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# Development of Pedestrian Systems in High-Density Three-Dimensional Mixed-Use Blocks: A Case Study of the Core Area of the East Square at Zhengzhou East Railway Station

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**Abstract:** High-density three-dimensional mixed-use blocks are becoming the central components of urban spaces. Developing a three-dimensional pedestrian system can meet the diverse and high-quality mobility needs of pedestrians across different spatial levels. This paper identifies the relationship between pedestrian systems and block spatial forms by summarizing the characteristics of high-density mixed-use blocks and the composition and functions of three-dimensional pedestrian systems. The paper proposes key points for constructing pedestrian systems in such blocks, including conducting thorough investigations, accurately forecasting pedestrian demand, reasonably arranging networks, and clarifying implementation measures. The paper further highlights the innovative focus on alleviating the sense of oppression that high-density blocks impose on pedestrians, accommodating the diverse pedestrian needs within mixed-use blocks, and coordinating three-dimensional spatial planning of blocks. Using the core area of the East Square at Zhengzhou East Railway Station as an example, the paper examines its multifunctional spatial characteristics and indicator scale, including transportation hubs, business, retail, leisure, and residential spaces, and the comprehensive development of its complex underground spaces. A people-centered approach is proposed to create multi-level pedestrian spaces and a multi-dimensional pedestrian network incorporating underground, ground-level, and above-ground components. The paper also proposes the construction of flexible and convenient aerial corridors and establishes actionable indicator control measures to ensure practical implementation. These strategies aim to promote green, low-carbon, healthy, and sustainable development within the blocks. **DOI:** 10.13813/j.cn11-5141/u.2024.0504-en

**Keywords:** pedestrian system; high-density three-dimensional mixed-use block; aerial corridor; underground pedestrian network; Zhengzhou East Railway Station

## 0 Introduction

As China's urban construction has transitioned into the stock development stage, urban spatial forms are increasingly shifting towards green and high-quality development models. Under the constraints of adhering to the red line for cultivated land protection, prioritizing ecological considerations, and strictly controlling new urban construction land, the high-density and three-dimensional organization of urban spaces, along with the diversification of functional layouts, have emerged as key development trends. In high-density urban environments, the integration of public green ecological spaces is essential to mitigate spatial oppression and enhance the quality of life within urban blocks. However, excessively large-scale greening areas can lead to the functional segregation of adjacent spaces [1], potentially undermining the integrity of urban blocks. In this context, the provision of continuous and comfortable pedestrian facilities becomes crucial for effective spatial design. Furthermore, the Guiding Opinions of the Ministry of Housing and Urban-Rural Development on Comprehensively Promoting the Construction of Urban Comprehensive Transportation Systems (Jiancheng [2023] No. 74) emphasizes the need to adapt to the requirements of high-quality urban development in the new era. Specifically, it calls for accelerating the construction of urban green and slow-speed traffic systems and enhancing the continuity, safety, and comfort of slow-speed traffic facilities to improve urban quality [2].

Research on the development of three-dimensional pedestrian systems within three-dimensional urban blocks has garnered increasing attention both domestically and internationally. Li [3] proposed a comprehensive methodology for establishing a three-dimensional slow-traffic system in high-density business core areas. Tu et al. [4] examined the strategy of integrating station areas with urban functions through a "three-dimensional pedestrian network + transportation core" approach, using Beijing's sub-central station as a case study. Wang et al. [5] investigated the impact of large urban commercial complexes on spatial structure and pedestrian accessibility within the urban three-dimensional pedestrian system, with Futian Central District in Shenzhen as an example. While these studies primarily focus on establishing three-dimensional pedestrian systems in

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single-function-dominated areas such as urban business districts, transportation hubs, and commercial zones, research and practical cases on implementing such systems in functionally mixed-use blocks remain relatively limited. This paper addresses this gap by analyzing the characteristics of high-density three-dimensional mixed-use blocks and pedestrian travel patterns, proposing key principles and innovative strategies for establishing a three-dimensional pedestrian system in such contexts.

# 1 High-density three-dimensional mixed-use block and pedestrian system

## 1.1 High-density three-dimensional mixed-use block

The street block represents the fundamental unit of urban spatial form and serves as the primary space for daily production and life activities. The Several Opinions of the Central Committee of the Communist Party of China and the State Council on Further Strengthening Urban Planning, Construction, and Management emphasizes the need to enhance the planning and construction of street blocks, promoting the development of open, accessible, appropriately scaled, well-equipped, and harmonious neighborhood blocks [6]. Distinct urban development periods exhibit unique morphological characteristics of street blocks. In the context of contemporary multi-dimensional and three-dimensional urban development trends, high-density three-dimensional mixed-use blocks are increasingly emerging as the core component of urban spatial composition.

