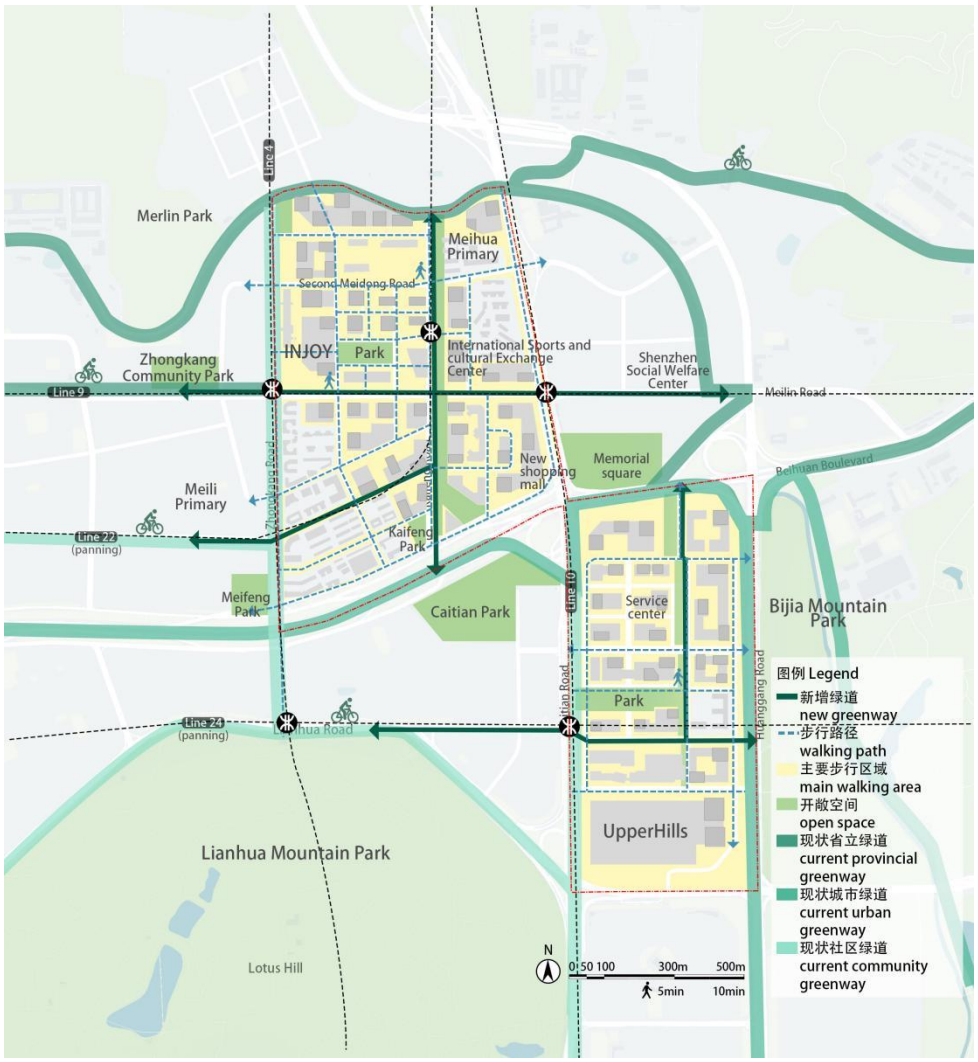


Figure 6-3 Ground-level pedestrian path (Source: the author)

(2) Aerial pedestrian paths

The repair of aerial pedestrian paths relies on the existing aerial corridors and platforms. The north-south connection of the Meicai Area is very important for the northern expansion of the Futian CBD. However, due to the division of the existing expressway and main roads, there are many bottlenecks in the conventional ground transportation connection. And the aerial pedestrian paths can take advantage of their extended and cohesive structural characteristics to connect fragmented spaces such as north-south spaces and functional urban spaces.

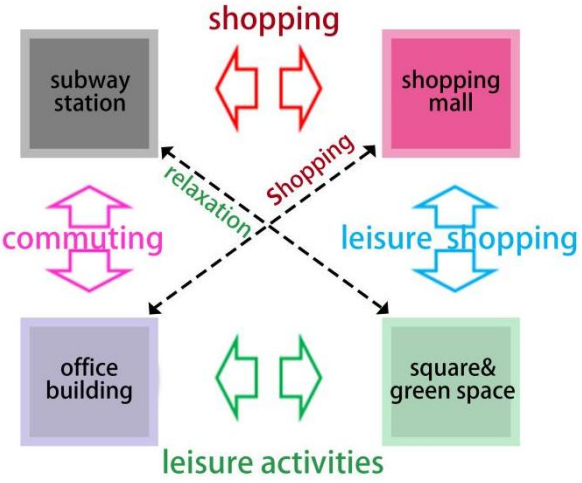


Figure 6-4 Purpose of walking between plots

(Source: the author)

The repair of aerial pedestrian paths around the rail station, as a link to gather popularity, stimulates the potential of the area, makes full use of commercial and industrial podiums, and combines public buildings and three-dimensional facilities to create an air roaming system. It compensates for the lack of public space on the ground and provides a leisurely air roaming experience without ground traffic interference. At the same time, it connects the north and south blocks and optimizes the walking streamline. In variety schemes of aerial pedestrian paths, the existing Hong Kong experience is used to build an air pedestrian system suitable for the Meicai Area.

Firstly, the main corridors are identified and the main service users are clarified. The layout of the main corridors are considered comprehensively in terms of both regional traffic and travel purpose. On the one hand, the nodes are clearly identified from the perspective of regional traffic, and a composite corridor of Shangmeilin Station (transport hub) - Commercial Complex - Caitian Center - Commercial Complex (Dongguailing Station) is established to ease the high volume of walking and interchanges. On the other hand, the main corridors are adjusted from the perspective of the purpose of travel between the various blocks, emphasising the links between open spaces such as rail stations, commercial offices and plazas and green spaces, focusing on serving the needs of commuting, shopping and

leisure between the blocks. (Figure 6-4). In this way, the layout of the main corridor is determined (Figure 6-5). This system is a corridor for the evacuation of people to the surrounding buildings and a place for the convergence of people from different directions in the surrounding area to the core area.

Secondly, the establishment of branch corridors based on the main corridors makes for a denser and more efficient aerial pedestrian network (Figure 6-6). The north and south areas provide multiple paths to meet the demand for quick commuter access and commercial migration activities. Pedestrians can cross multiple blocks safely and easily via the skywalk paths, continuing the shopping experience and making for a safe and enjoyable walking environment.

Finally, the layout of the aerial pedestrian path is formed by integrating public transport and the existing first floor platforms and street crossings (Figure 6-7). In order to strengthen the connectivity and convenience of walking, the integration of the bus terminal, the street crossing bridges, the existing bus stops, bicycle docking points and other transport facilities, so that the distance between the main corridor and the transport facilities is controlled within a pedestrian space of 200meters.

At the same time, pedestrian paths of different widths are set according to the flow of people and walking needs. According to the *Shenzhen Futian Central District Air Corridor Detailed Planning (2017)* the width of the corridor with mainly pedestrian traffic function should be controlled between 3-5meters; taking into account auxiliary functions such as resting and viewing can be widened to 6meters, more than 6meters wide should be subject to a special study according to the actual situation[75]. Combined with the situation that the stations, commercial complexes and public buildings have a large flow of people within 200meters of each other, the width of the pedestrian link is determined to be no less than 6meters (main link), while in areas with lower density of pedestrian flow the facilities are 5meters or 4meters (branch link). Through a reasonable scale of pedestrian space, the pedestrian flow of the station is effectively dispersed to the facilities around the station or to the ground-level, which greatly enhances the pedestrian flow carrying capacity, and also strengthens the connection between the subway stations and the surrounding functional facilities.

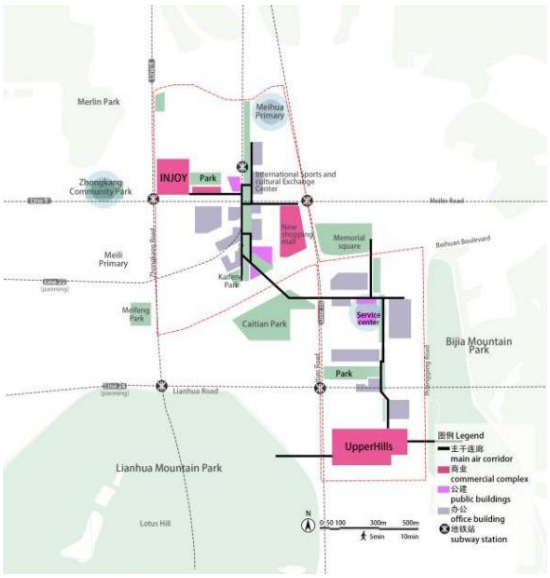


Figure 6-5 Distribution of main corridors

(Source: the author)

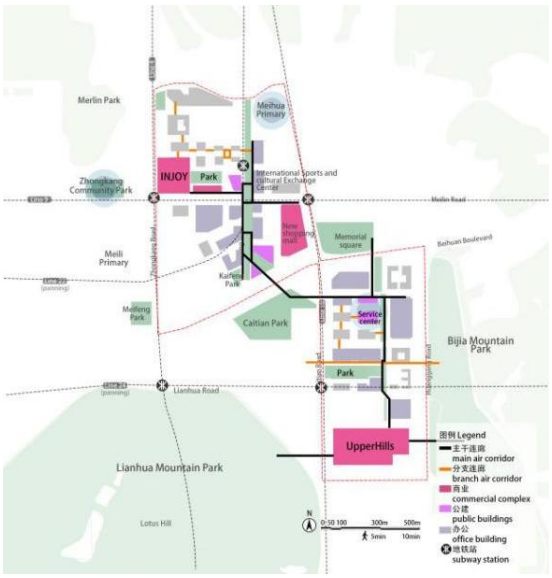


Figure 6-6 Branching corridors growing on the main stem

(Source: the author)

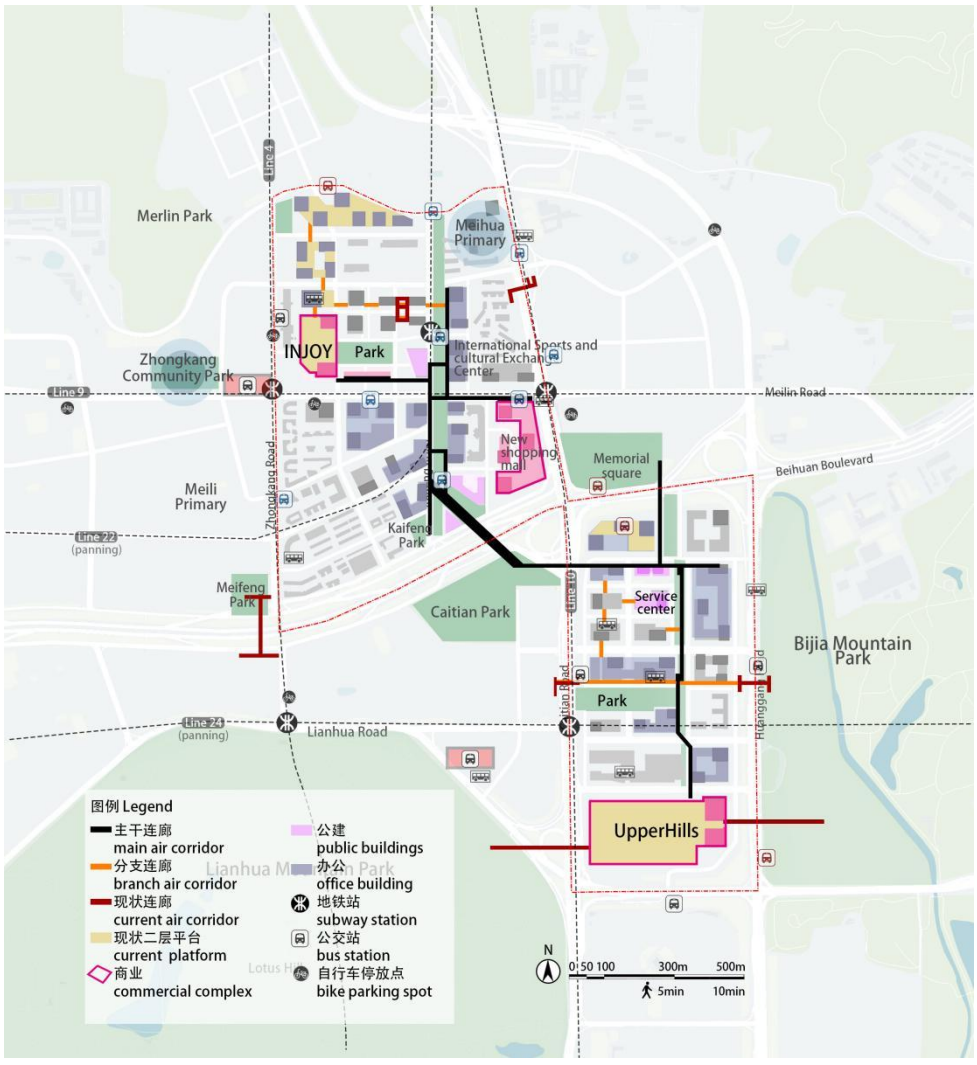


Figure 6-7 Aerial pedestrian path (Source: the author)

(3) Underground pedestrian paths

Underground pedestrian paths are an important part of the three-dimensional pedestrian system, which can link up with urban subway stations, underground commercial streets, sunken plazas and other functions, supporting the occurrence of various public activities. Moreover, underground pedestrian paths can better relieve the congestion and discomfort caused by high volumes of pedestrian traffic, and are one of the most important ways to solve the contradiction between people and vehicles, improve the public space system and stimulate urban vitality in high-density urban centers.

Through the preliminary analysis, it was found that the problem of underground walking in the Meicai Area lies in the weak connection between the underground pedestrian space of the rail station and the underground space of the surrounding buildings. For example, walkers at the Maling Station cannot directly reach the office buildings through the underground pedestrian path. A review of the relevant plans shows that the construction conditions of the underground space in the Meicai Area are complex and the possibility of repairing the underground walking paths is costly and limited. Specifically, the underground space in Meicai has a large number of municipal facilities and complex underground pipelines. And in the long term, it is planned that underground carriageways will be built to construct two underground ring roads in the north and south to relieve the pressure of surface car traffic[2]. Therefore, it is unlikely that the large and complete underground pedestrian paths will be built. However, it is possible to improve the underground pedestrian space of the commercial complexes connected to the subway station, to enhance the connection with the ground-level pedestrian paths.

