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EXPLORATION OF URBAN DESIGN CONCEPTS FOR UNDERGROUND PUBLIC SPACES IN RENEWAL AREAS

—— A CASE STUDY OF BEIJING’S UNDERGROUND SPACE CONSTRUCTION

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Abstract: Beijing has entered an era of stock planning, facing dual demands: tight spatial resource constraints and high-quality development needs. As a vital "fourth national land resource," the development of underground space is key to urban expansion, functional optimization, and quality enhancement. With growing public demand for better underground public space environments and experiences, exploring systematic and human-centered urban design approaches is crucial.This paper clarifies the practical needs, core challenges, and fundamental principles for designing underground public spaces in urban renewal areas, establishing a theoretical foundation. Building upon urban design theory within the urban renewal context, it focuses on balancing historical preservation, community needs, and underground development. The study develops an integrated design framework addressing both spatial structure and micro-place construction.Using Beijing as a case study, the paper analyzes practical experiences and challenges in underground development during urban RENEWAL. It validates and refines the proposed design approach through case studies, extracting transferable insight.

Keywords: Urban renewal; Underground public space; Urban design; Spatial quality; High-quality development; People-oriented

1. INTRODUCTION

Urban development in Beijing, China has entered a stage of urban RENEWAL, shifting from large-scale expansion to optimizing existing stock and enhancing quality. Under these constraints, cities face the challenge of achieving high-quality development within limited spatial resources. As the "fourth national spatial resource" beyond terrestrial, aquatic, and aerial spaces, underground space demonstrates growing strategic value in this renewal aera. Significant progress has been made in utilizing underground space to alleviate urban traffic, enhance comprehensive carrying capacity, and improve urban resilience, establishing systematic research foundations and practical outcomes. Future development will transition from infrastructure support to accommodating daily human needs. However, a systematic urban design methodology for improving underground space quality remains underdeveloped—particularly regarding how refined design approaches can effectively enhance overall quality and comprehensive value of underground public spaces amid complex renewal constraints. This represents a critical gap requiring urgent resolution.

Therefore, in-depth exploration of underground space development within the urban RENEWAL context—particularly the planning and design of underground public spaces—holds significant practical and strategic significance. This study aims to establish a scientific and systematic urban design framework for underground public spaces. It seeks to offer both theoretical foundations and practical guidelines for Enhancing environmental quality of underground spaces、optimizing functional organization and strengthening spatial attractiveness. Ultimately, this approach advances sustainable urban development and meets the growing public demand for high-quality living environments.

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2. CHARACTERISTICS OF UNDERGROUND PUBLIC SPACES AND DEVELOPMENT NEEDS IN URBAN RENEWAL AREAS

2.1. Characteristics of Underground Public Spaces

The unique physical environment and functional requirements of underground public spaces present distinct challenges for urban design: **First**, regarding physical and environmental attributes: The notable absence of natural light and ventilation frequently results in dim lighting and poor air quality, adversely affecting occupants' physical and psychological well-being[1]. **Second**, the lack of spatial references and natural orientation cues complicates navigation. As extensions of above-ground functions, underground spaces demand tight coordination with surface-level elements—including access points, transportation links, and complementary commercial activities—to ensure functional integration. **Third,** confined environments often induce psychological discomfort, manifesting as sensations of confinement and oppression. **Fourth,** implementation is strictly constrained by geological factors (e.g., geological formations, groundwater levels, soil properties), significantly complicating design processes and introducing uncertainties[2].

2.2. Core Challenges in Underground Space Development Under Urban RENEWAL

Underground space development within urban renewal contexts faces multiple core challenges: First, significant difficulties exist in coordinating with existing built environments. In historic urban areas, issues like building foundation stability, intricate subsurface utility networks, heritage conservation requirements, and fragmented property rights—compounded by historically fragmented development patterns—have resulted in scattered, isolated underground spaces lacking integrated network planning. This undermines systemic efficiency and connectivity benefits. Concurrently, substantial barriers impede aboveground-underground integration. Development fragmented by property boundaries creates functional conflicts, compromised pedestrian flows, and disjointed landscapes, hindering synergistic spatial development. Furthermore, the sequential "aboveground-first, underground-later" approach exacerbates planning delays and uncertainties, necessitating refined coordination mechanisms and advance provisioning strategies. Lastly, the multi-ownership, mixed-use nature of complex underground spaces substantially increases operational complexity in maintenance, safety management, and emergency response.