Block density is primarily reflected in the magnitude of building density. Long et al. [7] analyzed 3.357 million large-scale three-dimensional building datasets from the central urban areas of 63 large and medium-sized cities in China. They defined blocks with a building density exceeding 25% as high-density blocks and identified mixed-use high-density development as a relatively typical urban form in Chinese cities such as Beijing and Zhengzhou. A three-dimensional block refers to an urban street block formed by the integration of multi-level open spaces, building spaces, and urban facilities. Among these elements, multi-level open spaces constitute the fundamental framework of the form and function of a three-dimensional block. These spaces not only establish three-dimensional connections between the block and the surrounding urban environment but also serve as the primary venue for accommodating and guiding human activities within the block. The three-dimensional space of such a block decomposes the block into multi-level urban ground layers, emphasizing the spatial utilization at each level [8]. The essence of a three-dimensional block is manifested in the three-dimensionalization of its spatial form and functional structure. High-density and multi-functional mixed-use development represents the core characteristic of a three-dimensional block.

## 1.2 Three-dimensional pedestrian system

In light of topographic conditions, the layout of urban land use, and the circumstances of street blocks, it is advisable to establish sidewalks, pedestrian-only walkways, and pathways that are independent of the urban road system [9]. The urban three-dimensional pedestrian system precisely constitutes the synthesis of multiple pedestrian-only walkways and pathways. It typically refers to a multi-dimensional integrated three-dimensional pedestrian network formed by the mutual conversion of aerial, ground, and underground pedestrian facilities through three-dimensional transportation facilities.

### 1.2.1 Aerial pedestrian system

The primary function of the aerial pedestrian system is to facilitate three-dimensional street crossings and enable pedestrians to navigate high-traffic areas, thereby achieving pedestrian-vehicle separation and ensuring the continuity of pedestrian flow. With the increasing diversification of urban spatial structures and the growing complexity of urban functions, the aerial pedestrian system has progressively expanded its role in organizing urban activities, shaping urban landscapes, and enriching urban spaces. As a result, it has become an integral component of the three-dimensional pedestrian system.

### 1.2.2 Ground pedestrian system

The ground level has traditionally served as the primary pedestrian traffic space in cities, functioning as the main platform for pedestrian commuting, the assembly and dispersal of pedestrian flows, and leisure activities. Simultaneously, both the urban aerial pedestrian system and the underground pedestrian system rely on the ground pedestrian system for connectivity. Consequently, the ground pedestrian system forms the foundational traffic space within the three-dimensional pedestrian system, acting as the anchor and connecting bridge for aerial and underground pedestrian systems. Together, these three components constitute a comprehensive urban three-dimensional pedestrian system [10], providing a seamless, continuous, convenient, comfortable, and safe pedestrian environment.

### 1.2.3 Underground pedestrian system

The primary function of the underground pedestrian system is to enable the rapid and convenient movement of pedestrians below ground. With the ongoing diversification of underground space functions and the increasing demand for interconnected underground spaces across plots, the underground pedestrian system has gradually evolved into a larger-scale, interconnected network. Its functions have also diversified to incorporate commercial operations, cultural

 

displays, and other activities. Particularly in some urban central areas, the underground pedestrian system has become a significant space for pedestrian activities and, together with urban underground spaces, has formed multifunctional underground complexes.

### 1.3 Relationship between pedestrian system and spatial form of block

The pedestrian system is a critical subsystem of the urban integrated transportation system, and its organizational structure is closely linked to the broader urban transportation network. Urban transportation serves as the skeleton and veins of urban spatial form, making the characteristics of the pedestrian system intrinsically tied to the spatial configuration of urban blocks (Fig. 1).

Before the Industrial Revolution, urban block spaces primarily expanded horizontally. Walking was the dominant mode of transportation, and streets naturally functioned as pedestrian-oriented spaces. Street design during this period was guided by principles that prioritized pedestrian needs, aligned with pedestrian behavior, and fostered block vitality.

With technological advancements, block spaces began to extend vertically, both above and below ground. As individual motorized mobility gradually became the dominant mode of travel, street spaces increasingly prioritized accommodating the growing demand for vehicle traffic, leading to the compression and fragmentation of flat pedestrian spaces. Elevated pedestrian facilities, such as footbridges and pedestrian underpasses, emerged during this period, but these were largely isolated, point-based installations rather than integrated systems.

Subsequently, due to the scarcity of urban space resources, block spaces evolved toward three-dimensional and mixed-use forms. This shift generated significant pedestrian travel demands across various spatial dimensions, prompting the development of three-dimensional pedestrian facilities designed to meet the needs of pedestrians in different spaces.