Therefore, the repair of the underground pedestrian paths is mainly concentrated on the underground-level, with the aim of linking the core functional areas and core transport hubs. The underground-level is dominated by underground commercial and parking spaces. On the whole, the connection between underground commerce and subway stations is strengthened, and a pedestrian loop is built in the subway station hall and underground commercial space. The underground pedestrian path can directly reach the underground commercial space of commercial complexes such as Zhuoyuehui Mall and Shenye Shangcheng Mall, creating higher space value ; the underground space between commercial buildings is partially opened

to improve the connectivity of underground pedestrian paths (Figure 6-8). The development of the underground second floor takes into account the flow of people, commercial value and other factors. Most of them are used as underground garages, and some are reserved for subway stations.

Figure 6-8 Underground pedestrian path (Source: the author)

6.2.2 Adjusting Aerial Pedestrian Paths According to Property Rights

On the one hand, from the perspective of land property rights and construction, the land parcels in Meicai area are sorted out, and it is found that there are four kinds of land parcel construction in the site, which are completed, transferred land to be completed, transferred land not approved construction plan, and future land to be renewaled (Figure 6-9). As the construction of the air pedestrian paths need to coordinate the comprehensive consideration of multiple plots and multiple interests, the appropriate layout of the corridor is selected for

different construction situations (Table 6-2).

On the other hand, from the perspective of space function and energy saving, adjust the position of the pedestrian paths. It is like in the highly urbanised areas of Hong Kong, walkways are often connected to air-conditioned spaces in shopping centers and other commercial buildings, which can both relieve the thermal stress of pedestrians and save energy[76]. Therefore, the air conditioning space in shopping centers and commercial buildings can be fully utilized in the design, and the air pedestrian paths can be combined with it. Encourage more walking by providing air conditioning, covered or green sidewalks in these places.

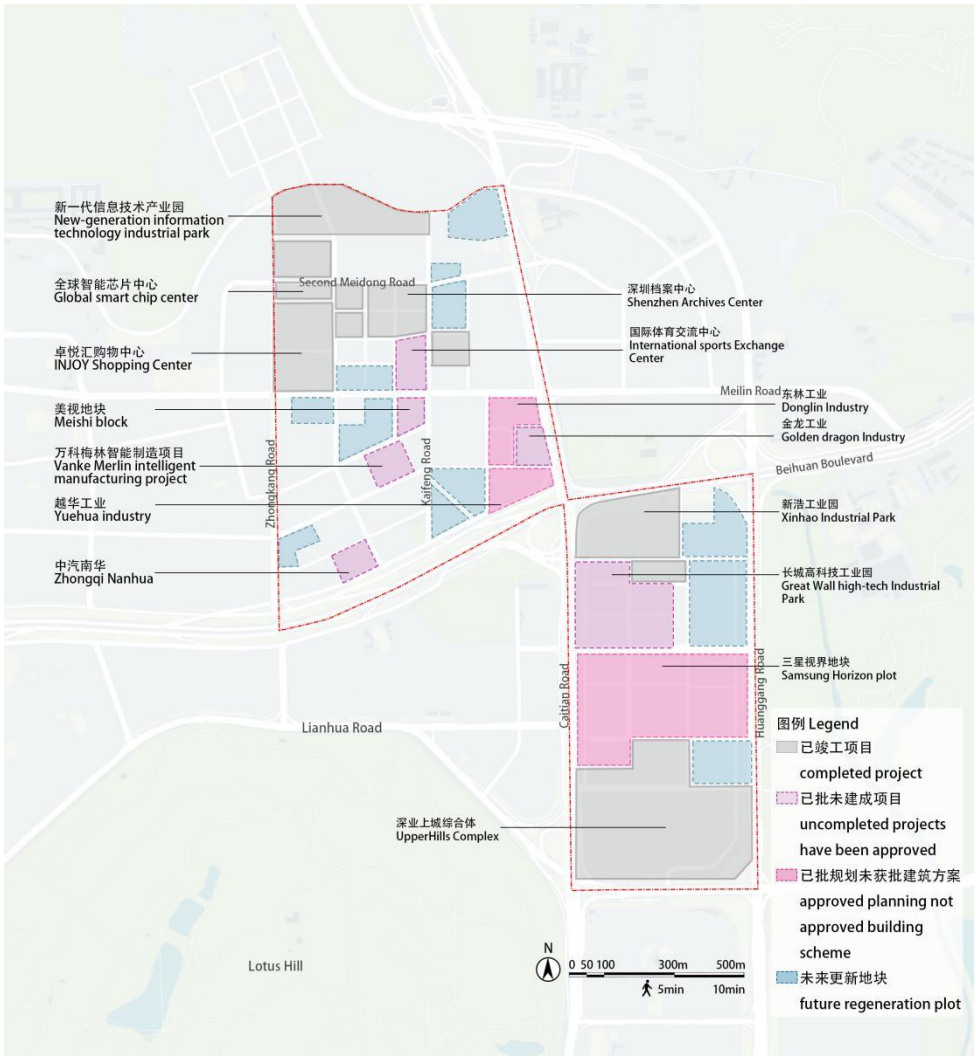
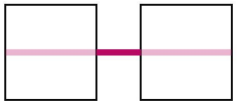
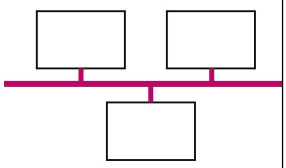


Figure 6-9 Plot ownership and construction stituation

(Source: the author, Data: Futian District Urban Renewal and Land Preparation Bureau)

Table 6-2 Forms of aerial pedestrian space (Source: the author)

Type		Form of connection	Advantages	Disadvantages	Applicable land
Penetration	Central		①Does not occupy public space ② Directly connects to the building space and helps to attract foot traffic	①Lack of open space ②Opening hours may be limited	Construction needs to considered simultaneously with architectural design. Suitable for: the land has not been approved for construction plan, the land to be renewaled in the future.
	Lateral		①Reduces interference with the main use of the building from crossing foot traffic ②Easy to provide 24-hour access	①Individual building units ②Users may walk longer distances	
External			①Direct and clear direction of pedestrian flow ②Does not affect architectural design ③Easy to provide 24-hour access	①Higher cost ②Larger in scale, mostly built by the government	Construction needs to consider the availability of space on the site. Suitable for: completed lands, offered for completion lands
Platform			①High pedestrian accessibility ②Easy to create a comfortable, high-quality pedestrian system	① Need to cooperate with multiple properties ②High cost of construction	Suitable for: high concentration of business offices with multiple properties in conjunction with development

Considering the property rights, functions and energy saving of the plot, the location of the aerial pedestrian paths are locally adjusted (Figure 6-10). Within the completed and released-to-be-completed plots, external linkages are used. Adopt penetrative corridors in future regeneration plots and in plots that have been released without an approved building scheme. The design of the corridor is considered in tandem with the architectural design to make full use of the internal space of commercial buildings and provide an air-conditioned pedestrian environment. In the functionally complex plots, a podium-style linkage is used as a node for the pedestrian life of the area. The platform is richly furnished with functions such as branded retail, small exhibitions, bookstores, coffee, etc.

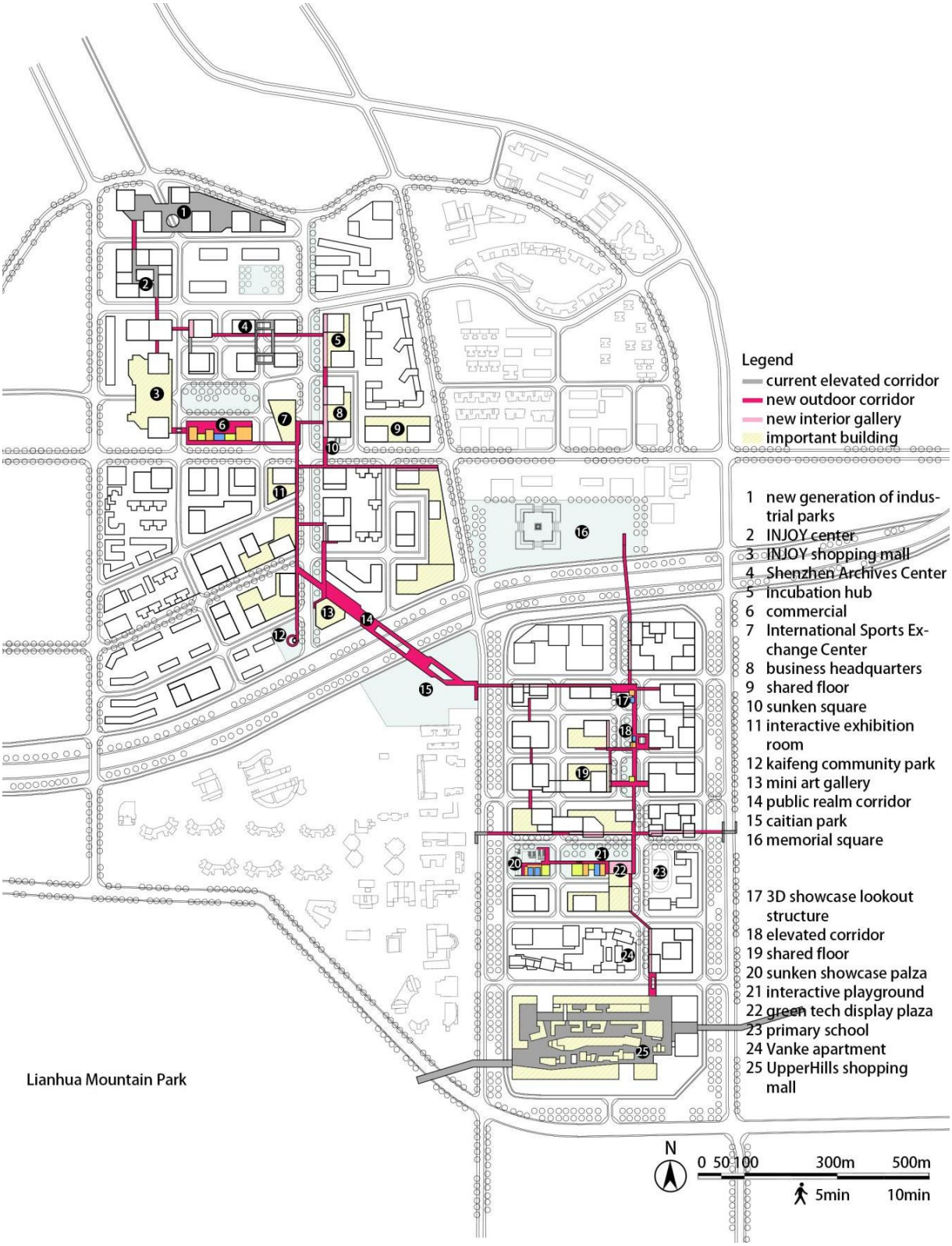


Figure 6-10 Master plan

(Source: the author)

6.3 Vertical Connections: Stitching Multi-level Pedestrian Network

By vertically connecting together the underground, ground-level and air level pedestrian paths, a natural transition between multiple levels of pedestrian paths is achieved, seamlessly linking multiple levels of urban life. According to the characteristics of the site and the location of static traffic, different types of vertical connections are provided at the connection between the main corridor and the underground pedestrian path to meet the needs of the public to walk and stop. Most of the walking paths of the branch corridors are completed inside the building, and vertical traffic relies on the building atrium and internal traffic for solutions.

Specifically, vertical connections of the transport node type are provided around the rail station, focusing on the need for convenient travel for commuters and strengthening links with neighbouring commercial buildings. Vertical connections of the landscape node type are set up near the city's squares and ground-level parks to integrate urban landscape resources and meet people's needs for rest and play.The vertical connection of street nodes is set up at important road intersections to strengthen the interaction between the ground and the ground and underground. Strengthen the connectivity and convenience of the multi-level pedestrian system, and truly form a three-dimensional pedestrian system that can be up and down, convenient and accessible, and easy to use by the public (Figure 6-11).

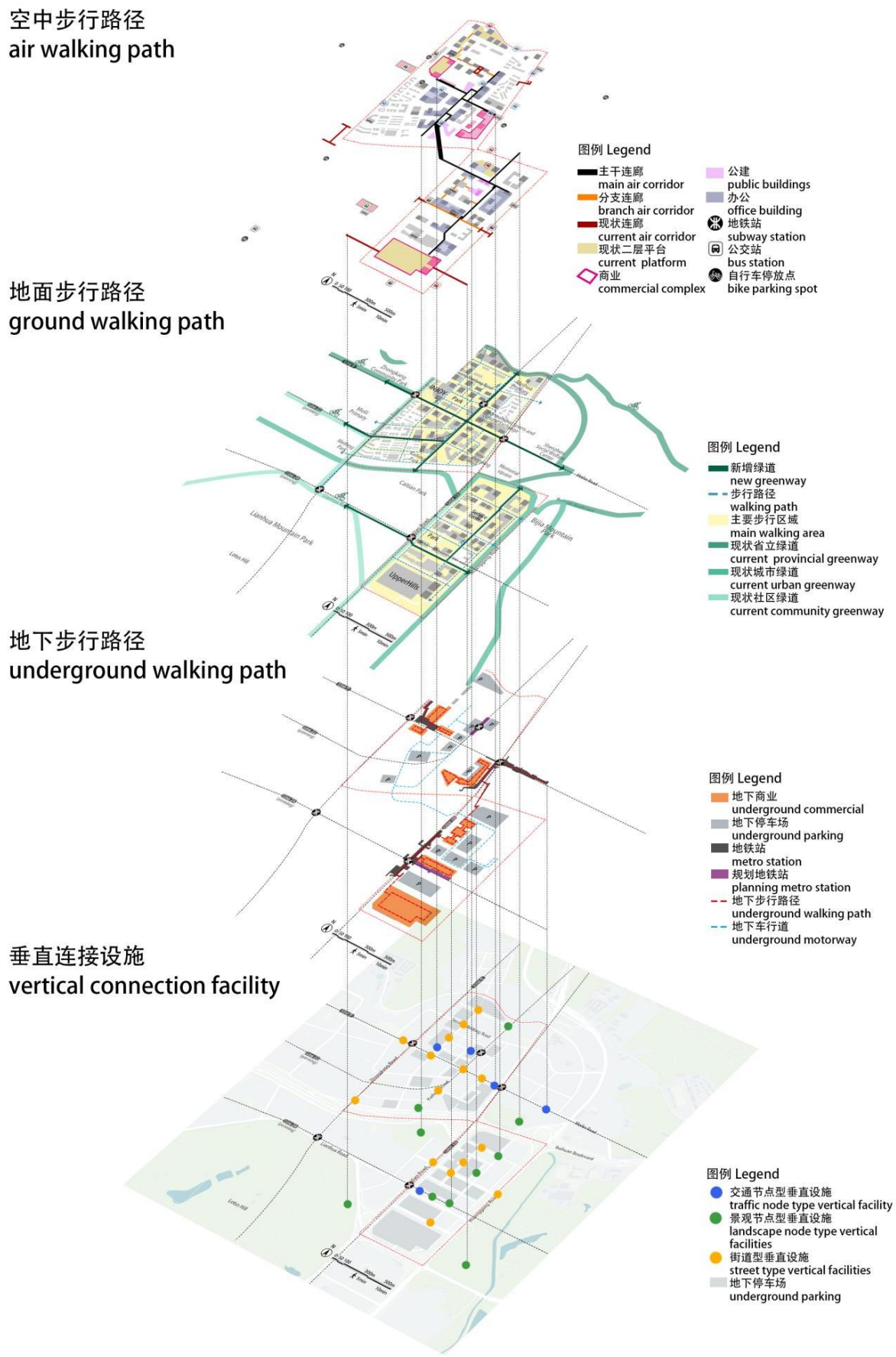


Figure 6-11 Distribution of vertical connections (Source: the author)

6.3.1 Vertical Connection at Transport Node

Vertical connections to the multi-level pedestrian system are provided at the traffic nodes near the and subway stations to ease the mass commuter flow and improve the connection to the ground and surrounding buildings.

