

Article

Research on the Renovation Design Path for Enhancing the Efficiency of Mixed-Use Office and Retail Spaces

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Abstract: Urbanization and the evolving demands of modern commercial environments have increasingly highlighted the necessity for sustainable urban renewal, particularly concerning existing building stock. This article focuses on how to systematically enhance the operational and spatial efficiency of mixed-use office and retail spaces during the process of existing building renovation. By conducting a comprehensive analysis from the perspective of architectural space design, this study addresses the inherent complexities of integrating diverse functional requirements within a single structure. After clarifying the core principles of spatial organization for multi-functional environments and establishing a renovation framework based on benefit orientation, specific analyses are conducted on critical issues. These include functional layout optimization, pedestrian flow organization, dynamic space usage, and the provision of human-centric facilities. To resolve these challenges, multiple targeted strategies are proposed, such as reshaping functional relationships, optimizing circulation route design, implementing flexible space conversions, and integrating advanced building facilities and smart technologies. Furthermore, a rigorous quantitative indicator system and detailed case comparisons are utilized to empirically evaluate changes in space efficiency, flow intensity, and overall energy consumption. The analytical results demonstrate that, under the premise of optimizing both the spatial structure and underlying business strategies, the proposed design path can effectively improve the utilization rate of composite spaces and enhance management orderliness. Ultimately, this research provides a robust theoretical foundation and practical reference for future sustainable renovation projects in high-density urban contexts.

Keywords: mixed-use spaces; spatial efficiency; building renovation; urban renewal; architectural design

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1. Introduction

As urban development progresses and the availability of usable space diminishes, mixed-use office and retail environments have emerged as a critical solution for maximizing spatial efficiency. Traditional building designs, such as standalone office complexes or single-function commercial spaces, often fail to address the multifaceted demands of modern urban life. This results in significant inefficiencies and underutilization of valuable space. To address these challenges, it is essential to explore innovative approaches to spatial design that prioritize multifunctionality and adaptability. By analyzing key aspects such as functional zoning, circulation systems, and the integration of advanced technological solutions, it becomes possible to optimize the performance and usability of mixed-use spaces. Such an approach not only enhances the practical utility of urban environments but also contributes to sustainable development by making better use of limited resources [1].

2. Theoretical Foundation for the Renovation Design of Mixed-Use Office and Retail Spaces

2.1. Organizational Logic of Composite Functional Spaces

The organizational logic of multi-functional spaces revolves around the systematic integration of diverse functional units to create cohesive yet interconnected spatial arrangements. Mixed-use office and retail spaces are not simply a juxtaposition of office and commercial functions; rather, they are designed with a comprehensive approach that considers spatial hierarchy, functional interfaces, and interaction points [2]. These designs take into account the varying needs, behavior patterns, duration of stay, and activity levels of different user groups. By carefully structuring functional zones, optimizing flow connections, and enhancing public spaces, these spaces aim to achieve a balance between distinct functionalities while fostering collaboration and resource sharing. The emphasis lies in maintaining clear functional boundaries while ensuring seamless interconnectivity, thereby creating an environment that supports both individual and collective activities in a harmonious manner.

2.2. The Thinking of Upgrading Existing Facilities Based on Space Efficiency

The spatial renovation under the condition of existing building update is not merely about repairing the original site or making local replacements. The core of this process lies in reconstructing and reconfiguring the spatial value within the existing building environment [3]. For office and retail spaces, the principle of "prioritizing efficiency" requires starting from the question of "how the given space can accommodate more appropriate behaviors," inspecting the structural composition, traffic relationships, interface forms, and public space settings. This approach transforms the originally relatively stable spatial units into a system with multiple functional capacities. Theoretically, this method is grounded in the principles of resource-efficient renovation, adaptive reuse, and functional conversion, emphasizing the enhancement of spatial value within limited conditions. It recognizes the improvement of place utilization through low-impact, gradual, and structural optimization models. This strategy is not confined to expanding the physical volume or introducing new business types. Instead, it establishes a more adaptable and stable organizational framework by analyzing the potential, usability, and transformability of the original space. This framework supports the efficient operation of diverse and complex spatial activities. By focusing on flexibility and adaptability, this method ensures that existing spaces can meet evolving demands while minimizing unnecessary interventions and maximizing resource efficiency.