With the growing emphasis on urban development concepts such as sustainability, people-centered design, green and low carbon, and livable and business-friendly environments, pedestrian facilities have evolved from purely transportation-focused functions to mixed-use roles. This transformation aims to address the diverse development needs of urban spaces and the high-quality, diversified demands of pedestrian travel.

## 2 Key points and crucial innovations for the construction of pedestrian systems in high-density three-dimensional mixed-use blocks

### 2.1 Key points for the construction

The construction framework of pedestrian systems in high-density three-dimensional mixed-use blocks is shown in Figure 2, including the following key points.

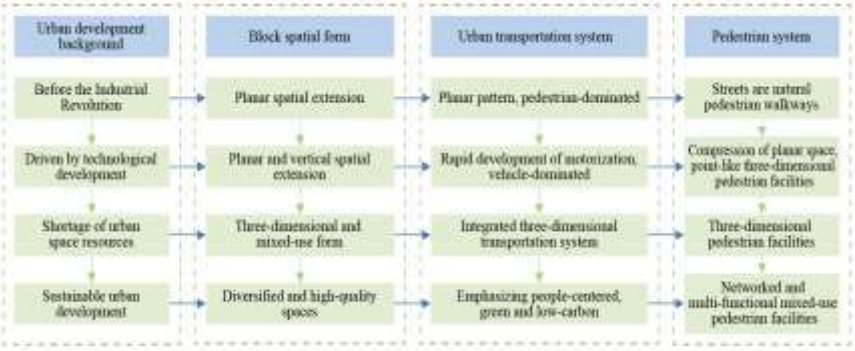


**Fig. 1** Relationship between pedestrian systems and spatial forms of blocks

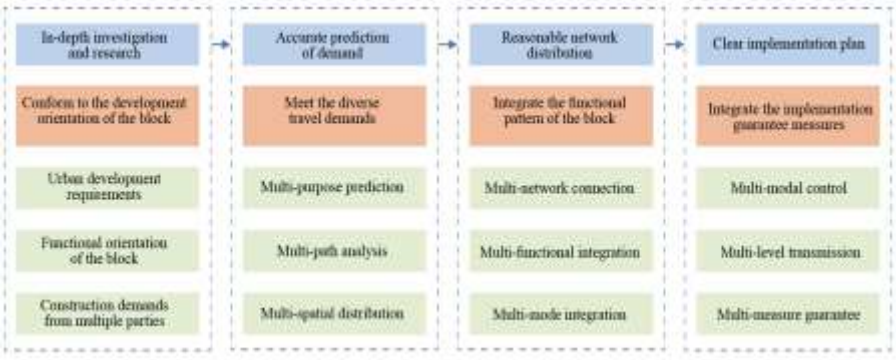


**Fig. 2** Framework for developing pedestrian systems in high-density three-dimensional mixed-use blocks

### 2.1.1 In-depth investigation and research

As urbanization transitions from rapid growth to high-quality development within the territorial space system, cities should place greater emphasis on implementability and prioritize addressing practical issues as the fundamental starting point. Consequently, the construction of pedestrian systems should begin with a thorough assessment of the current situation to identify actual problems and stakeholder demands.

### 2.1.2 Accurate prediction of demand

Accurate prediction of pedestrian travel demand is a prerequisite for the scientific construction of pedestrian systems and a critical factor in achieving the integration of pedestrian facilities with blocks. In high-density three-dimensional mixed-use blocks, pedestrian flows are heterogeneous. When predicting the scale and distribution of pedestrian demand, it is essential to consider both the generation and attraction points of pedestrian flows from various functions, including transportation hub assembly and dispersal, commuting to work, leisure activities, business meetings, and transfer connections, and to examine travel scale, path characteristics, and spatial distribution patterns.

### 2.1.3 Reasonable network distribution

Based on the three-dimensional spatial structure of the blocks, the distribution of business types, architectural forms, and layered features, an appropriate development model for pedestrian systems should be identified. This includes formulating a clear pedestrian network structure and rationally planning the network layout according to the overarching principles of strengthening primary pedestrian axes, improving secondary pedestrian channels, optimizing supporting pedestrian paths, and enhancing key pedestrian nodes. The goal is to establish a comprehensive three-dimensional pedestrian network with a multi-level layout that serves diverse user groups.

### 2.1.4 Clear implementation plan

At both micro and macro scales of block design, pedestrian systems should prioritize feasibility and guidance. After determining the pedestrian network plan, further measures should be developed in alignment with the development mode, construction, operation, and management needs of the blocks. These measures should address the construction entities of pedestrian facilities, their public attributes, space utilization, construction forms, architectural aesthetics, and safety management. By establishing non-motorized transportation priority zones and pedestrian priority lanes, managing motor vehicle demand, constructing underground urban roads, and enhancing public transportation services, the quality of pedestrian space environments can be significantly improved.