In the case of Kaifeng Station, for example, the planned subway station concourse is not well connected to the ground-level, and sight lines, light and natural wind cannot pass through. Moreover, the underground space is cut off and lacked organic connections with the surrounding buildings. Therefore, the vertical connection mode of traffic nodes is reconstructed by means of three-dimensional repair and combining with the new sports communication center in the future. In the underground space of the original office building and the new sports center, a partial slope release and the addition of a lift are used to achieve mutual accessibility and all-age friendliness. The sunken plaza in front of the sports center allows light and natural wind to enter the underground space, naturally connecting the underground space, the ground-level and the sky corridor to achieve green penetration.

At the same time, a new part of the ground floor commercial area is added at the sunken plaza to facilitate public access. In the vertical connection of the sky corridor, the existing building is partially renovated to provide a shared platform for the public to stay and rest at the connection with the corridor. The transition from public space to private space is achieved (Figure 6-12).

On the whole, through the multi-layer space, the pedestrian space is effectively enriched and the lack of pedestrian space in the area is alleviated. Besides, the multi-level pedestrian space is longitudinally stitched in a barrier-free way to achieve all-age friendliness and green infiltration.

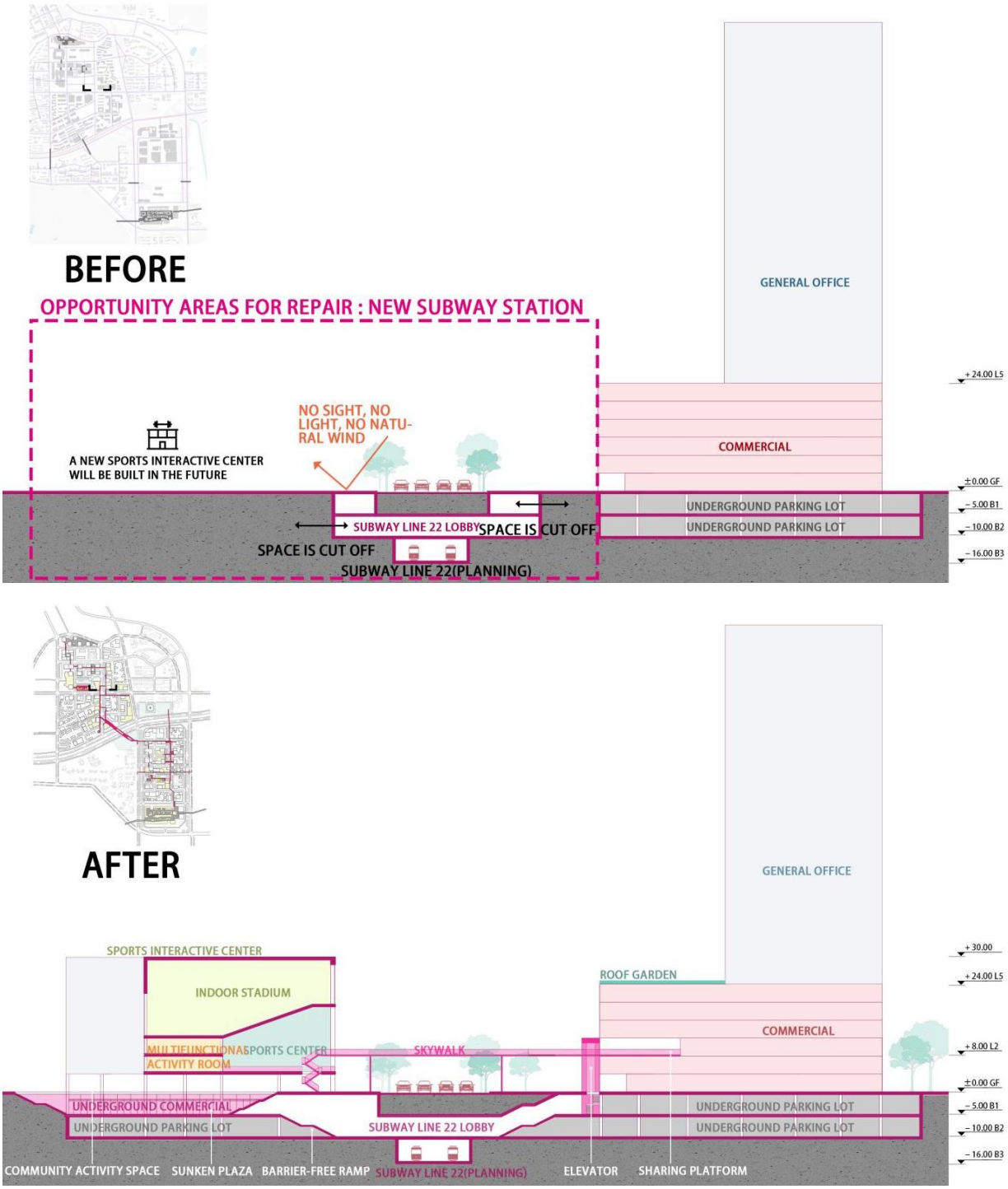


Figure 6-12 Section of a vertical connection at the traffic node (Source: the author)

6.3.2 Vertical Connection at Landscape Node

Vertical connection facilities are arranged in conjunction with urban landscape green spaces, so that pedestrian paths are closely linked to the urban landscape.

Taking the park near Dongguailing Station as an example, the current community park space lacks richness and interest, and is poorly used. Moreover, the connection between the

subway station concourse and the cityscape is not strong and the space is rigidly separated. Therefore, the vertical connection mode at the landscape node is reconstructed, the community park is partially transformed, the natural light is introduced into the underground space, and the huge height difference between the ground and the subway station hall is eliminated on the streamline organization. The connection between the subway station and the ground-level is strengthened through a sunken plaza and a multifunctional grass slope, where pedestrians on the ground- level interact with the people in the underground passageway. The connection between the air corridor and the park is linked to the ground-level by a stair terrace with ornamental features. Small functional boxes, such as community businesses, gyms and bookshops, are arranged under the skywalk to create a continuous vibrant interface at ground-level (Figure 6-13).

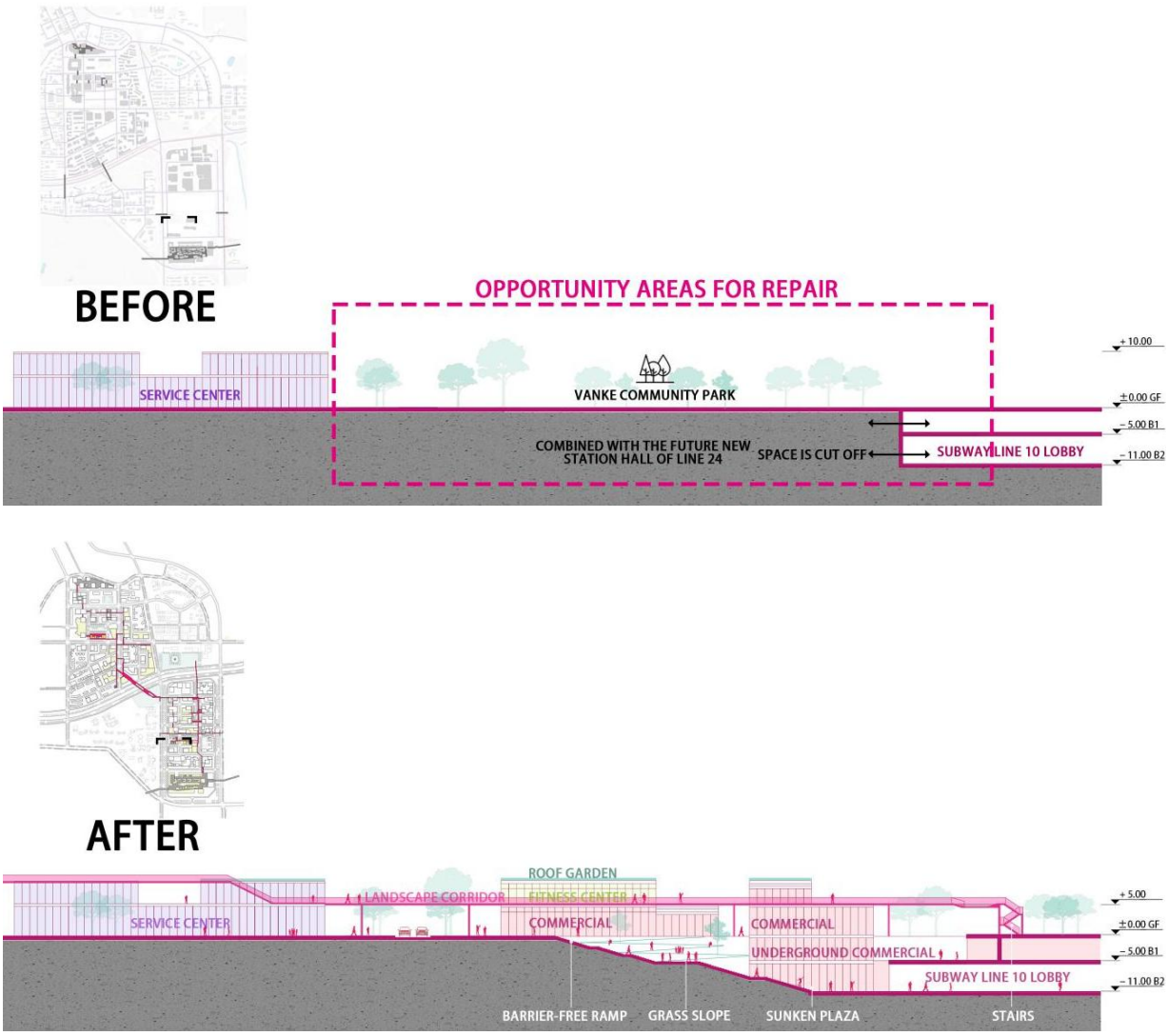


Figure 6-13 Section of a vertical connection at the landscape node (Source: the author)

6.3.3 Vertical Connection at Street Node

The vertical connection facilities of street nodes are set up at important intersections, and the traffic cores with functions such as bookstores, coffee, rest stations and other functions are added, and the multi-level pedestrian system is longitudinally stitched.

At the intersection of Lianke II Road, for example, the existing road is flanked by completed office buildings and old factories to be renewed, and the width of the pedestrian path is narrow. The intersection is transformed with new vertically connected nodes that are closely linked to the multi-level pedestrian path and building spaces. And, by limiting the building setbacks of the new buildings, more at-grade pedestrian space is provided (Figure 6-14).

Specifically, the podium of the current office building is functionally replaced, and the closed office function of the first floor is transformed into a commercial and shared office, which is organically integrated with the pedestrian path. It is encouraged to release some of its interior space to create an open sky deck, interconnected with the aerial walking path, to provide a place for citizens to interact and move around. For new commercial office buildings in the future, consider the connection to the sky walkway in the building design, using external staircases and traffic cores to interconnect with the ground and underground. The first floor of the building is elevated to provide more space for ground-level activities, as a platform for public communication and corporate displays. The negative floor of the building can be partly used as an underground commercial space, with vertically connected light wells to bring light to the underground space while interconnecting with the ground-level.

Figure 6-14 Section of a vertical connection at the street node (Source: the author)

6.4 Connotation Expansion: Creating a Container for Public Life

6.4.1 Climate-adapted Forms of Pedestrian Paths

Shenzhen's climate is characterised by a hot and humid climate, with high temperature, rainy and humid summers and prevailing south-westerly and south-easterly winds. The average annual temperature is 22.4° C , and the high temperature period of the whole year is up to 7 months.

A comfortable pedestrian system can facilitate the movement of pedestrians, and provide shade for pedestrians in adverse weather conditions. These advantages make the urban environment more pedestrian-friendly. Therefore, from the perspective of climate adaptation, the design of the sky corridor should meet the basic goals of shading and heat insulation and rain and moisture prevention to adapt to the hot and humid and rainy climate. Where conditions permit, the introduction of air conditioning systems to alleviate the thermal pressure of pedestrians and improve the comfort of the walking environment.

The width and height of the pedestrian space affect the shading capacity and are the key factors affecting thermal comfort. According to available studies, the size of the top shading facility can be determined by the heighth of the facility from the ground. As shown in Figure 6-15, the relationship between the size of the top shading facility and the sustainable shading range at 24°N is reflected, where "a" and "b" are the distances from the boundary of the shaded area to the edge of the shading facility, which can be used as a reference for the design of the top shading in the Meicai Area.