Addressing these challenges constitutes a critical pathway toward high-quality underground space development and sustainable urban renewal—urgently requiring in-depth exploration by academia and industry.

2.3. Practical Demands for Underground Public Space Development Driven by Urban RENEWAL

As cities transition into urban renewal phases, the strategic value of underground public spaces intensifies, positioning them as critical pathways to meet multifaceted urban development needs:

- **Enhancing Public Space Quality and Vitality**. Urban renewal prioritizes human-centered environments. Underground public spaces—as integral components of urban spatial systems—require thoughtful design to create **pleasant, safe, and attractive social venues**. Integrating cultural, recreational, and experiential functions can revitalize historic districts.
- **Augmenting Urban Functions and Infilling Gaps**. Historic urban areas often suffer from **inadequate and unevenly distributed** public services, municipal infrastructure (e.g., parking, utility tunnels, substations), and civil defense facilities. Underground spaces effectively address these gaps through functional diversification, strengthening public service capabilities[3].
- **Optimizing Transportation and Pedestrian Networks**. Integrated with transit systems, continuous, accessible, and comfortable underground pedestrian networks improve mobility experiences, connect key nodes, and enable pedestrian-vehicle separation.
- **Preserving Cultural Heritage and Identity**. Through measured and context-sensitive interventions, underground spaces can address community needs while accommodating museums or galleries that activate cultural heritage, fostering regionally distinctive underground environments.
- **Advancing Urban Resilience and Sustainability**. Eco-design and low-impact development models promote sustainable underground space utilization, directly contributing to urban resilience goals.

3. URBAN DESIGN FRAMEWORK FOR UNDERGROUND PUBLIC SPACES IN RENEWAL AREAS

3.1. Theoretical Foundations

Urban design is a discipline examining the interplay between physical urban forms and human activities/perceptions—provides fundamental theoretical underpinnings for underground public space design. Kevin Lynch's *Image of the City* emphasizes five key elements (paths, edges, districts, nodes, landmarks) crucial for spatial cognition[4]. Jan Gehl advocates human-centered approaches, prioritizing behavioral needs and public life while stressing how the quality of streets, squares, and other public spaces determines urban vitality[5]. Gordon Cullen's *Townscape* theory reveals methods for crafting engaging urban experiences through spatial sequencing and placemaking. Collectively, these theories highlight the dynamic relationship between activity, space, and perception, underscoring the imperative to create meaningful places that foster social interaction. This is particularly critical in underground environments lacking spatial references, where clear spatial organization and distinctive nodal design are essential for establishing user orientation and spatial comprehension.

3.2. Design Objectives

The urban design of underground public spaces in stock renewal areas fundamentally prioritizes human activities, experiences, and perceptions—transcending traditional engineering-centric mindsets to achieve human-centered multi-scale integration and systematic development. This approach aims to create multifunctional, interconnected, pleasant, vibrant, and sustainably resilient underground public space systems that organically extend and complement above-ground urban life. Focusing on internal structural organization, functional layouts, and pedestrian circulation systems within underground networks, this study establishes a spatial framework through nodal design and network design to advance urban design theory for underground environments.

3.3. Structural Dimension: Organizational Framework and Circulation System Design

3.3.1. Shallow Underground Spaces

In renewal areas, fragmented development of underground spaces has resulted in isolated "underground pods." Priority should be given to establishing integrated shallow underground pedestrian networks through optimizing hierarchical connectivity, enhancing wayfinding systems, and improving spatial sequencing, rhythm, and legibility.

A multi-tiered pedestrian network must be structured according to pedestrian flow volumes and destination significance, comprising primary pathways (connecting major nodes and zones), secondary pathways (linking minor nodes or plots), and connector pathways (accessing individual buildings or facilities). Path alignment should align with natural movement patterns, key functional distributions, and nodal attractions to effectively guide pedestrian flow while avoiding excessively long, monotonous, or disorienting corridors.

Spatial experience should be enhanced through deliberate variations in passage width, clear height, and spatial transitions (e.g., from confined passages to open atria), coupled with sequential organization of flooring materials, wall finishes, ceiling configurations, lighting schemes, and color applications. This approach creates rhythmic, engaging, and intuitively navigable spatial sequences that reinforce environmental legibility.

Implementation requires incentive policies and technical guidelines promoting underground interconnectivity between adjacent plots and new/renovated developments. Specific measures include mandating interface locations, standardizing cross-section dimensions, and specifying elevation requirements to integrate fragmented point-based and linear spaces into cohesive networks.