3. Challenges in the Renovation of Mixed-Use Office and Retail Spaces

During the renovation process of mixed-use office and retail spaces, one of the most significant challenges arises from the inherent contradiction between the original architectural design and the diverse functional requirements of the new usage. Many existing buildings were initially constructed with a singular purpose, either as office buildings or retail shops, and their structural elements—such as column spacing, floor height, entrance configurations, vertical transportation systems, and equipment pipeline layouts—were tailored to these specific uses. When transitioning to a composite renovation phase, these fixed physical attributes often become barriers to accommodating new, multifaceted functions. Office spaces, for instance, are typically designed to prioritize stability, continuity, and a quiet working environment, whereas retail spaces emphasize openness, dynamic flow, and ease of access for customers. These contrasting requirements lead to significant differences in spatial interfaces, environmental atmospheres, and user behavior patterns [4]. If the renovation design fails to effectively reconcile these disparities, it can result in poorly defined functional zones, disorganized spatial connections, and overlapping usage areas. Such issues can disrupt the interaction among various user groups within the shared public space, ultimately hindering the operational efficiency and overall harmony of the composite environment.

4. Design Approaches for Enhancing the Utilization Efficiency of Mixed-Use Office and Retail Spaces

4.1. Reconstructing the Functional Layout of the Composite Space

The reconfiguration of the composite space primarily involves optimizing the spatial layout by integrating the distinct characteristics of office areas and retail activities. This approach aims to balance the overall carrying capacity of the building while improving the comprehensive utilization rate of the space. To achieve this, the spatial types can be categorized into three levels: "core area - transitional area - public area." Office units, which require stable environmental conditions for productivity, can be strategically placed in quieter locations or on higher floors to minimize disturbances [5]. Conversely, retail spaces, which prioritize visibility and accessibility, can be positioned on the first floor near entrances and exits to attract foot traffic. The central hall, public rest areas, and open conversation zones can serve as transitional spaces, facilitating seamless interaction between office and retail functions. Furthermore, the spatial usage can be quantitatively assessed by introducing the usage area coefficient, denoted as η , which is calculated using the formula $\eta = A_u / A_t$, where A_u represents the usable area and A_t represents the total building area. This coefficient provides a measurable indicator of the improvement in space utilization before and after functional layout optimization.

$$\eta = \frac{A_u}{A_t} \# (1)$$

Among these metrics, η serves as a critical parameter for evaluating spatial efficiency, offering insights into how effectively the building's layout supports its intended functions. Additionally, the pedestrian density model can be employed to analyze the distribution of people within key areas of the space. In this model, q represents the number of people per unit area, N denotes the total number of people, and A signifies the corresponding area of the space. By applying this model, planners can assess whether the space's capacity and accessibility align with user needs, ensuring that congestion is minimized and movement flows are optimized. This dual approach—combining the usage area coefficient and pedestrian density model—provides a comprehensive framework for evaluating and enhancing the functionality of mixed-use spaces [6].

$$q = \frac{N}{A} \# (2)$$

Key areas within the composite space can be analyzed using the pedestrian density model to ensure optimal functionality and user experience [3, 7]. The parameter q , which quantifies the number of people per unit area, serves as a critical measure for identifying potential congestion points and evaluating the adequacy of spatial capacity. By calculating q as N divided by A , where N represents the total number of occupants and A is the area of the space, planners can pinpoint areas that may require adjustments to improve accessibility and flow. This analysis is particularly useful in high-traffic zones, such as retail areas, where maintaining a balance between accessibility and comfort is essential. By integrating this model with other spatial optimization strategies, planners can create environments that are both efficient and user-friendly.