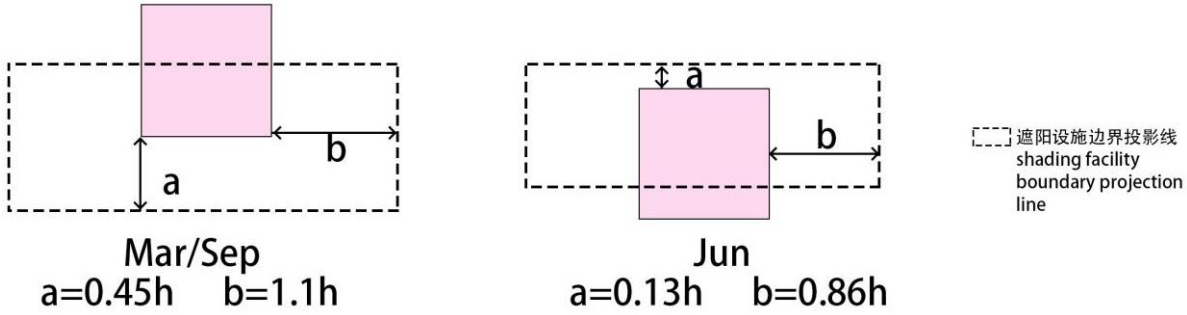


Figure 6-15 Relationship between top shading facilities and shaded areas at 24°N

(Source: redrawn from reference [77])

According to the previous section, the width of the main corridor in the Meicai Area is not less than 6meters, and the width of the branch corridors is 4-5meters. The net height under

the bridge of the link corridor is 4.5meters according to the *Shenzhen Design Guidelines for Pedestrian Bridges and Link Corridors 2017*, which stipulates that the minimum net height under the flyover across secondary urban roads and branch roads is 4.5meters[78]. This study discusses how much width is required to provide continuous shading for a 2.5meters wide walkway underneath a typical 4.5meters high link (no shading on either side of the walkway, only top shading), based on Figure 6-15, using the Zhujiang Delta month of June as an example.

As shown in Figure 6-16, in June, for the east-west corridor (exposed to the south sun), to provide continuous shade to the 2.5meters wide walkway below the 4.5meters high corridor, the corridor width would need to be increased by 0.59meters to the south over the width of the walkway, for a total width of approximately 3.09meters. For a north-south facing corridor (exposed to the west and east sun), to provide continuous shade to the 2.5meters wide walkway below the 4.5meters high corridor, the width of the corridor would need to be increased by 3.87meters in each direction from east to west, for a total width of approximately 10.24meters.

It can be seen that the east-west corridor can easily provide shade to the pedestrian space underneath the corridor, while the north-south corridor is subject to both easterly and westerly sunlight, and the top of the corridor can provide limited continuous shading. Therefore, the north-south corridor should be shaded at the side by vertical shading elements or greenery.

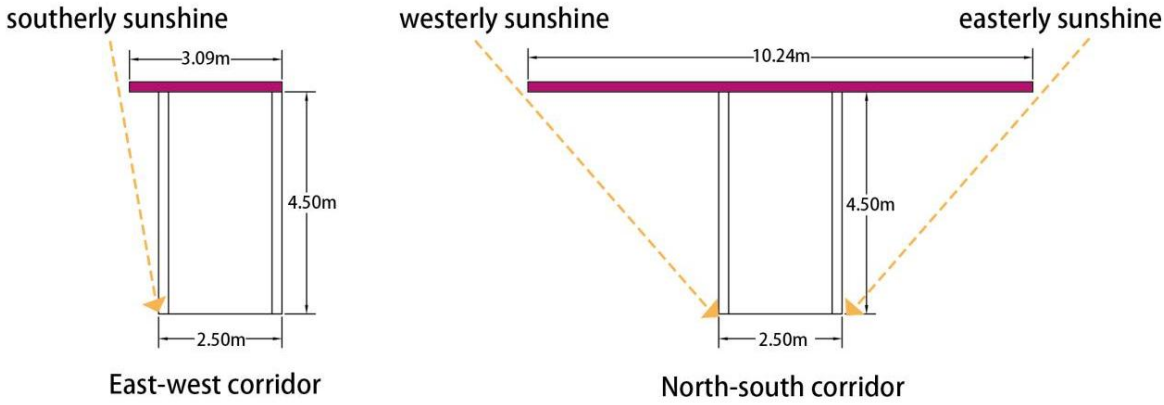


Figure 6-16 Section of the June walking path at 24°N with continuous shading (Source: the author)

The main corridor in the Meicai Area is north-south oriented, and the morphological design of the corridor should take into account not only the shading at the top but also the

shading at the sides. In the case of the main corridor in the Caitian area, for example, the enclosed top interface is used to provide shade when it rains, and the semi-enclosed side interface not only meets the requirements of shading and ventilation, but also provides a good view of the sky (Figure 6-17). At the side interface, vertical metal mesh panels or a combination of outer metal mesh panels and inner sun panels are used, with 2-4 sun panels in groups, leaving gaps between each group, thus forming a permeable side interface of the corridor. This makes it possible to walk here without fear of the elements and in cool comfort.

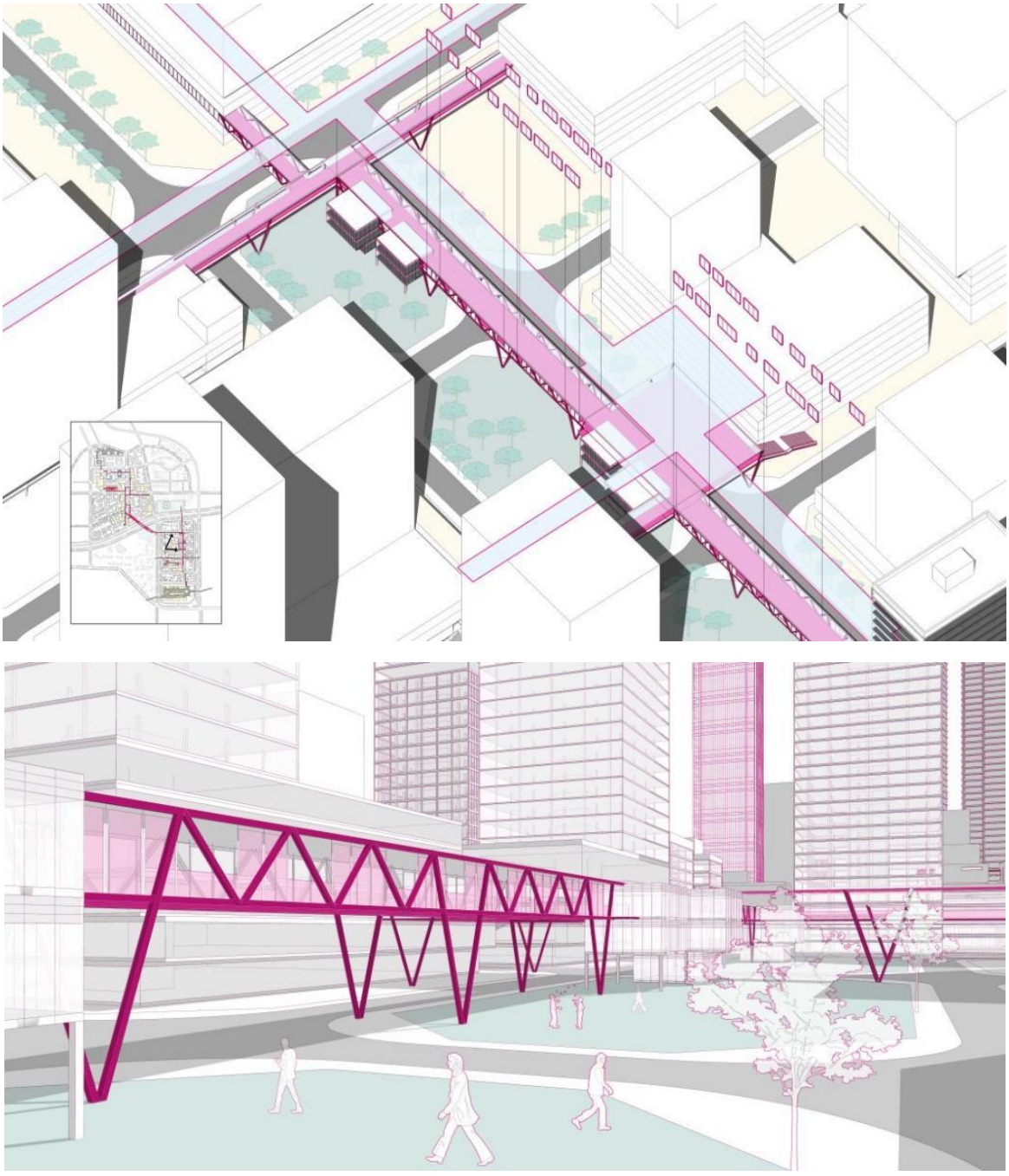


Figure 6-17 The form of north-south pedestrian space adapted to climate (Source: the author)

6.4.2 Node Space for Diverse Demands

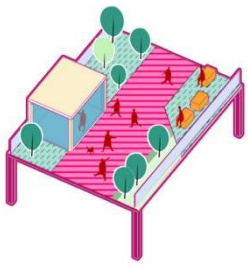
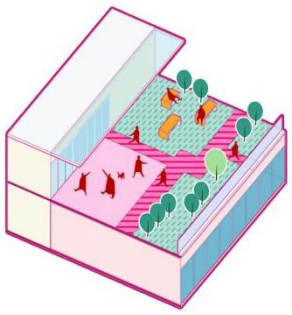
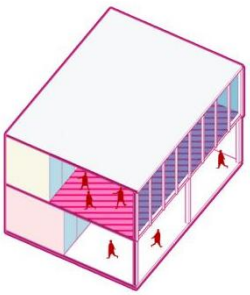
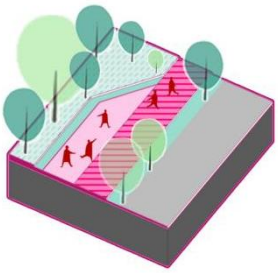
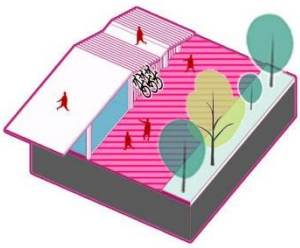
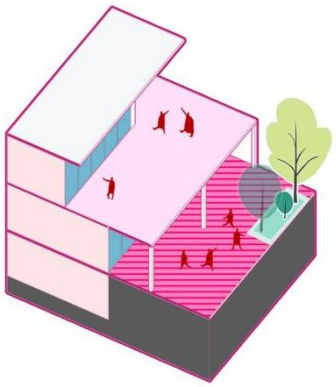
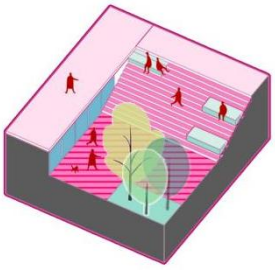
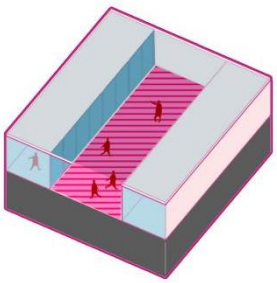
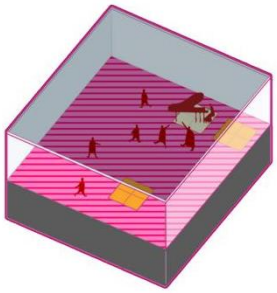
Through preliminary analysis, it was found that the users of the pedestrian space in the Meicai Area can be divided into urban youth groups, neighbourhood residents and tourist visitors. Specifically, the youth group needs to adapt to the fast-paced life of Shenzhen and needs convenient public transport, social space and rest space. The neighbourhood residents cover a wide range of ages, including the elderly, middle-aged, young people and children. Combined with the preliminary character interviews, they need outdoor activity space, children's playground, etc. Visitors' demand for pedestrian space needs to meet their needs for consumption and city sightseeing. So they need parking, dining, outdoor activities, exhibition spaces, etc. (Figure 6-18).

Figure 6-18 Analysis of population demand difference (Source: the author)

According to the differentiated needs of different people, three different spatial characteristics of external space, integrated architectural space and internal space are combined in the three-dimensional pedestrian system, and various nodal spaces are implanted. The spatial connotation of the pedestrian system is expanded to make it functionally composite rather than a single traffic function (Table 6-3). On the air corridor, combine landscape design and the implantation of small functional facilities to form a composite urban connecting space. For example, where structural loads allow, green paving and weakly rooted landscape trees are added to the corridor to form an ecological corridor in combination with urban greenery. On the ground-level walking paths, the areas along the street setbacks of the buildings are fully utilised as public open spaces. In addition, the space under the bridge of the sky corridor is used as a leisure station and bicycle parking point to alleviate the conflict

between bicycle parking and walking. The underground pedestrian route is strengthened with a connection to the subway station. A sunken plaza, an underground shopping street and an underground exhibition hall have been incorporated to provide a convenient commute while enriching the levels and interest of the underground pedestrian path.

Table 6-3 Types of pedestrian node space (Source: the author)

	external space	integrated with buildings	internal space
elevated walkway	 outdoor corridor	 roof garden	 interior walkway
ground walkway	 boulevard walk	 embeded boxes	 commercial arcade
under-ground walkway	 sunken plaza	 underground shopping street	 underground exhibition hall

6.4.3 Scene Creation for Various Activities

In three-dimensional pedestrian system, the scene design is refined to provide a comfortable and hierarchical pedestrian space to stimulate the occurrence of urban pedestrian life. The three-dimensional pedestrian system becomes an urban container that embraces all aspects of public life.

In the industrial park in the Caitian area, the aerial corridor connects the ground-level public space with the rooftop garden in the sky to meet the diverse needs of the public for rest and interaction. The design of intelligent variable paving is introduced on the corridor, putting in functions such as physical interactive games, festival atmosphere creation and path guidance to enhance the interest of the walking path (Figure 6-19).

In the sunken plaza leading to the subway station, partial subsidence is used to alleviate the height difference between the subway station and the ground, stitching together the pedestrian space between the ground and underground. Barrier-free ramps and vertical lifts are provided to evacuate the flow of passengers entering and leaving the station. Commercial shops and public resting facilities are incorporated into the plaza, and resting platforms are designed in conjunction with the sloping surface to make the sunken plaza a vibrant place (Figure 6-20).