## 2.2 Key points of innovation

### 2.2.1 Mitigating the oppressiveness in high-density blocks is of paramount importance

The convenience, comfort, and safety of pedestrian facilities are pivotal in shaping the travel experience of residents. The development of pedestrian systems should incorporate innovative thinking and a human-centric approach, moving away from the traditional vehicle-dominated paradigm. This shift involves challenging conventional practices of compressing pedestrian spaces and prioritizing vehicular movement over pedestrian needs (Fig. 3). In particular, within high-density three-dimensional mixed-use urban blocks, it is essential to prioritize creating and maintaining enjoyable pedestrian spaces. This approach helps mitigate the overwhelming impact of high-density urban structures on pedestrians. Providing high-quality pedestrian facilities should be considered a fundamental strategy for managing regional mobility and reinforcing the primacy of pedestrian traffic within urban blocks.

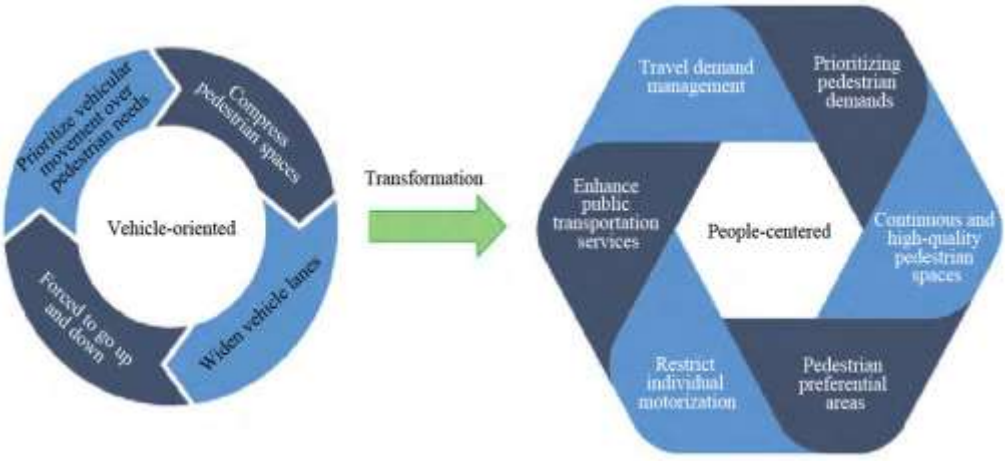


**Fig. 3** Conceptual transition in pedestrian system development

### 2.2.2 Meeting diversified demands poses a challenge

One of the key characteristics of high-density three-dimensional mixed-use blocks is functional integration. Within a relatively small area, these blocks can accommodate diverse functions such as passenger transport hubs, commercial complexes, business centers, residential areas, and parks. This diversity attracts and serves various pedestrian groups with distinct travel needs, including commuters, travelers at transport hubs, residents engaging in leisure activities, shoppers, entertainment seekers, and business professionals. Therefore, the primary challenge in constructing the pedestrian system for high-density three-dimensional mixed-use blocks lies in addressing the multifaceted functional requirements. By analyzing travel purposes, pedestrian flow volumes, travel routes, and activity spaces, and implementing strategies of pedestrian flow diversion, pressure dispersion, and differentiated services, well-developed pedestrian facilities can be integrated to unify the diverse spaces within the blocks, thereby creating a cohesive and vibrant urban environment.

### 2.2.3 Coordinating the three-dimensional spatial configuration of the block space is the core point

A defining feature of high-density three-dimensional mixed-use blocks is their three-dimensional spatial configuration. In central urban areas constrained by limited land resources, these blocks undergo simultaneous vertical expansion (both above and below ground) and horizontal integration, forming comprehensive spatial networks. This development paradigm results in more open and shared ground-level spaces, increasingly diverse and complex above-ground structures, and more dynamic and multifunctional underground spaces. Through vertical connectivity and seamless horizontal integration, the entire blocks evolve into a cohesive multi-dimensional spatial system. Pedestrian facilities constitute an essential component of these three-dimensional mixed-use blocks, serving as the critical system that enables true spatial integration and vertical connectivity. By means of a networked pedestrian infrastructure, the entire three-dimensional blocks are interconnected. Furthermore, through a multi-planar pedestrian system, the entire spatial framework of the blocks is cohesively integrated, thereby facilitating the developmental requirements of the three-dimensional spatial configuration.