A practical example of this approach can be observed in the renovation of a three-story mixed-use space in the Suzhou Industrial Park of Jiangsu Province. The total building area A_t is 3,000 square meters. Prior to the renovation, the office, commercial, and public areas within the building were segregated, resulting in an effective usable area A_u of 2,220 square meters. The usage area coefficient was calculated as $\eta = 2,220 / 3,000 = 0.74$. The retail area on the first floor occupied approximately 600 square meters and accommodated up to 180 customers during peak hours, leading to a pedestrian density of $q = 180 / 600 = 0.30$ people per square meter. This high density highlighted significant congestion issues. During the renovation, the retail area on the first floor was expanded to 780 square meters, the second floor was reconfigured to include shared negotiation and office spaces totaling 260 square meters, and the third floor was designated for independent office units. Vertical transportation and public nodes were also reorganized to improve connectivity. Post-renovation, the effective usable area increased to 2,460 square meters, resulting in a new usage area coefficient of $\eta = 2,460 / 3,000 = 0.82$. The peak pedestrian density in the retail area decreased to $q = 180 / 780 \approx 0.23$ people per square

meter, alleviating congestion and enhancing accessibility. This renovation demonstrates how strategic spatial adjustments can clarify structural layouts, smooth transitions between office and retail functions, and significantly improve overall space utilization efficiency [8].

4.2. Optimize the Flow System Involving Multiple Entities

Optimizing the streamline system of multiple entities involves a comprehensive approach to reconstructing entry paths, traffic organization, and node transformation, tailored to the behavioral differences among office workers, consumer groups, and logistics service personnel. A key strategy is the layering of different types of flow lines through the organization of "diversion connection guidance." For instance, the spatial distinction between the Princess Office entrance and the commercial entrance can be achieved by combining vertical transportation systems such as elevators, escalators, and stairs to create relatively independent traffic systems. Additionally, buffer spaces and transition nodes can be strategically placed at shared interfaces to facilitate the orderly conversion of different pedestrian flows. This approach not only enhances the efficiency of movement but also minimizes potential conflicts between different user groups. Furthermore, the integration of a guidance system and spatial interface design can significantly improve path recognition, ensuring that users can navigate the space intuitively. To quantitatively analyze and optimize the streamline system, a pedestrian density model can be introduced. This model allows for the assessment of key nodes by examining the density of main entrances, traffic nodes, and shared spaces. By identifying areas at risk of congestion, adjustments can be made to the spatial scale and traffic paths to enhance flow efficiency [7]. For instance, if a particular entrance exhibits high pedestrian density, its width can be increased, or alternative routes can be introduced to alleviate pressure. Moreover, unit time traffic indicators can be employed to further refine the optimization process.

$$q = \frac{N}{t} \# \quad (3)$$

Among these indicators, q represents the number of people passing through a specific route per unit time (people/s), while t represents time. This calculation provides a quantitative measure of the throughput of a given flow line, which can then serve as a basis for optimizing various aspects of the traffic system. For example, the width of the flow line can be adjusted to accommodate higher throughput, ensuring that the system can handle peak traffic volumes without congestion. Similarly, the capacity of nodes, such as intersections or shared spaces, can be evaluated and modified to improve their ability to manage pedestrian flow. Traffic organization methods can also be refined based on these indicators, enabling a more efficient and orderly movement of people. By systematically analyzing these factors, it becomes possible to create a traffic system that not only meets the needs of its users but also operates at an optimal level of efficiency. This approach underscores the importance of data-driven decision-making in the design and management of complex flow systems.

Consider the renovation project of a mixed-use office and retail complex in Yuhang District, Hangzhou City, Zhejiang Province as a practical example. Initially, the design did not differentiate between office and commercial entrances, resulting in a shared public hall on the first floor measuring approximately 400 square meters. During peak hours, this space accommodated about 240 people, leading to a flow density of $q = 240 / 400 = 0.60$ people per square meter. This high density restricted local patency, as the main passage, with a width of 3 meters, experienced a throughput of approximately 150 people per minute, corresponding to a flow rate of $q = 150 / 60 = 2.5$ people per second. The congestion was severe, highlighting the need for a more efficient design. During the renovation, office entrances were relocated to one side, and a dedicated elevator group was added to provide direct access to office floors. For commercial traffic, the flow was redirected to the atrium and escalator system, with a 120-square-meter transitional waiting space introduced in the public area to disperse the flow. Post-renovation, the

shared hall accommodated approximately 180 people during peak hours, reducing the flow density to $q = 180 / 400 = 0.45$ people per square meter. Additionally, improvements in path planning and flow guidance design reduced the throughput of the main passage to 120 people per minute, corresponding to a flow rate of $q = 120 / 60 = 2.0$ people per second. This case study demonstrates that by organizing multi-subject flow lines hierarchically and optimizing key nodes, it is possible to alleviate pressure in critical areas while enhancing the operational efficiency and spatial order of the overall flow system.