In the urban park, combine ground-level greenery and landscape vignettes to create a vibrant atmosphere for interaction. Make the most of the urban landscape to create more attractive public spaces that host a diverse public life (Figure 6-21). Removable multi-functional boxes are placed along the pedestrian paths to meet the diverse needs of people for consumption, interaction and rest, while accommodating the changing nature of future businesses (Figure 6-22).

Overall, a sense of spatial belonging is created through an approachable scale, establishing a positive interaction between people and space and stimulating the potential public attributes of the space. The pedestrian space is given the character of a place, thus evolving into a high-quality public space, which in turn nourishes a high concentration of living scenes and gives a new connotation to the three-dimensional pedestrian system.

Figure 6-19 Multi-level pedestrian space scene

(Source: the author)

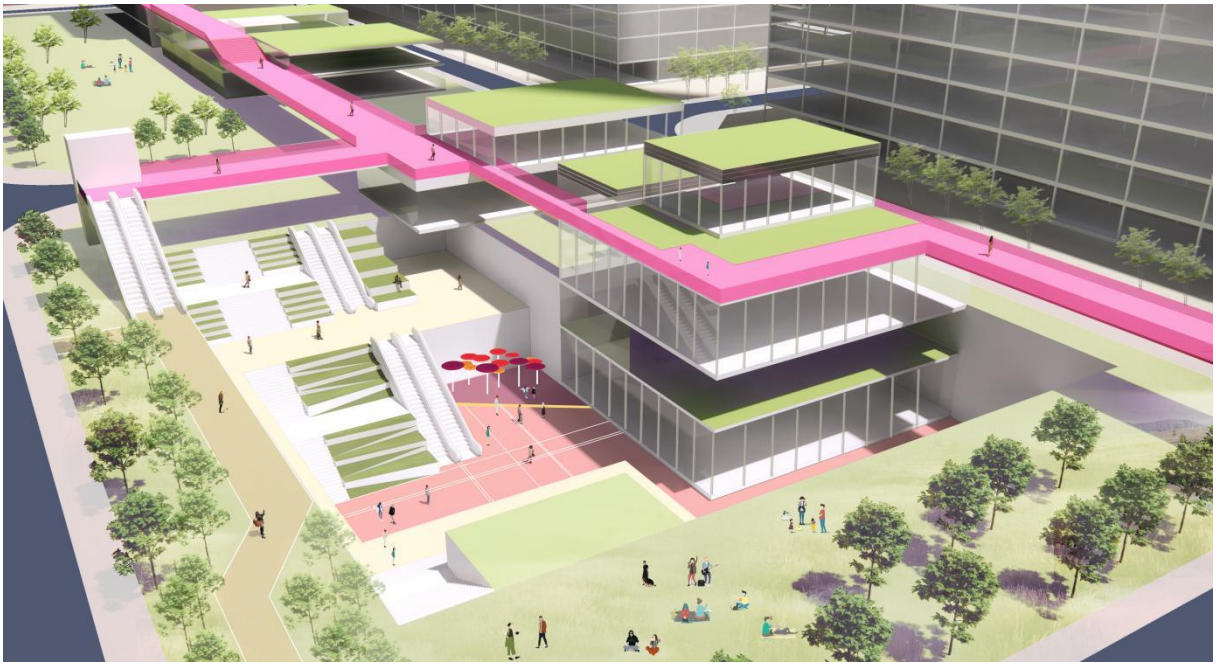


Figure 6-20 Sunken plaza scene

(Source: the author)

Figure 6-21 Interactive park scene

(Source: the author)

Figure 6-22 Corridor market scene

(Source: the author)

6.5 Implementation Strategy : Public-private Collaboration

The three-dimensional repair of the pedestrian system faces the challenge of coordination between public interest and private property rights. The construction of the pedestrian path will involve coordination with the surrounding owners and the management and operation of subsequent facilities. The enthusiasm of private owners in the implementation process is not high, and the actual space quality is difficult to guarantee. Therefore, in response to these problems, the implementation strategy of public-private collaboration is introduced to establish a flexible and friendly collaborative relationship. Through the floor area ratio incentive system to mobilize the enthusiasm of the owners, with the help of the chief designer system to ensure the implementation and dynamic optimization of the planning, to promote the quality of the pedestrian system to create.

6.5.1 Implementation Entities of Aerial Pedestrian Paths

On the whole, the air pedestrian paths are designed by the government-led integration, and the market participates in the construction. The government led the construction of the main corridor, the reserved interface between the main corridor and the parcel boundary, and the corridor across the municipal road between the parcels. Developers are responsible for the construction and operation of corridors within the parcel (Figure 6-23).

According to different land types and characteristics, the implementation entities of air

pedestrian paths are determined (Table 6-4). For example, for the land that has been approved for renewal units and the land that will be renewed in the future, the construction requirements will be implemented into the land transfer points, land transfer contracts, and corridor construction agreements. The corridors within the parcel are built and operated by the developer, and the corridors across the municipal roads between the parcels are built by the government. For the completed plots, the land developers are encouraged to connect with the air corridor through the construction area incentive policy. For green space and municipal roads, the government is responsible for the integrated design, construction and operation.

Figure 6-23 Classification of implementing entities in the air pedestrian paths (Source: the author)

Table 6-4 Classification of air corridor implementation entities (Source: Compiled from reference [2])

Plot Type	Building body	Implementation method
Granted renewal units but not offered for sale	Developers construction and operation, government integration design	The construction requirements of the air pedestrian path are implemented in the key points of land transfer, land transfer contract and corridor construction agreement with the statutory plan. The corridors within the parcel are built by the developers, and the roads between the parcels are built by the government.
Waiting for renewal	Developers construction and operation, government integration design	The government participates in the whole process control, and implements the construction requirements of the air pedestrian path into the regulatory guidelines, the transfer points, the land transfer contract, and the air pedestrian path construction agreement. The corridors within the parcel are built by the developers, and the roads between the parcels are built by the government.
Transferred and completed	Developers construction and operation	Through incentive policies such as floor area ratio incentives, developers are encouraged to build air pedestrian paths. Land developers submit written commitments, apply for connecting corridors and ensure that corridors are open 24 hours a day.
Green spaces and municipal roads	Government	Integrated design, construction and operation.

6.5.2 Design Guidelines for Pedestrian Space

For the construction of the pedestrian space by the developer, reference is made to the creation of Privately Owned Public Space in Hong Kong, which is controlled and guided by urban design guidelines, giving the possibility and tolerance for continuous changes in public life and guiding the localization and everydayisation of Privately Owned Public Space. In the creation of Privately Owned Public Space, public interest is often subordinated to commercial interest and subtly obscured by the design and management of the space. Urban design can play a key role in promoting social integration and inclusive development [66].

Therefore, combined with the overall design of the three-dimensional pedestrian system in the area, detailed guidance and control guidelines are implemented in the renewal unit planning. For future renewal land, the urban design guidelines are used in advance, that is, the owners should accept the provisions of the urban design guidelines on the publicity of urban space while completing the land transaction. In the urban design guidelines, the control elements of the three-dimensional pedestrian system are divided into rigid elements and

elastic elements. Among them, the rigid elements include the direction and width of the air pedestrian path, the scale of public space, and the building retreat. The elastic elements include the location of the ground pedestrian path, the location of the public space, the specific location of the air pedestrian path, the vertical entrance and exit of the pedestrian, the horizontal entrance and exit of the pedestrian, etc.

Taking a regeneration unit in the Caitian area as an example, the design guidelines focus on expressing the orientation of the air pedestrian path, the location of horizontal and vertical entrances and exits for pedestrians, and distinguishing between corridors within the plot and those across the street (Figure 6-24). Depending on the location of the pedestrian space, vertical entrances and exits are included at the intersections of the roads, with a distance between them of 90-200meters. It is proposed to enrich the function of the pedestrian paths by including functions such as sitting, viewing and public displays in the corridors and public spaces. Furthermore, design guidelines are proposed for the function, width, clear height, facilities and form of the corridor. The width of the air pedestrian path needs to be greater than 4meters, the corridor that takes into account the auxiliary function can be partially widened to 6meters or more than 6meters, and the net height in the pedestrian path needs to be greater than 2.5meters, which is determined according to the special research. At the junction of the air pedestrian path and the building, the design of the building needs to reserve the interface. In terms of facilities, sunshade and rainproof facilities should be set up. Moreover, the north-south corridor should provide lateral sunshade facilities or other auxiliary sunshade and cooling facilities.

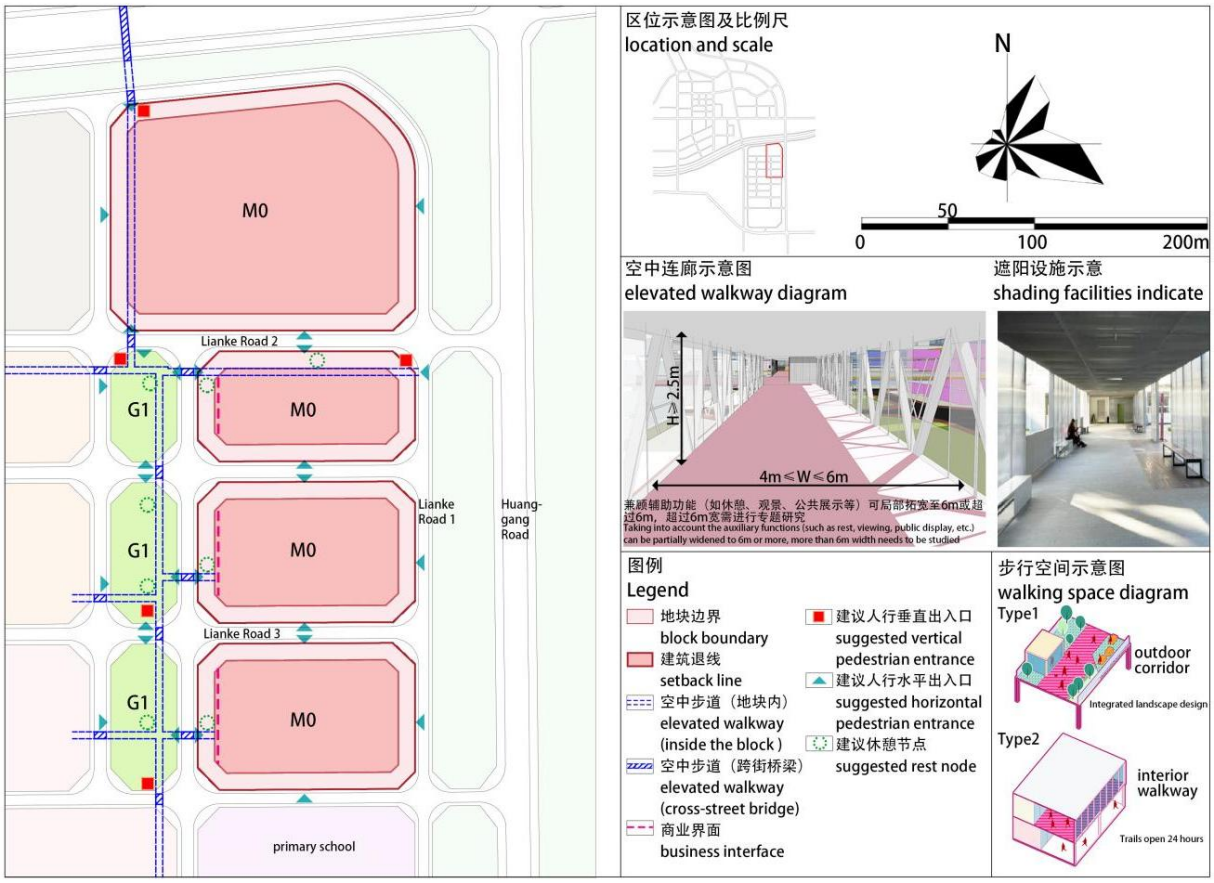


Figure 6-24 Design guidelines for pedestrian space (Source: the author)

6.5.3 FAR Bonus System Ensures the Public Interest

The Floor Area Ratio(FAR) Bonus was used to incentivize developers to build multi-level pedestrian system to ensure that public benefits are realized. There have been several successful examples of this in actual construction projects (Table 6-5). Internationally, the US and Japan incentivize developers to build above and below ground pedestrian networks through FAR Bonus. In China, the Hong Kong government provides incentives for developers to connect buildings to the sky walk system by exempting the area associated with the public walkway or more floor area bonus for using land or areas within buildings as public walkways. In Shenzhen's proposed floor area ratio incentive criteria in 2019, Article 6(3) provides for FAR Bonus for building three-dimensional pedestrian system that meet the criteria, capped at 30% of the base FAR.

Table 6-5 Examples of promoting construction of three-dimensional pedestrian system through FAR Bonus

(Source: Compiled from references[79-82])

Location	Project	Specific details
America	New York Central Station area	By introducing **Air Rights Developmen**t to promote the construction of urban surface and underground transportation systems, the 1982 *Floor Area Bonus for Subway Station Improvements* provided that parcels of land could **receive a floor area bonus of more than 20% of the maximum** FAR for the construction of transportation facilities associated with underground platforms, concourses, plazas or connections[79].
Japan	Tokyo Otemachi Development	For the Otemachi Building, three initiatives were proposed to contribute to the area, one of which was to improve the ground and underground pedestrian network, in particular by **providing direct access to the surrounding rail stations** from the shared concourse on the ground and basement levels of the building. The project was evaluated in 2007 and received the highest developed FAR in Tokyo at the time, 16 [80].
Hong Kong	Hong Kong Skywalk System	PNAP No. APP-108 states that the use of land or areas within a building for public access and the concessions that may be granted by the Building Authority (BA) upon acceptance of the **dedication exempt the area associated with the public access or a greater floor area bonus** [81]. The Sustainable Building Design Guidelines stipulate that the maximum exempted area for commercial and residential types is 10% of the gross floor area.
Shenzhen	Shenzhen multi-level pedestrian system	In the *2019 Regulations for Reviewing the Planned Floor Area Ratio of Urban Renewal Units of the Shenzhen Municipal Demolition and Redevelopment Category*, for the purpose of connecting urban bus stations, rail stations or important urban public spaces, surface passageways, underground passageways and overhead corridors that are approved to be open to all citizens unconditionally for 24 hours and for which t**he responsibility and costs of construction are borne by the implementing entity**, the corresponding projected area is included in the bonus volume, **with the bonus ceiling being 30% of the base floor area ratio** [82].