3.3.2. Integrated Design of Underground Spatial Nodes

Key nodal integration requires coordinated design across three typologies: transportation hubs, commercial centers, and cultural venues.

At transportation hubs (subway stations, bus terminals), traditional corridor-style transfers should be transformed into living-room-style or street-style interchange spaces to eliminate monotonous underground walking experiences. This facilitates seamless transfers between transportation modes while establishing direct underground connections between hubs and adjacent commercial, office, and residential areas, enabling gradual transitions from public to private realms.

For commercial centers, underground spaces should extend and complement above-ground retail through compelling commercial atmospheres, featured atriums or sunken plazas, and diverse commercial formats that attract pedestrian flow and enhance commercial vitality.

Cultural and sports facilities should incorporate semi-underground designs, incorporating sunken plazas, lightwell atriums, and underground squares at strategic nodes. These open/semi-open public spaces not only

improve natural lighting and ventilation but also provide venues for recreation, social interaction, and small-scale exhibitions—strengthening the public character of underground environments while reinforcing visual and spatial connections with surface-level urban fabric.

3.4. Micro-Level Dimension : Placemaking and Environmental Quality Enhancement

Micro-scale design critically shapes user experiences and environmental quality in underground spaces. Key strategies include spatial proportioning, natural element integration, and artificial environment optimization to enhance comfort.

- **Spatial Proportioning and Interface Design**: Space dimensions (width, height, length) must align with functional typologies, pedestrian flows, and activity characteristics to prevent oppressive or excessively vast sensations. Critical interfaces—walls, floors, and ceilings—require deliberate material selection, color schemes, textural qualities, and lighting treatments that support functional objectives and atmospheric goals while ensuring navigational clarity, durability, maintainability, and aesthetic coherence.
- **Integration and Simulation of Natural Elements**: Natural light introduction via skylights and light tube systems reduces reliance on artificial lighting in deep underground areas. Natural ventilation leverages wind/thermal pressure effects through optimized vent placement to supplement mechanical systems, ensuring air freshness. In illuminated zones, shade-tolerant vegetation and ecological water features enhance aesthetics and microclimates.
- **Artificial Environment Refinement**: Comprehensive improvements encompass advanced lighting and acoustic design, systematic wayfinding and information systems, public art reflecting regional cultural identity,user-oriented amenities addressing behavioral need.

4. DESIGN MODELS AND BEIJING PRACTICES

Beijing has pioneered diverse approaches to underground public space utilization amid stock renewal. Representative case studies illustrate practical applications of the proposed urban design framework.

4.1. Networked Underground Spaces and Vitality Enhancement in Urban Cores: Cases of Wangfujing/Financial District Renewal

Urban cores (e.g., Wangfujing, Financial Street, CBD) feature high-density built environments with persistent traffic congestion and commercial competition, necessitating enhanced public space quality and economic vitality. Early underground developments suffered from poor connectivity, outdated facilities, and obsolete commercial formats.

Regionally, unified underground planning aligned with transit integration establishes district-wide pedestrian networks and comprehensive service systems. Locally, new or renovated underground passages connect disparate commercial buildings, offices, hotels, and cultural facilities into networked retail complexes. Strategic placement of sunken plazas and atriums creates attractive public nodes that channel pedestrian flow and intensify commercial vibrancy.

At the micro-scale, high-quality commercial environments are achieved through unified wayfinding systems, optimized lighting and HVAC controls, premium finishes, and culturally resonant art installations. These high-investment projects demand intensive coordination; success hinges on unified planning, phased implementation, and refined operational management — particularly regarding property rights delineation and centralized administration to enable effective shallow-space interconnectivity.