## 3 Practical cases

### 3.1 Overview and characteristics of the block

The core area of the east square of Zhengzhou East Railway Station (hereinafter referred to as “the block”) is the core of the Zhengzhou Comprehensive Transportation Hub area and is the future urban development center and international business and trade circulation service center of Zhengzhou City. It strives to create a comprehensive urban gateway area centered on transportation distribution and integrating international finance, high-end business, living, shopping, entertainment, and leisure.

### 3.1.1 Urban gateway area with high-density mixed-use development

The block covers an area of approximately 2.26 square kilometers, centered around Zhengzhou East Railway Station. It includes various transportation hub nodes such as urban rail transit stations, the Zhengzhou Passenger Transport General Station, and bus interchange stations. The block has seen the development of approximately 4 million square meters of high-density office, commercial, and residential buildings, along with 1.5 million square meters of underground space. In this block, the predominant building heights exceed 45 meters, with 22 plots featuring building heights taller than 100 meters, constituting approximately 41% of the total. Additionally, 35 plots exhibit a building density of 65% or higher (see Fig. 4), representing about 65% of the total plots. Furthermore, 36 plots have a floor area ratio of 5.0 or greater (see Fig. 5), accounting for 67% of the total. In the future, there will be substantial pedestrian traffic between various plots and key transportation hubs, including high-speed railway stations, urban rail transit stations, bus terminals, and public transport facilities. Given the high standards required for the quality of the regional pedestrian environment, it is imperative to develop a safe, comfortable, and continuous pedestrian network. This initiative aims to establish a model zone for green and low-carbon travel.

### 3.1.2 A three-dimensional and complex underground space complex

Based on the hierarchy of pedestrian accessibility, the first underground level of the block is designed to accommodate transportation hubs, sunken plazas, pedestrian crossings, and commercial spaces. The second and third underground levels are dedicated to motor vehicle parking facilities, vehicular circulation corridors, and urban rail transit infrastructure. In accordance with the people-centered principle, an approximately 6-kilometer-long underground vehicular circulation corridor (see Fig. 6) has been constructed. This infrastructure guides approximately 60% of vehicles to the underground from distant entry points, thereby achieving effective separation of pedestrian and vehicular traffic at ground level. Consequently, this design creates a safer and more comfortable environment for pedestrians on the surface.

Simultaneously, a coordinated development model for the underground spaces of more than 50 plots within the block is proposed. This model facilitates the open sharing and efficient utilization of underground space resources, thereby creating favorable conditions for the interconnection of the underground pedestrian system.


**Fig. 4** Illustration of building density of blocks


**Fig. 5** Illustration of floor area ratio of blocks

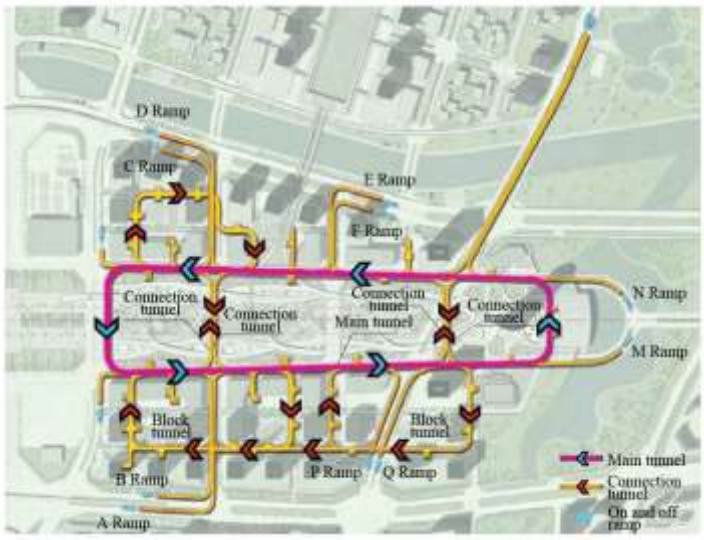


**Fig. 6** Underground vehicular ring corridor connecting the blocks

## 3.2 Construction of the three-dimensional pedestrian system

### 3.2.1 Creating multi-level pedestrian spaces to accommodate diverse travel demands

The block integrates high-speed railway stations, urban rail transit stations, and urban industrial functions in a highly coordinated manner. During peak hours, the pedestrian flow reaches 32,500 person-trips, with passenger flows for various travel purposes converging and interweaving. Among these, the passenger flow for high-speed railways is 3,200 person-trips, while that for urban rail transit is 23,700 person-trips. Both groups exhibit high sensitivity to walking time and have stringent requirements for the convenience of

 

the pedestrian network. Additionally, the passenger flow for shopping, leisure, and business exchanges totals 5,600 person-trips. This group places greater emphasis on the comfort of walking facilities, the diversity of the spatial environment, and the vibrancy of the block.