Therefore, a reasonable FAR Bonus policy can be developed in the development and construction of land parcels by allowing developers to receive a percentage of the FAR Bonus by contributing a certain percentage of underground pedestrian space, ground pedestrian space, air pedestrian space or public facilities. Specifically, bonus can be set for ground-level walkways, underground walkways, skywalks (24-hour unconditional access to all citizens) that articulate with subway stations, bus stops or urban public spaces, and incentives for covered walkways that provide greenery to ensure the public interest (Figure 6-25).

Moreover, it is necessary to reasonably set the maximum limit of the FAR Bonus, control

the area of development, and avoid the loss of control in the later management. For example, in 1990, the development of underground space in the central business district of Montreal, Canada, began to introduce the control of the floor area index (l 'indice de superficie de plancher) for assessing land prices. Before that, the pedestrian network of underground commercial corridors, plazas and passageways in the central area developed dramatically and now reaches a length of about 30 km [83]. Hong Kong has also progressively bound the ceiling of FAR Bonus in recent years, with the area incentive system involving aerial pedestrian system moving from crude to refined management[84]. Therefore while formulating FAR Bonus policies to motivate developers, it is also important to reasonably stipulate the maximum limits and conditions of the incentives so that the public interest can be maximized.

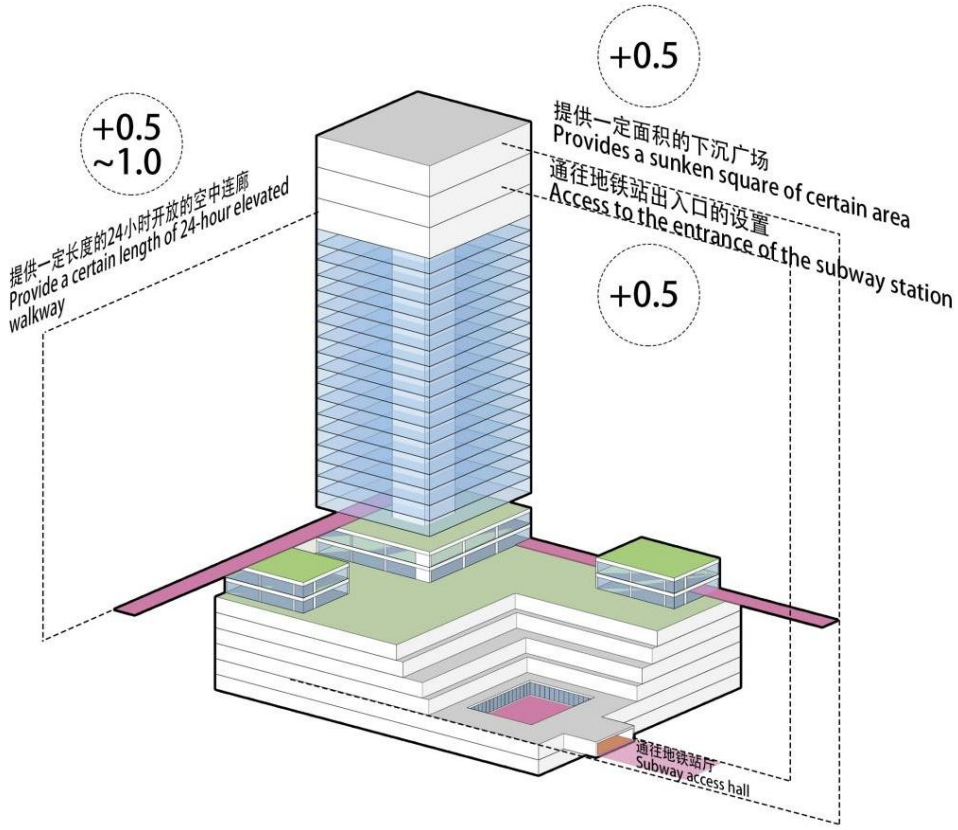


Figure 6-25 FAR Bonus policy for pedestrian system implementation

Source: redrawn from the *Shenzhen Bay Super Headquarters Detailed Underground Space Plan*

6.5.4 Chief Designer System Guarantees Dynamic Optimization

The construction of the three-dimensional pedestrian system is not achieved overnight, but needs to be continuously optimized and improved. The land ownership of Meicai District

is complex[85]. With the help of the urban chief designer system, it can provide optimization consultation for the design scheme, collect construction feedback, and continuously optimize the existing urban design implementation strategy. For example, in the urban design of the Pazhou Area in Guangzhou, the chief designer system was used to bring the urban design closer to the optimum. Services and guidance are provided throughout the process, with consultation and negotiation with the owner based on the urban design guidelines, combined with engineering and technology optimization and implementation to safeguard public interest and environmental benefits, and the Pazhou Area is now taking shape[86]. The repair of the pedestrian system in the Meicai Area can be optimized with the help of the chief designer system, so that the planning and design can be optimized and approached on the basis of maintaining the optimal principle of public value.

Therefore, the repair of pedestrian system can use the chief designer system to optimize the planning and design on the basis of maintaining the optimal principle of public value.

6.6 Measurement of the Impact of the Repaired Pedestrian System

In order to measure the impact of the three-dimensional pedestrian system of the area, ArcGIS was used as a tool for spatial analysis, based on OSM data (open street map), the existing traffic system model and the traffic model after the three-dimensional repair were structured respectively, and through ArcGIS network analysis the following were measured.

(1) Changes in 5 and 10-minute walking accessibility around subway stations in the area;

(2) Changes in the shortest paths between the subway stations and the major nodes (office and residential) in the area.

Due to the complexity of the pedestrian system, this study idealizes the current pedestrian path, that is, the specific pedestrian environment and elevation value of the road are not taken into account. With this in mind, the repaired pedestrian system planning still expands the walking accessibility range of subway stations to a certain extent, optimizes the shortest path from subway stations to main office nodes and the shortest path from subway stations to the entrances and exits of residential areas within 1 km around the site.

6.6.1 Walking Accessibility Around Subway Stations

In terms of pedestrian accessibility around the subway stations, the three-dimensional

repaired pedestrian system has greatly increased the pedestrian accessibility, and to a certain extent, improved the pedestrian accessibility around the stations(Figure 6-26). In particular, the 5 or 10-minute walking distance to Dongguailing Station in the Caitian Area has been greatly improved. In addition, the new aerial pedestrian space basically covers the 5 or 10 minute walking distance around the stations, providing a new way of walking for residents in the area.

Figure 6-26 Comparison of 5 and 10-minute walking accessibility around stations before and after repair

(Source: the author)

6.6.2 The Shortest Path Between Subway Stations and Major Nodes

In terms of the shortest paths from the stations to the major office nodes, this design changes the situation of relying too much on the high-grade roads such as the Beihuan Avenue and Caitian Road, and provides a new path for the access of the north and south plots in the area (the pedestrian path of the combination of parks and air corridors). For example, in the future, the industrial park in the Caitian Area can be quickly reached from Kafeng Station or Maling Station to work via the aerial corridor system or the underground walkway, reducing walking time and eliminating the need to cross the main city road twice via culverts. Through the three-dimensional pedestrian system, people can walk from the subway station directly to

the commercial center and the city park, providing an efficient, safe and comfortable walking experience(Figure 6-27).

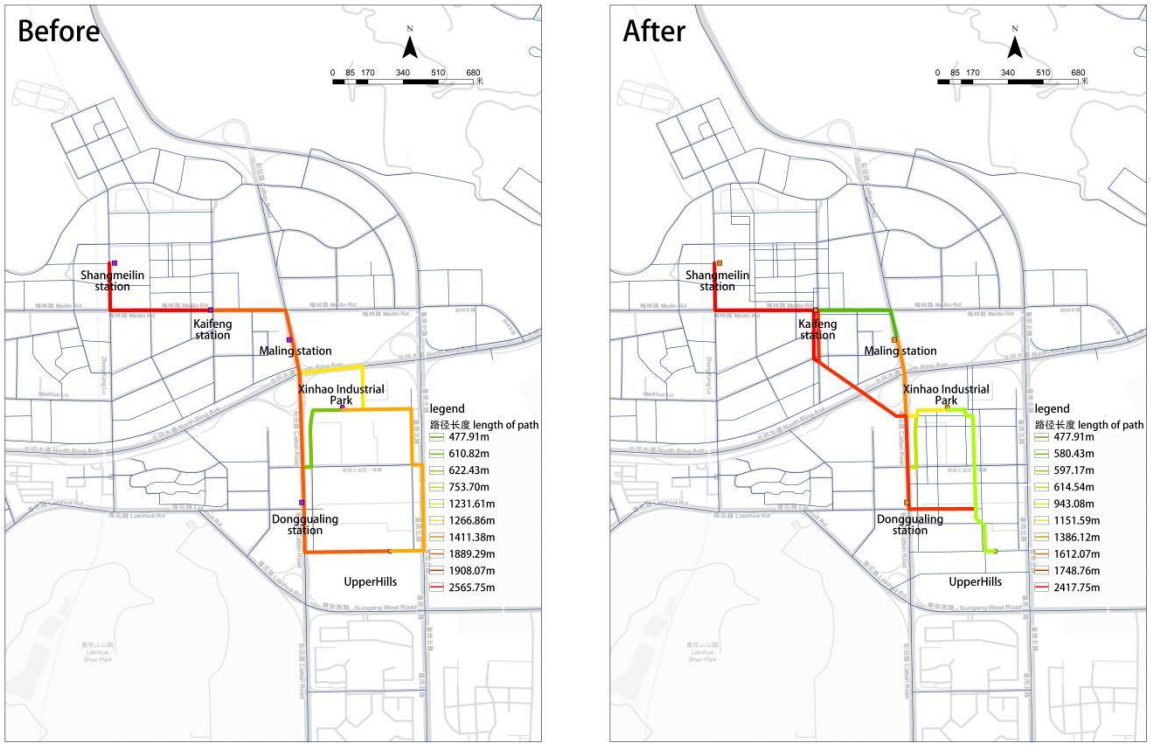


Figure 6-27 Comparison of distribution of shortest paths from stations to office before and after repair

(Source: the author)

In terms of the shortest paths from the station to the entrance/exit of the residential area (within 1km of the station), the majority of the pedestrian paths were reduced in length to varying degrees (Figures 6-28, 6-29). Specifically, 41% of the path lengths have been optimized to some extent, and approximately 28% of the paths have been optimized to a greater extent (distance reduced by more than 100m). Most of the repaired shortest paths between the station and the entrance/exit of the neighbourhood are located in urban side streets and air corridors, improving the walking experience to a certain extent, as the original

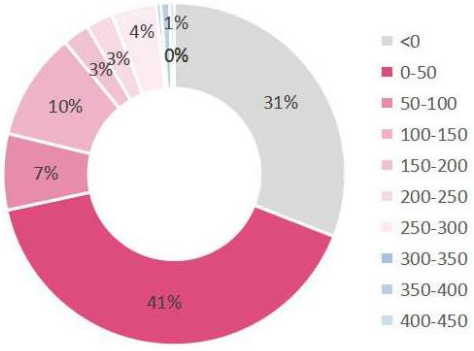


Figure 6-28 Variation in pedestrian path length

(Source: the author)

high dependence on the main urban roads has been improved. Moreover, the three-dimensional repair of some of the pedestrian paths permeates the industrial space, improving the isolation of the existing industrial space from the community space and promoting a mix of social functions. Compared with the pedestrian system optimization method of road right redistribution, the three-dimensional repair approach can organize walking traffic and promote functional compound more efficiently. Therefore, the use of three-dimensional repair can improve the "last mile" of walking paths in the area, both from a distance and a walking experience perspective.

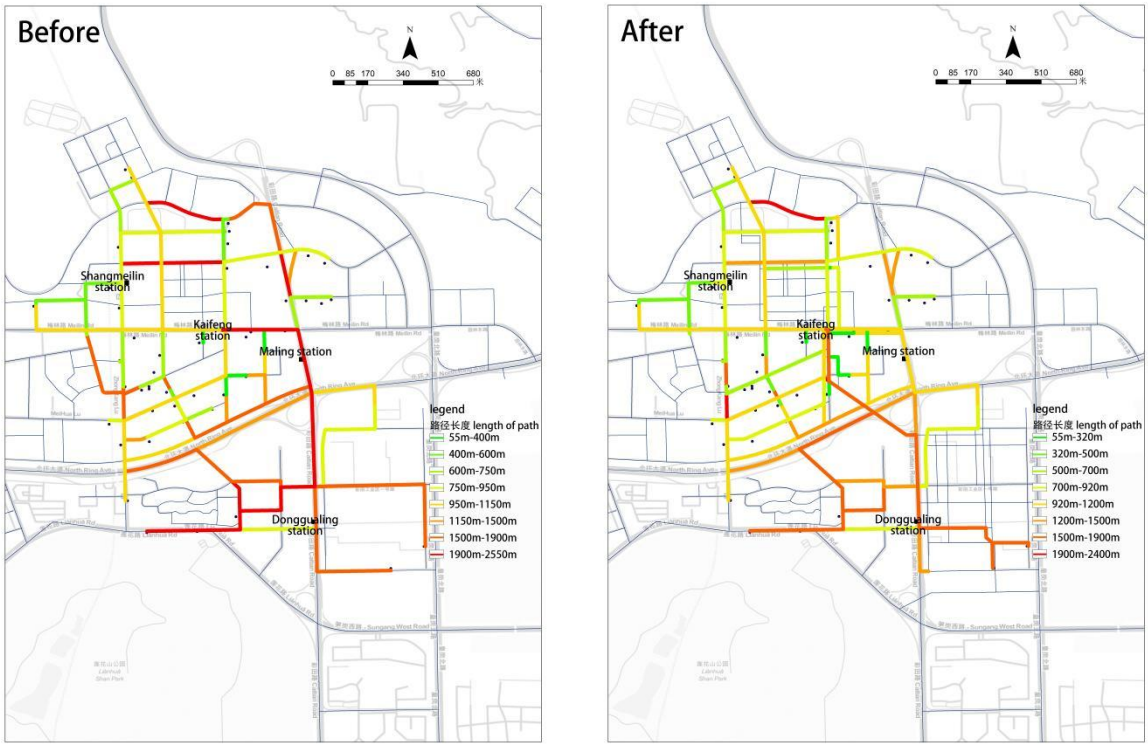


Figure 6-29 Comparison of distribution of shortest paths from stations to residential before and after repair

(Source: the author)

In summary, the three-dimensional repaired pedestrian space on the urban ground floor improves the accessibility of walking around the subway stations, optimizes the shortest paths between the stations and the offices and residences, provides a combination of parks and aerial corridors, and shortens the length of some of the walking paths. Moreover, the shortest paths from the stations to the entrance and exit of the residential area penetrates the industrial space, to a certain extent facilitating the mobility of elements between the two and the mixing of urban functions.