4.3. Enhance the Elastic Transformation Capability of Spatial Units

Enhancing the elastic transformation capability of spatial units involves achieving functional transformation and efficiency optimization across varying times and scenarios. This can be accomplished through strategies such as variable interfaces, modular construction, and shared principles. For instance, movable partitions, foldable interfaces, and modular furniture systems can be employed to dynamically adjust space boundaries [6, 9]. These adjustments enable phased transitions between office areas, commercial zones, and public spaces within the same physical environment. By reserving equipment interfaces and standardizing unit sizes, the cost of functional changes can be minimized. Additionally, introducing space utilization rate indicators provides a quantitative measure of transformation effectiveness. This metric evaluates how efficiently a space is used over a given period, offering valuable insights for further optimization.

$$U = \frac{T_u}{T_t} \# \quad (4)$$

The space utilization rate, denoted as U , is calculated by dividing the actual usage time of a specific space (T_u) by the total available time within a statistical period (T_t). This metric reflects the temporal efficiency of space usage [10, 11]. Furthermore, the analysis can be complemented by the unit area carrying capacity index, which measures the intensity of space usage under different functional conditions. This index, represented as E , is determined by dividing the number of people using the space (N) by the total area of the space (A). Together, these metrics provide a comprehensive understanding of both time-based and spatial efficiency, enabling the formulation of flexible conversion strategies tailored to specific needs.

$$E = \frac{N}{A} \# \quad (5)$$

The unit area carrying capacity index, E , serves as a critical measure of spatial intensity, calculated by dividing the number of occupants (N) by the area of the space (A). This index is particularly useful for assessing how effectively a space accommodates varying functional demands. By integrating this index with temporal data, such as the space utilization rate (U), a more nuanced understanding of spatial performance can be achieved. This dual analysis facilitates the development of targeted strategies for optimizing space usage, ensuring that both time and spatial dimensions are effectively leveraged to meet diverse operational requirements.

A practical example of enhancing spatial elasticity can be observed in the renovation of a 500-square-meter area on the second floor of an urban complex in Nanshan District, Shenzhen City, Guangdong Province. Initially designated for office support functions, this space was utilized for approximately 6 hours daily, resulting in a low space utilization rate of $U = 6 / 24 = 0.25$. To address this inefficiency, movable partitions and modular design methods were implemented, dividing the area into a collaborative office zone and a temporary product display section. During weekdays, the space functions as a meeting and office area, while during evenings and weekends, it transforms into a brand pop-up store and event venue. Post-renovation, the average daily usage time increased to 14 hours, raising the utilization rate to $U = 14 / 24 \approx 0.58$. Additionally, during retail activities, the space accommodates approximately 200 people, resulting in a unit area carrying capacity of $E = 200 / 500 = 0.40$ people per square meter [12, 13]. This transformation not only significantly improved temporal efficiency but also enhanced the space's adaptability to diverse functional requirements. By enabling variable organization and time reuse, the

renovation has imbued the space with greater operational flexibility and vitality, demonstrating the practical benefits of elastic spatial design.

4.4. Strengthening Facility Integration and Embedding of Technical Systems

The renovation of multi-purpose spaces should prioritize integrated configuration and embedded integration of technical systems, ensuring that environmental adaptability, energy consumption requirements, and operational coordination are fully considered. This approach aims to enhance the operational efficiency of spaces while maintaining their flexibility. Implementation can be approached through three key aspects: First, collaborative design of HVAC, lighting, water supply and drainage, and information systems can be undertaken to minimize the space occupied by equipment and optimize equipment utilization. This integration not only reduces redundancy but also ensures seamless functionality across systems. Second, the establishment of an intelligent control platform utilizing advanced sensors and data collection technologies enables immediate responses to changes in temperature, brightness, and personnel flow, ensuring that the space adapts dynamically to user needs. Third, the combination of reservation management plans with feedback information mechanisms can refine management methods for public and high-frequency spaces, improving overall operational efficiency. In terms of technical evaluation, the heat transfer calculation formula commonly used in building thermal engineering provides a quantitative basis for analyzing insulation performance and energy consumption reduction. Specifically, Q represents the heat transfer quantity of the enclosure structure per unit time (W), U is the heat transfer coefficient (W/(m²·K)), A is the heat transfer area (m²), and ΔT is the temperature difference between inside and outside (K). This formula is instrumental in identifying areas for improvement in building insulation to achieve energy savings.