Based on the scale and spatial distribution characteristics of pedestrian travel demands, a multi-level pedestrian space framework of "one axis, three cores, five corridors, and eight nodes" is proposed (see Fig. 7). The primary pedestrian axis, formed by a continuous aerial landscape ribbon bridge and an underground pedestrian passageway within the east-west green belt, connects key destinations including the high-speed railway station, urban rail transit station, and Lianhu Park. The Zhengzhou Passenger Transport General Station and the public bus hub serve as key nodes to establish pedestrian connection passageways, fulfilling the requirements for rapid and convenient passenger flow distribution at transportation hubs. In conjunction with the central green plazas on the north and south sides, secondary pedestrian axes are created around the layout of ground-level commercial functions, addressing the pedestrian demands for shopping, leisure, and communication.

### 3.2.2 Construction of a multi-dimensional pedestrian network to enhance the spatial quality of the three-dimensional mixed-use block

Integrating the characteristics of three-dimensional space and considering the layout of both ground and underground commercial functions, the concept of a "multi-layered surface" is proposed. This approach facilitates the construction of a multi-dimensional pedestrian network, with the underground level serving as the primary component, the ground level as the secondary component, and the above-ground level as the complementary component.

(1) An interconnected underground pedestrian network

Integrating underground spatial elements such as transportation hubs, commercial facilities, and sunken plazas. By optimizing the connection channels for urban rail transit, constructing cross-sectional connections across major urban roads, establishing municipal public corridors that link various plots, and opening up and controlling internal public corridors within key plots, a comprehensive underground pedestrian network is formed within the block. This network utilizes the underground space of the fluid entity as the primary pedestrian axis, with four central sunken plazas in the north and south areas serving as distribution cores. It connects the underground commercial facilities and transportation nodes across major plots (see Fig. 8), achieving seamless and convenient connections throughout the entire block's underground space and enhancing spatial integrity.

(2) A ground-level pedestrian network of pleasant scale

The layout of the block follows a typical "nine-grid" pattern. The original nine blocks are integrated into a unified and open block, centered around a central green core that connects the surrounding eight plots. The internal road network emphasizes the principles of narrow roads, small blocks, and dense connectivity. Branch roads have a right-of-way width of 16 meters, with a block size of 100 meters, resulting in a road network density exceeding 10 km·km$^{-2}$. Based on the existing ground-level road network, further optimization of the ground-level pedestrian space is proposed. Specifically, the sidewalk width requirements are as follows: for 16 m roads, the sidewalk width should be no less than 3.5 m; for 25 m, 30 m, and 35 m roads, the sidewalk width should range from 5 to 7 m; and for roads wider than 35 m, the sidewalk width should exceed 4 m and integrate with internal walkways within the adjacent green spaces. Additionally, the main pedestrian passages are clearly defined, and primary pedestrian zones are delineated to form a high-quality street environment characterized by pleasant scale and convenient walking.