6.7 Chapter Summary

Based on the results of the previous analysis, this chapter proposes a three-dimensional repair scheme for the pedestrian system on the ground floor of the city in Meicai Area.

Firstly, based on the core problems of the current situation and the necessity of three-dimensional repair, the objectives and principles of three-dimensional repair are determined.

Secondly, three spatial schemes of three-dimensional repair are proposed: 1) spatial connectivity to establishing a convenient and accessible pedestrian network; 2) Vertical connection to vertically connect multi-level pedestrian network; 3) Connotation expansion to create a container of public life. And put forward the implementation strategy of public-private collaboration, clear the implementation entities of the pedestrian system, pedestrian space design guidelines and FAR Bonus and the chief designer system to ensure the realization of the public interest.

Finally, ArcGIS network analysis is used to measure the pedestrian system after three-dimensional repair. It is found that the accessibility of walking around subway stations is improved, and the shortest path between subway stations and offices and residential points is optimized. Moreover, the repaired shortest path from the subway station to the entrance and exit of the residential district penetrates the industrial space, which promotes the flow of factors and the mixing of urban functions between the two to a certain extent.

Through the repair programme of the pedestrian space on the ground floor of the city, it explores how to stitch the pedestrian space at different levels in a three-dimensional way, and promote the urban functions related to public life to unfold at different elevation levels.

Conclusion and Prospects

1. Research Conclusion

In the background of the city's three-dimensional ground floor development and the fragmentation of urban pedestrian space in the highly developed urban zones, the concept of the ground floor of the city as a project space is introduced to investigate an approach for repairing the pedestrian system in three-dimensional form. The following are the primary conclusions:

(1) This study examined the transformation, spatial characteristics, and main functions of pedestrian systems in the background of the city's three-dimensional ground floor development.

Unlike the ground-level pedestrian spaces, which rely on urban land, three-dimensional pedestrian space relies on the urban bases of different elevations, and its traffic connectivity is manifested as the continuity of horizontal traffic and the conversion of vertical traffic. It creates multi-level access points, promotes the mixing of urban functions and social integration, and provides multi-level parking spaces. In terms of spatial characteristics, it has multiple types of pedestrian spaces and multi-level pedestrian paths.

(2) Based on the theory and corresponding case study, this study proposed principles and an approach for repairing the pedestrian system on the ground floor of the city.

The ground floor of the Meicai Area in Shenzhen, which has the chance for space repair, is chosen as the project space, with the pedestrian system serving as the design boundary. First of all, the pedestrian system problem and the need for three-dimensional repair are investigated by using an approach that combines pedestrian space analysis with a public life survey. Secondly, the goals, principles, and strategies for the three-dimensional repair of the pedestrian system in the Meicai Area are proposed. By identifying pedestrian fracture areas and optimizing the two types of elements, path and node, an organic and efficient spatial network is developed to align it with pedestrian needs. Finally, the implementation strategy of public-private collaboration is proposed for the repaired pedestrian system and the research results are verified using ArcGIS network analysis. It was found that the accessibility of walking around subway stations is improved, the shortest path between subway stations and

major nodes (office and residence) is optimized, the factor mobility between industrial space and community space is improved, and urban functions closely related to public life are promoted at various spatial levels.

2. Research Prospects

The ground floor of the city is a concept summarized by Ms. Masboungi from France through a large number of practical projects in Europe. Because a systematic theory and design methodology have not yet been developed for it, additional practical project experience is needed to support the construction of the theory.

The ground floor of the city is a project space, and we need to recognize our neglect of the ground floor space in the past and understand the city from the perspective of the ground floor and pedestrians. Furthermore, there are many areas worth investigating for renovating the ground floor of the city, such as resource integration, value estimation, and operational strategies. Thus, this study still needs to delve deeply into its examination of design methodology and other parts of the ground floor.

The urban area with many high-rise buildings is a fact in the high-density urban environments, yet the ground floor of the city is an operable object, and the intersection of public and private spaces offers it flexibility and elasticity. In the construction boom of transportation infrastructure such as subways and light rail, we need to re-examine the value of the ground floor space and create one that serves the public interest, satisfies pedestrian friendly conditions, and promotes sustainable development of the city.

References

[1] 卢济威, 王一．地面立体化——当代城市形态发展的一个新趋势[J]．城市规划学刊,2021(03):98-103.

[2] 深圳市城市规划设计研究院. 梅林-彩田片区城市更新统筹空间规划[R]．2017.

[3] Masboungi A. (Ré)aménager Les rez-de chaussée de La ville[C]． Pairs: Le Moniteur, 2013.

[4] Kickert C.C. Active centers-interactive edges: The rise and fall of ground floor frontages[J]. URBAN DESIGN International,2016(21)：55-77.

[5] 莫浙娟, 王世福, 邝慧清, 等. 平台都市主义的理念重构——城市立体空间实践中现代主义教条模式的批判与承袭[J]．新建筑,2023(01):134-139.

[6] 韩冬青, 冯金龙. 城市·建筑一体化设计[M]．南京:东南大学出版社, 1997.

[7] 董贺轩. 立体城市：空间营建理论与实践[M]．南京：东南大学出版社，2017.

[8] Tan Z., Xue C. Q. L. The Evolution of an Urban Vision: The Multilevel Pedestrian Networks in Hong Kong, 1965–1997[J]. Journal of Urban History, 2015,42(4)：688-708.

[9] Gold, John R. The Practice of Modernism: Modern Architects and Urban Transformation, 1954-1972[M]. London and New York: Routledge, 2007:146-164.

[10] 黄键文, 张伟国, 徐莹. 从诺利地图到瓦齐城绘：18 世纪罗马微观城市空间的创新研究引介[J]. 南方建筑，2018(4):57-62.

[11] KÖHLER D. Large city architecture: the mereological mode of the quantified city[J]. International Journal of Parallel, Emergent and Distributed Systems, 2017, 32 (S1): 163-172.

[12] BUCHANAN C. Ministry of transportation[R]. Traffic in towns. H. M. Stationery Office,1963.

[13] SMITHSON A. Team 10 meeting 1953-1984[M]. Rizzoli International Publication, Inc. 1991.

[14] 王一, 郑奋. 高密度环境下的城市公共空间建构——景观都市主义的策略与方法[J]. 南方建筑, 2015(5): 64-69.

[15] 翟俊. 基于景观都市主义的景观城市[J]. 建筑学报,2010(11):6-11.

[16] OMA Office Work. https://www.oma.com/projects/les-halles.

[17]柯布西耶. 光辉城市[M]. 金秋野, 王又佳，译. 北京：中国建筑工业出版社, 2011.

[18]朱亦民. 史密森夫妇的建筑思想研究[D]. 华南理工大学, 2019.

[19]董林旭. 地下空间与城市现代化[M]. 北京：中国建筑工业出版社，2005.

[20]董贺轩. 城市立体化设计——基于多层次城市基面的空间结构[M]. 南京：东南大学出版社, 2011.

[21]邹颖, 寒梅. 在梦想中探索人类未来的家园——评 MVRDV 的新书《KM3》[J]. 建筑师, 2007(5):61-66，25.

[22]胥一波, 斯坦法诺·博埃里.从“垂直森林”到“森林之城” 一个非人类中心主义的城市现象[J]. 时代建筑,2016(06):66-71.

[23]Cho I. S., Trivic Z., Nasution I. Towards an Integrated Urban Space Framework for Emerging Urban Conditions in a High-density Context[J]. Journal of Urban Design,2015, 20(2):147–168.

[24]罗小虹. 国内外城市中心区立体步行交通系统建设研究[J]. 华中建筑,2014,32(08):127-131.

[25]Frampton A., Solomon J. D., Wong C.. City Without Ground[M]. Berkeley: ORO. 2012.

[26]庄宇, 吴景炜. 高密度城市公共活动中心多层步行系统更新研究[J]. 西部人居环境学刊,2017, 32(04):13-18.

[27]汤永净. 蒙特利尔城市地下步行网络的建设[J]. 地下空间与工程学报,2009,5(04):651-654.

[28]亢德芝, 胡娟, 曹玉洁, 等. 美国城市空中连廊规划建设研究及其启示——以明尼阿波利斯为例[J]. 国际城市规划,2014,29(05):112-118.

[29]肖锐琴. 香港空中步行系统精细化设计与启发[J]. 上海城市规划,2021(01):119-126.

[30]焦阳. 立体步行空间系统的发展及西岸传媒港项目的多元设计实践[J]. 工业设计,2018(07):101-104.

[31]Sun G., Webster C., Zhang X. Connecting the city: A three-dimensional pedestrian network of Hong Kong[J]. Environment and Planning B: Urban Analytics and City Science,2019,0(0)1-16.

[32]高桥洋介. 城市空间魅力营造项目[R]. 深圳：中国建筑学会立体城市与复合建筑专业委员会国际学术论坛,2021.

[33]王欣然, 殷子渊. 基于可达性的站域立体步行系统活力耦合研究[J/OL]. 地下空间与

工程学报,2023.

[34]Admiraal H., Cornaro A.. Why underground space should be included in urban planning policy – And how this will enhance an urban underground future[J]. Tunnelling and Underground Space Technology,2016(55):214–220.

[35]谭峥. 都市多层步行网络之“地形系数”探析[J]. 建筑学报,2017(05):104-109.

[36]杨晓川,任子茹,黄睿, 等. 复合交通背景商业综合体多首层接驳空间探讨——以广州机施集团塘口项目为例[J]. 南方建筑,2019(05):38-41+125.

[37]Wang W. The Vertical Street as Everyday Place in the High-Density City: A Case Study of Mong Kok, Hong Kong[J/OL]. Space and Culture,2023.

[38]姜洋,王悦,余军, 等. 基于 PLPS 调研方法的步行和自行车交通规划设计评估[J]. 城市交通, 2011, 9(05):28-38.

[39]赵春丽,杨滨章,刘岱宗. PSPL 调研法:城市公共空间和公共生活质量的评价方法——扬·盖尔城市公共空间设计理论与方法探析(3)[J]. 中国园林, 2012, 28(09): 34-38.

[40]Frank L, Grammenos F, Hawkins CC. Fused Grid Assessment: Travel and environmental impacts of contrasting pedestrian and vehicular connectivity[R]. Canada Mortgage and Housing Corporation,2007.

[41]Tan Z., Xue C. Q. L. Walking as a Planned Activity: Elevated Pedestrian Network and Urban Design Regulation in Hong Kong[J]. Journal of Urban Design, 2014,19(5):722-744.

[42]顾汝飞,苏涛. 浅析铁路车站综合体与城市空间的整合[J]. 华中建筑, 2012,30(10):101-104.

[43]朱星平,吕斌. 札幌站前通地下广场开发与运用的借鉴[J]. 地下空间与工程学报, 2014, 10(02): 247-252.

[44]杨春侠,吕承哲,徐思璐, 等. 伦敦金丝雀码头的城市设计特点与开发得失[J]. 城市建筑,2018(35): 101-104.

[45]吴亮,陆伟,于辉, 等. 轨交枢纽站域步行系统发展的模式、逻辑与机制——基于三个亚洲案例的比较研究[J]. 国际城市规划,2020,35(01):88-95.

[46]Anciaes P. R., Jones P.. Estimating preferences for different types of pedestrian crossing facilities[J]. Transportation Research Part F: Traffic Psychology and Behaviour, 2018(52): 222–237.

[47]Harris A.. Vertical urbanisms:Opening up geographies of the three-dimensional city[J]. Progress in Human Geography,2014,39(5)：601–620.

[48]AUC. RÉINVENTER LYON PART-DIEU[R/OL]. 2015.

[49]Grand Lyon. LES CAHIERS PART-DIEU[R/OL]. 2012.

[50]Planning Department. subwayplan: The Selected Strategy; Executive Summary[R]

[51]张纯,刘志,张玥, 等. 市场力量驱动形成的 TOD 廊道——以泰国曼谷为例[J]. 都市快轨交通,2022, 35(04):20-26+57.

[52]Robertson, Kent. “Pedestrian Skywalk Systems: Downtown's Great Hope or Pathway to Ruin?” [J]. Transportation Quarterly,1990,42 (3): 457–484.

[53]Zacharias J. The Central–Mid-levels Escalator as Urban Regenerator in Hong Kong[J]. Journal of Urban Design,2013,18(4):583-593.

[54]EPADESA. LA DÉFENSE SEINE ARCHE STRATEGIE 2025[R/OL]. 2015.

[55]EPA. La défense Seine Arche. Réflexions pour un territoire vers un projet stratégique et opérationnel[R/OL]. 2012.

[56]EPA. La défense Seine Arche. Vers un territoire durable[R/OL]. 2012.

[57]EPA. La défense Seine Arche. Une histoire de LaDéfense Seine Arche Par François Leclercq[R/OL]. 2011.

[58]李明烨. 由《拉德芳斯更新规划》解读当前法国的规划理念和方法[J]. 国际城市规划,2012,27(05):112-118.

[59]Équipe Leclercq. LA DÉFENSE VERS UN QUARTIER D'AFFAIRES A HAUT NIVEAU DE SERVICES[R/OL]. 2016.

[60]Tang B., Wong S. A longitudinal study of open space zoning and development in Hong Kong[J]. Landscape and Urban Planning,2008,87(4)：258–268.

[61]Tang B. Explaining the inequitable spatial distribution of public open space in Hong Kong[J]. Landscape and Urban Planning,2017(16):80–89.

[62]胡依然,张凯莉,周曦. 城市制度影响下的香港中区高架步行系统研究[J]. 国际城市规划,2018,33(01):128-135.

[63]香港特别行政區政府規劃署. 香港规划标准与准则[S]. 2018.