$$Q=U \cdot A \cdot \Delta T \# (6)$$

Among them, Q represents the heat transfer quantity of the enclosure structure per unit time (W), U is the heat transfer coefficient (W/(m²·K)), A is the heat transfer area (m²), and ΔT is the temperature difference between inside and outside (K). These parameters are essential for analyzing how to enhance the insulation performance of buildings, thereby reducing energy consumption. Additionally, in the domain of power management, the power calculation formula serves as a critical tool for quantifying energy usage under varying operational modes. Specifically, W represents the power consumption (kWh), P is the equipment power (kW), and t is the operating time (h). This formula provides a robust quantitative framework for evaluating facility integration and technology embedding, enabling precise adjustments to energy consumption based on system operation dynamics [14]. By leveraging these formulas, stakeholders can make informed decisions to optimize energy efficiency and operational effectiveness in renovated spaces.

$$W=P \cdot t \# (7)$$

In the formula, W represents the power consumption (kWh), P is the equipment power (kW), and t is the operating time (h). This calculation method offers a quantitative basis for assessing energy consumption changes under different system operation modes, facilitating the integration of facilities and embedding of technologies. For example, by analyzing power consumption patterns, it becomes possible to identify inefficiencies and implement targeted improvements. This approach ensures that energy usage aligns with operational demands, reducing waste and enhancing overall system performance. Furthermore, the formula supports the development of predictive models that can anticipate energy needs based on historical data and real-time inputs, enabling proactive adjustments to system operations. Such methodologies are integral to achieving sustainable energy management in modern infrastructure projects.

Take a certain renovation project in Chaoyang District, Beijing as an example. The first and second floors were designated for retail and shared spaces, while the third floor was allocated for office areas [3]. Prior to the renovation, there was a notable lack of interconnection between the lighting and air conditioning systems, leading to

inefficiencies in energy usage and operational coordination. For one retail area with an approximate size of 200 square meters, the heat transfer coefficient was initially 1.5 W/(m²·K), and the temperature difference between indoors and outdoors during winter was about 10 K. Consequently, the heat transfer amount was calculated as $Q = 1.5 \times 200 \times 10 = 3000$ W. Simultaneously, the total power of the lighting system in this area was 10 kW, with an average daily operating time of approximately 12 hours, resulting in electricity consumption of $W = 10 \times 12 = 120$ kWh. During the renovation process, high-performance insulation materials were introduced, reducing the heat transfer coefficient to 0.8 W/(m²·K). Additionally, an intelligent lighting and air conditioning linkage control system was implemented to adjust operations based on personnel flow and time variations. Post-renovation, the heat transfer amount decreased to $Q = 0.8 \times 200 \times 10 = 1600$ W, while the average daily operating time of the lighting system was reduced to 8 hours, corresponding to electricity consumption of $W = 10 \times 8 = 80$ kWh. This comprehensive optimization not only achieved significant energy savings but also enhanced the utilization rate and management level of the infrastructure, demonstrating the value of integrated technical systems in modern renovation projects.

5. Conclusion

This article conducts a systematic analysis of strategies for improving the efficiency of mixed-use office and retail space utilization from three interrelated dimensions: theoretical foundations, practical constraints, and renovation pathways. On this basis, it proposes a design framework centered on functional layout reconstruction, circulation system optimization, flexible transformation of spatial units, and coordinated integration of facilities and technical systems. The findings indicate that the efficient operation of composite spaces depends not only on the rational organization of physical space, but also on the coordinated adjustment of management mechanisms, user behavior patterns, and temporal allocation of functions. Therefore, renovation should address both spatial structure and operational logic, so that organizational order, adaptability, and service performance can be enhanced while still responding to diverse and changing demands. In addition, the introduction of quantitative indicators and case-based comparative analysis provides a more objective basis for evaluating existing utilization conditions and renovation outcomes, thereby improving the rigor, feasibility, and scientific validity of subsequent design decision-making.

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