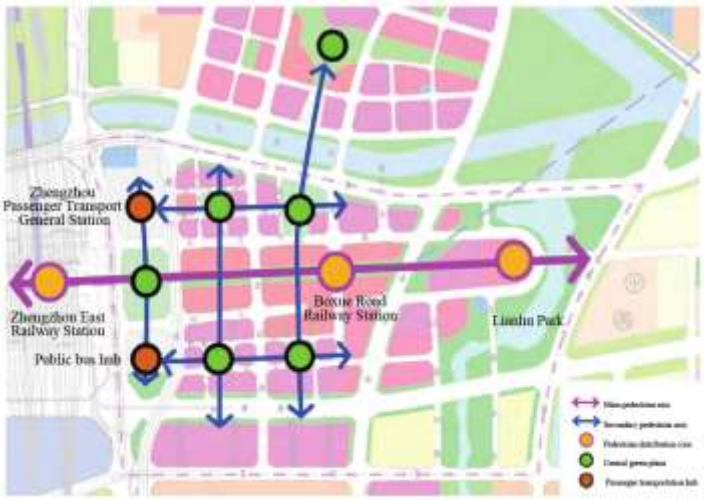


**Fig. 7** Multi-level pedestrian space structure

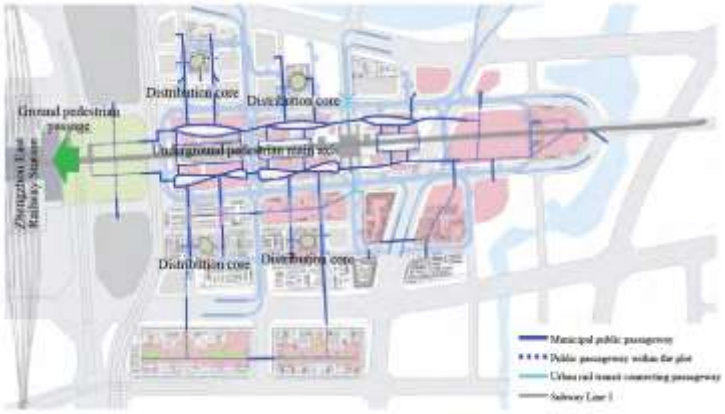

**Fig. 8** Underground pedestrian network of blocks

(3) Zoned and contiguous sky pedestrian corridors

The spatial organization within the block exhibits a clustered layout pattern. Centered around the New Era Plaza in the southern sector and the Station East First Street complex in the northern sector, two aerial corridor systems have been established (see Fig. 9). These systems strategically link key nodes such as Zhengzhou Passenger Transport General Station, public transportation hubs, major buildings, and critical road segments, thereby enhancing the integration of above-ground built environments within the block.

### 3.2.3 Connecting urban rail transit stations to facilitate TOD comprehensive development

Surrounding the highly trafficked Boxue Road Railway Station of Subway Line 1, two north-south pedestrian passageways are constructed, connecting the underground pedestrian spaces of the north and south functional areas and integrating with the first-floor underground pedestrian network of the fluid entity. This forms a transportation core that connects the underground spaces of multiple plots and the multi-level underground pedestrian networks. Achieving efficient coverage of the block within a 500-m walking distance from the urban rail transit station for the street blocks (see Fig. 10), pedestrians from multiple directions can quickly reach the high-speed railway station and the surrounding areas through the urban rail transit station and the underground pedestrian network, realizing the integration of the station and the city.

### 3.2.4 Integrating diverse functions to enhance the comfort of pedestrian space

In high-density three-dimensional mixed-use blocks, narrow and monotonous pedestrian spaces are significant factors causing a sense of oppression for pedestrians. Thus, while fulfilling the transportation function, the spaces of pedestrian facilities should incorporate as many public functions as possible. A strategy is proposed to integrate viewing and resting spaces into aerial corridors, creating diverse and engaging environments. By incorporating measures such as adding resting facilities, enriching spatial colors, integrating ecological landscape resources, and designing flexible spatial forms, the pedestrian infrastructure can not only facilitate passage but also achieve multiple functions including the organic organization of urban activities, provision of leisure and strolling areas, and hosting exhibition and publicity events. This approach enhances the diversity and comfort of the pedestrian environment.

**Fig. 9** Aerial pedestrian corridors of blocks

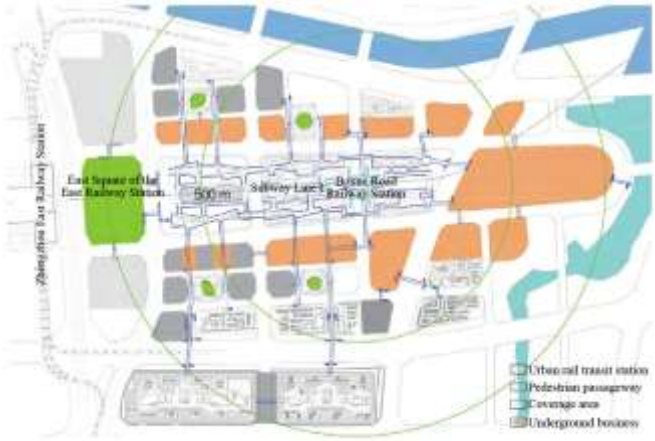


**Fig. 10** Coverage of subway stations in blocks

### 3.2.5 Enhancing the spatial characteristics of the block through a flexible and diverse aerial corridor system

To avoid the influence of aerial corridor systems on the overall landscape image of the block, based on factors such as building functions, facade forms, ownership relationships, and spatial characteristics, four construction forms of aerial corridors, namely the central penetrating type, the side type, the external type, and the platform type, are proposed (see Fig. 11 and Table 1). Among them, the central penetrating type is set between the commercial buildings of Huarun New Era Plaza, the side type is set between the buildings on the north side, the external type is set between the buildings on the north and south sides, and the fluid entity, between the cross-industry functional buildings and the passenger transport hub buildings, and across the Qili River to the north, while the platform type is set between the office and conference and exhibition buildings of Huarun New Era Plaza.