[64]KAYDEN J. S. Privately owned public space: the New York City experience[M]. New York: John Wiley & Sons, 2000.

[65]于洋. 纽约市区划条例的百年流变（1916—2016）——以私有公共空间建设为例[J]. 国际城市规划,2016,31(2): 98-109.

[66]简祎, 罗洁梅, 王安琪, 等. 私有公共空间与空间正义之博弈——以香港为例[J]. 国际城市规划,2023，38(03):73-82+98.

[67]吴颖婷. 城市公共步行空间的设计控制研究[D]. 华南理工大学,2016.

[68]雷雪姣. 二层步行系统的问题反思与改进对策——以广深 CBD 地区为例[J]. 工程技术研究,2021,6(03):21-23.

[69]福田区人民政府. 福田区重点区域质量型开发建设实施细则梅林-彩田片区[R]. 2019

[70]杨旭. 回归人本需求——深圳高密度城市环境下的产业空间发展研究[J]. 建筑技艺,2019(07):122-123.

[71]王泽坚. 立体城市的认知更新[R]. 深圳：中国建筑学会立体城市与复合建筑专业委员会国际学术论坛,2021.

[72]简·雅各布斯著. 美国大城市的死与生[M]. 金衡山译.译林出版社, 2005.

[73]HELSEL S. Taipei operations[M]. Taipei: Human Environment Group, 2004.

[74]杨·盖尔. 交往与空间[M]. 中国建筑工业出版社, 2002.

[75]深圳市规划国土发展研究中心. 深圳福田中心区空中连廊详细规划[R]. 2017.

[76]Jia S., Wang Y., Wong N.H., et al. Influences of the thermal environment on pedestrians' thermal perception and travel behavior in hot weather[J]. Building and Environment,2022(226).

[77]G.Z.Brown, DeKay Mark. 太阳辐射·风·自然光[M]. 中国建筑工业出版社, 2008.

[78]深圳市交通运输委员会. 深圳市人行天桥和连廊设计指引（试行）[R]. 2017.

[79]翁超, 庄宇. 空间权与“空间经济”视角下纽约中央车站地区的百年更新[J/OL]. 国际城市规划:1-23[2023-07-07].

[80]同济大学建筑与城市空间研究所, 株式会社日本设计. 东京城市更新经验城市再开发重大案例研究[M]. 上海：同济大学出版社, 2019.

[81]Buildings Department. Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers APP-108[S]. 2009.

[82]深圳市城市更新和土地整备局. 深圳市拆除重建类城市更新单元规划容积率审查规定[S]. 2019.

[83]CASTEX J., BLAIN C., LEFEBVRE V. Sols artificiels, sursols, dalles: étude historique

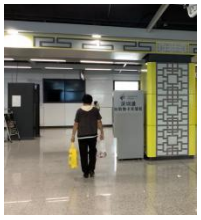
comparative[R]. Paris: APUR, 2005.

[84]肖锐琴，刘雷．香港空中步行系统的规划实施运作研究[J]. 国际城市规划,2020,35(02):136-143.

[85]朱骏.管控、协调与监督：深圳市梅彩片区城市总设计师工作机制研究[J].规划师,2023,39(01):91-95.

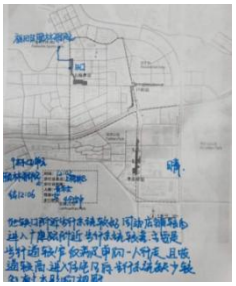
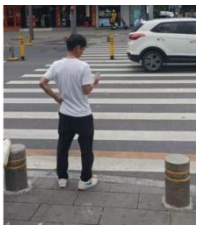
[86]孙一民. 中观尺度的城市大型工程项目的科学营建——关于总设计师制度的思考[J].当代建筑,2022(05):19-23.

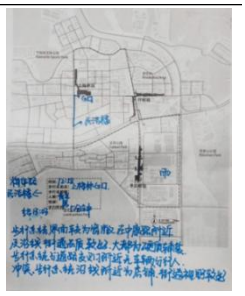
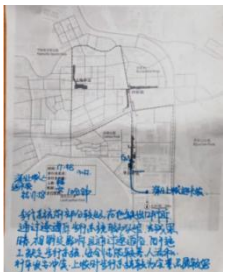
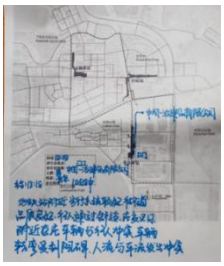
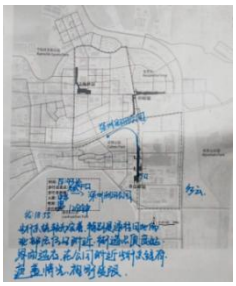
Appendix1 Pedestrian Flow Following Records

	Starting point	destination	age	gender	Walking time	Photos	Pedestrian flow line
1	Maling Subway Station Exit E	Meihua Primary	child	male	12min		
2	Maling Subway Station Exit B	Xinhao Industrial Park	youth	male	10min		
3	Maling Subway Station Exit A	China Resources	youth	female	5min		
4	Maling Subway Station Exit D	Traffic Training Center	middle-aged	male	6min		
5	Maling Subway Station Exit C	Youth League Cadre Training Center	youth	male	5min		
6	Maling Subway Station Exit C	Electrical and Mechanical Building	the aged	female	3min		

7	Maling Subway Station Exit E	Trimble Brothers Hotel	youth	female	3min		
8	Maling Subway Station Exit E	Yuehua Road Bottom Merchant	middle-aged	female	3min		
9	Maling Subway Station Exit A2	Xinhaoedu Industrial Park	youth	female	5min		
10	Maling Subway Station Exit C	Huachao Building	youth	male	12min		
11	Donggua-ling Subway Station Exit D	Shenzhen Ultimate People's Court	youth	female	7min		
12	Donggua-ling Subway Station Exit A	Vanke Apartment	middle-aged	female	7min		
13	Donggua-ling Subway Station Exit B	Xinhaoedu Downstairs Shop	youth	male	6min		

14	Donggua-ling Subway Station Exit C	The Caitiancun Community	Youth and middle-aged	Mother and daughter	4min		
15	Donggua-ling Subway station Exit D	Caitian road	youth	female	7min		
16	Shangmeilin Subway Station Exit D	Futian District Second People's Hospital	youth	female	7min		
17	Shangmeilin Subway Station Exit G	Meili Primary	Childr-en	female	7min		
18	Shangmeilin Subway Station Exit E	Shenzhen Oxygen Group Co., LTD	youth	female	8min		
19	Shangmeilin Subway Station Exit B	Futian District New Generation Industrial Park 1	middle-aged	male	4min		
20	Shangmeilin Subway Station Exit G	Shangmeilin Building Restaurant	youth	male	2min		

21	Shangmeilin Subway Station Exit E	Shanghai Meilin Zhuo Yuexi	youth	female	min		
22	Shangmeilin Subway Station Exit D	International Fintech City	youth	male	7min		
23	Shangmeilin Subway Station Exit E	Merlin Center Square North	the aged	female	10min		
24	Shangmeilin Subway Station Exit B	Yilin Yayuan 9 CD unit	youth	female	4min		
25	Shangmeilin Subway Station Exit G	The Golden Treasure Hotel	youth	male	7min		
26	Shangmeilin Subway Station Exit C	MissHcir's Hair Salon	youth	male	5min		

27	Shangmeilin Subway Station Exit G	Meihua Road Minhao Building	youth	male	5min		
28	Donggua-Ling Subway Station Exit G2	Deep Uptown Decathlon	youth	female	10min		
29	Donggua-Ling Subway Station Exit E	China One Zhi Construction Co., LTD	youth	Couple	12min		
30	Donggua-Ling Subway Station Exit G2	Shenzhen Radio, Television and Film Group	middle-aged	male	4min		
31	Donggua-Ling Subway Station Exit F	Shenzhen Caitian Park North	middle-aged	male	12min		
32	Donggua-Ling Subway Station Exit F	Shenzhen Radio, Television, film and Television Group Hub Building	youth	female	2min		

攻读硕士学位期间取得的研究成果

一、已发表（包括已接受待发表）的论文，以及已投稿、或已成文打算投稿、或拟成文投稿的论文情况（只填写与学位论文内容相关的部分）：

序号	作者（全体作者，按顺序排列）	题　　目	发表或投稿刊物名称、级别	发表的卷期、年月、页码	与学位论文哪一部分（章、节）相关	被索引收录情况

注：在“发表的卷期、年月、页码”栏：

1 如果论文已发表，请填写发表的卷期、年月、页码；

2 如果论文已被接受，填写将要发表的卷期、年月；

3 以上都不是，请据实填写“已投稿”，“拟投稿”。

不够请另加页。

二、与学位内容相关的其它成果（包括专利、著作、获奖项目等）

Acknowledgement

I always imagined what graduation would be like, but I never thought that it would be an ordinary evening in Shenzhen, where I would knock down a line that would be the beginning of this farewell ceremony.

These years of study in SCUT are my precious memories, and I am very lucky to be able to study in SCUT. Looking back on these years now, it is a happy and fulfilling time, no matter it is the heated discussion in the Specialized Teaching, the hasty and apprehensive footsteps along with the ringing of the class bell in the No. 34 Building, or the cheering and jumping figures on the playground. Two years time passes by, and this time it's finally my turn to say goodbye to SCUT.

As graduation is approaching, it is hard to express my gratitude. First of all, I would like to thank all the professors in my supervisor group, Zhou Jianyun, Mo Zhejuan, Qi Dongjin, He Jinghuan, Fu Juan, Marco Trisciuoglio, Michela Barosio, as well as all the professors I met in the past, such as Lin Xiang, Xiao Ming, Xia Hanming, etc. All of you are the best guides for me in my life. You are all the best guides in my study, and are the guiding light when I travel in the ocean of knowledge. It is your patient and interesting explanations that help me to clear the fog, fill in the blind spots of knowledge, and get a breakthrough and growth. In particular, I would like to thank Prof. Mo Zhejuan, who helped me in every step of my thesis, from topic selection to thesis structure and site design. Whether it is to help me develop my ideas when choosing the topic, or to encourage me after each group meeting, or to help me clarify the direction when I am confused, or to tell me that I have already done a great job when I have self-doubt. From Prof. Mo, I see the qualities of self-discipline, delicacy and softness. Thank you for your constant help and encouragement, which has made my study journey a warm and fulfilling one.

I would like to thank my family for giving me the strongest trust and encouragement, as well as moral and material support, so that I can always run forward with hope and love. I would especially like to thank my mom, you always patiently listen to me about the little things in life, tolerate my willfulness, and do your best to give me the best and let me do what I want to do the most. And my father, grandmother, uncle, great-uncle, aunt and sister, it is

with your love that I have made one footprint after another, and I hope that time goes a little slower, so that my companionship can be a little more.

I would like to thank all the friends I have met in different stages of my life for the fun we had together. I will always remember the dreamy travels in Europe of the “Italian Travel Group”, and the six months we spent together at the Politecnico di Torino were a pure and wonderful time. The lectures in the classroom of Lingotto, the long talks in Moncalieri, the pink sunset on the beach of Barcelona, the countdown to New Year's Eve in the streets of Vienna, the snowstorm in the Norwegian Forest, the moment when the Tower of Paris was lit up, etc. Thanks to Xiaohan and Panxin in the “little cobbler”, we completed the group work during the postgraduate period together and developed our own whimsical ideas. And I would like to thank Wenju, Meiwen, Jingyi, and Qinyu, we set off from HQU to further places together. Your bravery, enthusiasm, loveliness, and quirks have enriched my life and made me feel sincere and beautiful friendship, so that I am never alone along the way.

Thank my best friend, Yan Wenju, for accompanying me through those happy, broken, or dull moments. Thank you for your advice when I was complacent, and for your soft words when I was down. It is you who let me know that I am never alone on the road of study, and this time I can finally say to you with a smile, "We are finally going to the Elf Island in our hearts with our common dream".

Finally, I have to thank myself for persisting all the way, for my own efforts and persistence. I came with nothing, but now I have returned fully loaded. I have seen countless sunsets and occasional sunrises on campus, and I have also experienced the frustration of being frustrated in my thesis, job search, and life, and I have felt the tension and joy of getting my IELTS score. All of these experiences are still fresh in my mind, and they tell me the meaning of hard work and perseverance. I know that this road has endless bumps in it, but there is no difficulty that can make me give up so easily.

"Every dream is like a random door leading to a different world, and your story is now the starting point." Studying so far, I finally came to the front where I need to cut through the thorns and thistles alone. Looking back on the road, countless warmth is hidden deep in my heart, which is transformed into bright lights on the way forward. I hope I can keep the love of life, explore the unknown, and keep walking!

3.答辩委员会对论文的评语

（主要内容包括：1.对论文的综合评价；2.对论文主要工作和创造性成果的简要介绍；3.对作者掌握基础理论、专业知识程度、独立从事科研工作能力以及在答辩中表现的评价；4.存在的不足之处和建议；5.答辩委员会结论意见等）

硕士研究生姚菲灵所完成的题为《深圳梅彩片区城市首层步行空间的立体修补探索》的学位论文，选题具有一定的理论意义和较好的实用价值。作者详细地归纳和评述了一定量的有关文献，较好地掌握了该领域国内外的研究现状和发展方向。

论文研究内容完整，研究方法较正确，完成了下列研究成果：1、解析了在城市立体化发展背景下步行系统的转变、空间特征以及主要职能。2、基于理论与相应案例研究，提出了城市首层步行空间修补的原则与方法。将具有空间修补契机的深圳梅彩片区城市首层系统作为项目空间，以其中的步行系统作为设计边界。用立体修补的方式，创造和地面环境一样的步行空间。研究成果具有一定的理论价值和实用价值。

论文概念清晰，结构完整，叙述适当，分析充分。答辩中作者较好地回答了答辩委员们提出的问题。

答辩委员会同意通过硕士学位论文答辩，同意毕业，并建议授予硕士学位。

论文答辩日期：2023 年 9 月 4 日　　答辩委员会委员 5 人

表决票数：同意毕业及授予学位（5）票

同意毕业，但不同意授予学位（0）票

不同意毕业（0）票

表决结果（打"√"）：同意毕业及授予学位（√）

同意毕业，但不同意授予学位（　）

不同意毕业（　）

答辩成员签名	（主席）　　Mauro Berta（线上参会，秘书代签）
答辩秘书签名	