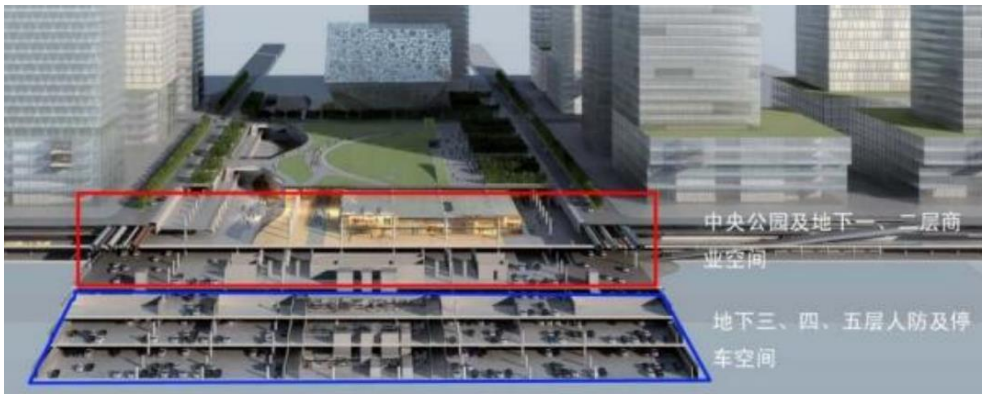

Figure 1. *Beijing CBD Core Area Vertical Design Schematic*
(B1-B2: Commercial Space; B3-B5: Civil Defense & Parking)

4.2. Transforming Existing Transit Stations into Compact Urban Lounges: Ping'anli Metro Station Integration Project in Xicheng District, Beijing

Located within Beijing's core functional area adjacent to the historic Xinjiekou district, Ping'anli Station serves as a quadruple-line interchange (M4, M6, M19, planned M3). The renovation project replaces traditional corridor-style transfers with a concourse-style interchange hall. A triple-height atrium channels natural light deep underground, enhancing spatial comfort while strengthening navigational clarity.

The newly added underground integration zone features pre-embedded interfaces for future connections to eastern and northern developments. This "satellite concourse" optimizes multimodal transitions, catalyzing a symbiotic "transit-community" development model. Crucially, courtyard-inspired dispersed volumes mitigate the visual impact of large-scale infrastructure on the surrounding low-rise historical fabric, preserving neighborhood character through sensitive massing articulation.

Figure 2. *Design of Public Reception Space at Ping'anli Station Underground Hub*

4.3. Semi-Underground Cultural Facility: Beijing's Three Hills and Five Gardens Art Center

Located in the northwest corner of Haidian Park, Haidian District, the Three Hills and Five Gardens Art Center is Beijing's first non-heritage-site art museum developed underground. Spanning 21,000 m² with 19,000 m² situated below grade, its four subterranean levels extend over 30 meters deep. A 14-meter clear height integrated with lightwells floods exhibition spaces with natural light, ensuring visual transparency and comfort.

As a custodial, research, and interpretive hub for Haidian's cultural legacy across eras, the center advances community cultural development through diverse public programs. It fulfills a dual mandate: safeguarding regional heritage while fostering artistic exchange within a modern cultural complex harmonizing conservation, exhibition, and natural landscape integration.

Figure 3. *Above-Ground & Semi-Submerged Structures of Haidian San Shan Wu Yuan Arts Center*

4.4. Community-Driven Underground Micro-Space Activation: Ganluxiyuan Digua Community in Chaoyang District

Digua Community exemplifies Beijing's innovative repurposing of derelict underground spaces—abandoned basements and civil defense shelters—into neighborhood hubs through *spatial reconfiguration + community co-creation*. The Ganluxiyuan project transformed 1,500 m² of basement into a "Shared Living Room" featuring free-access zones (book café, "Digua University") and fee-based amenities (board game rooms, table tennis).

Similarly, Anyuan Beili's 560 m² Digua Community integrates "Task-Lit Reading Nooks" and "Community Fitness Corners," hosting elder Peking opera clubs and student gatherings. This model pioneers a *multi-stakeholder governance framework* with government oversight, resident-led operations, and cross-sector partnerships.

Figure 4. Underground Public Space Renewal: DiGua Community
(Left: Ganluxiyuan, Chaoyang | Right: Anyuan Beili Community)

5. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

High-quality underground public spaces transcend mere transportation nodes or commercial extensions, emerging as vital venues for civic interaction, cultural engagement, and recreational activities that constitute modern urban vitality. Within stock renewal contexts, further research should advance:

Intelligent Systems: Implementing digital twins and IoT technologies across underground space lifecycles to establish smart management frameworks.

Resilience Enhancement: Optimizing disaster response capabilities through risk-informed design that strengthens mitigation and recovery functions.

Eco-Innovation: Developing energy-efficient systems and ecological materials for low-carbon operations.

Adaptive Reuse: Innovating retrofitting techniques and reprogramming strategies for civil defense structures and obsolete facilities.

Governance Reform: Revising property rights regimes and planning approvals to enable integrated administration.

Coordinated advancement in these domains will catalyze high-quality underground space development, promoting sustainable spatial utilization and enhanced human habitats.

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