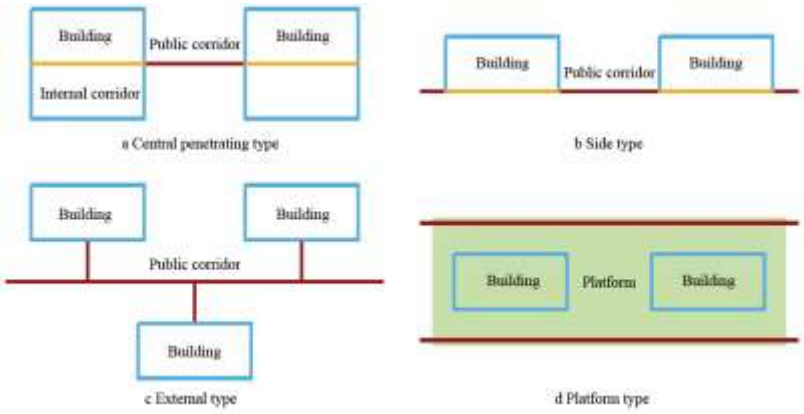


**Fig. 11** Four types of corridor construction forms

**Tab.1** Comparison of advantages and disadvantages of the four types of corridors

| Construction from | Advantages | Disadvantages |
|---|---|---|
| Central penetrating type | Directly connect the interior space of the building and help attract pedestrian flow<br>Occupy a small amount of public space and require less government investment | Lack open space and have poor public attributes |
| Side type | Have a minor impact on the interior space of the building<br>Prone to be open to the outside for an extended period | Have a certain influence on the building facade |
| External type | Independent of individual buildings and have a limited impact on building design<br>Have a strong public attribute and can be open 24 hours<br>Clear pedestrian direction | Occupy a large amount of public space<br>Basically constructed by the government and have a high investment pressure |
| Platform type | Conducive to creating a high-quality pedestrian environment<br>Have good accessibility and flexible space | Have certain requirements for the design of the building platform<br>Introduce a large number of public passenger flows to the private platform |

### 3.2.6 Utilizing schematic-based regulatory requirements to enhance the feasibility of the scheme

To ensure optimal implementation feasibility and provide effective guidance for scheme design, a schematic-based control and guidance approach has been adopted. This approach systematically documents the spatial coordinates, elevation data, and functional zoning of underground utility pipelines, vehicular corridors, and pedestrian facilities. The graphic-based plan explicitly specifies the vertical alignment, cross-sectional configuration, width, clearance, functional allocation, and spatial organization of both underground and aboveground pedestrian passages. Additionally, it incorporates essential safety and resilience requirements such as fire protection, ventilation, and flood prevention measures. The plan also defines the principal attributes and scale parameters of aerial corridors and underground passages (see Fig. 12).

## 4 Conclusions

As the spatial form of the block is evolving towards a high-density, three-dimensional, and mixed-use trend, researching the pedestrian system at the block scale has become a key task in exploring how to create urban spatial characteristics and enhance urban spatial quality from the meso-micro level. This paper takes the construction of the three-dimensional pedestrian system in the core area of the east square of Zhengzhou East Railway Station as an example, focusing on the relationship between the pedestrian system and the spatial form of the block. It is emphasized that the key points in constructing the pedestrian system within a high-density three-dimensional mixed-use block include conducting in-depth investigations and studies, accurately predicting demand, rationally planning the network, and clearly defining implementation strategies. The key points of innovation focus on alleviating the sense of oppression in high-density blocks, meeting diverse demands, and coordinating the three-dimensional development of blocks. Given the particularity of the case and the dynamic changes in the urban block spatial form, as well as the increasing demands for safety and resilience in urban space development, how to design a pedestrian system that can continuously adapt to the diversity of urban space and ensure safety and resilience requires ongoing discussion and research.

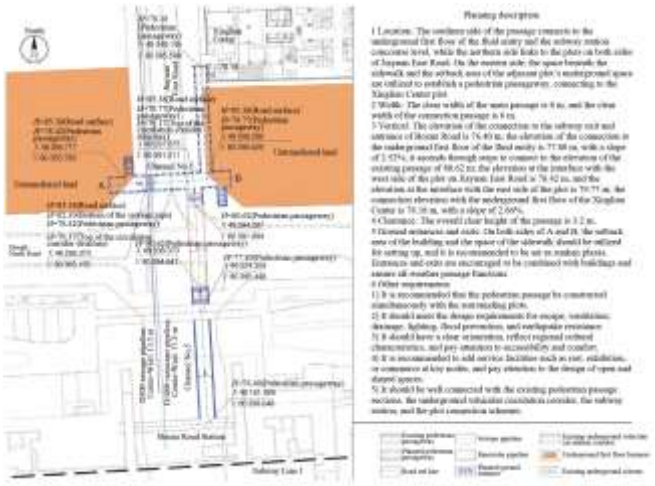

**Fig. 12** Implementation requirements for the schematic plans

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