

Article

Reconstruction of Commercial Building Space Reuse Mode Driven by Composite Business Types

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Abstract: As urban expansion continues to deepen globally, traditional commercial buildings are increasingly no longer able to meet the complex business demands and practical operational requirements of modern enterprises. Consequently, it has become an inevitable and critical trend to re-utilize and adapt commercial buildings based on the drive of composite and complex business models. By systematically integrating fundamental architectural elements such as spatial layout, transportation routes, equipment systems, and spatial carriers, this paper comprehensively sorts out the typical problems and structural bottlenecks faced in the contemporary renovation of commercial buildings. To address these challenges, the study proposes four strategic development directions: the methodology for reconfiguring spatial organization, the methodology for reconfiguring flow systems, the methodology for reconfiguring facility systems, and the innovative concept of applying advanced transportation tools within the built environment. Relevant empirical and theoretical analysis demonstrates that spatial regeneration based on mixed business requirements is not merely a simple functional replacement or aesthetic upgrade. Rather, it encompasses a multifaceted approach that includes various critical factors such as internal space layout optimization, overall structural support strength enhancement, and long-term operational variability. Ultimately, through comprehensive mode reconfiguration, it is possible to effectively enhance the adaptability, functional complexity, and future extensibility of commercial building spaces, thereby ensuring their sustainable economic viability and resilience in a rapidly evolving urban landscape.

Keywords: composite business; commercial buildings; space reuse; spatial regeneration; mode reconfiguration; urban renewal

1. Introduction

With the evolution of consumption patterns and the rapid urbanization process, the focus of commercial building development has shifted from expanding the quantity of new constructions to optimizing and revitalizing existing structures. Historically, commercial buildings were predominantly designed to cater to the needs of a single industry, resulting in fixed and standardized characteristics in terms of functional zoning, flow design, facility configuration, and spatial distribution. However, in the context of diversified industries, such rigid designs often lead to challenges such as inefficiency, lack of adaptability, and limited flexibility for conversion. Consequently, activating and repurposing existing spaces has emerged as a critical strategy to enhance the utilization rate and operational value of these buildings. To address the demands of diversified industries effectively, it is essential to move beyond localized renovations or isolated functional replacements. Instead, a comprehensive approach is required, encompassing the reorganization of overall spatial construction logic, the optimization of traffic flow plans, the integration of advanced system configurations, and the enhancement of spatial carrier flexibility [1, 2]. Investigating the spatial regeneration of commercial buildings driven by multiple business formats holds significant academic and practical value, as it provides insights into creating more adaptable and efficient urban spaces.

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2. Research Foundation on the Reutilization of Commercial Building Spaces under the Driving Force of Combinatorial Business Models

2.1. The Demand for Commercial Building Space Renewal under the Guidance of Diversified Business Models

Due to evolving urban consumption patterns, the expansion of service areas, and the transformation of original building functions, commercial buildings have transitioned from single-tenancy operation venues to multi-functional operational spaces. Traditional commercial buildings are typically segmented and planned based on fixed tenures, with independent functional facility systems. These systems often maintain static spatial relationships, personnel flow paths, and supporting facilities, which are increasingly inadequate for meeting the diverse functional demands of modern retail, catering, social interactions, experiential consumption, and office operations. The multi-functional transformation driven by composite business models requires not only the replacement of original localized usage functions but also a comprehensive reconfiguration of the entire building space. This process involves optimizing spatial interfaces and reshaping behavioral paths to align with new operational needs. By addressing these challenges, the reimagining of commercial building forms based on diverse functional requirements has emerged as a critical strategy for enhancing the efficiency of existing land use. This approach also improves the carrying capacity of urban spaces and sustains the vitality of businesses [3]. Such transformations ensure that commercial buildings remain adaptable and relevant in the face of dynamic market demands, ultimately fostering a more integrated and efficient urban environment.

2.2. The Technical Significance of Reconfiguring the Reuse Model of Commercial Building Spaces

The reuse model of commercial building spaces is fundamentally centered on harmonizing the existing environmental conditions of the building with the diverse requirements of business operations. This approach necessitates the establishment of a comprehensive improvement pathway that integrates and reorganizes previously fragmented, rigid, and inefficient spatial elements. By doing so, it becomes possible to coordinate and optimize functional layouts, flow planning, equipment configurations, and framework boundaries, thereby enhancing the feasibility and stability of space transformation projects. This research direction significantly contributes to expanding technical methodologies for renovating commercial building stocks, while also improving the precision and refinement of renewal scheme designs [4]. Furthermore, it serves as a valuable auxiliary tool for volume calculation, boundary control, flexible arrangement, and system coordination during the introduction of diversified business operations. The transition from a one-time use iteration to a model of continuous optimization is facilitated through this approach, ensuring that spatial transformations are not only sustainable but also adaptable to evolving business needs. This framework provides critical support for achieving long-term operational efficiency and spatial functionality in commercial buildings.

2.3. The Main Issues Regarding the Reuse of Commercial Building Spaces under the Influence of Diversified Business Models

With the development of diversified commercial business models, the challenges associated with reusing commercial buildings extend beyond functional limitations and are deeply rooted in the inability of existing architectural technologies and systems to adapt to evolving conditions. Early commercial buildings were designed with relatively independent spatial patterns, where elements such as floor division, vertical separation, transportation connections, and equipment rooms were tailored to meet the specific needs of their initial functions. This rigid design approach has made it difficult to achieve effective spatial reorganization during subsequent renovations [5, 6]. The introduction of new composite business models has further complicated this issue, as these models often impose unique requirements on structural elements such as load standards, floor height,

smoke exhaust and ventilation systems, water supply and drainage pipe diameters, circuit layouts, and fire prevention barriers. Consequently, the original building systems frequently encounter issues such as excessive or insufficient capacity, the absence of reserved water outlets, and limitations in renovation methods. Additionally, structural challenges such as the difficulty of demolishing certain areas, significant conflicts in pipe relocation, and high construction complexity have transformed space reuse into a comprehensive technical renovation endeavor. This process now requires the integration of expertise from multiple disciplines, including structural engineering, mechanical and electrical systems, fire protection, and operational management. These interdisciplinary efforts are essential to address the technical and logistical challenges posed by the reuse of commercial building spaces, ensuring that they can meet the demands of modern business models while maintaining safety and functionality.

3. Reconstruction Path of Commercial Building Space Reutilization Mode Driven by Composite Business Formats

3.1. Reconfiguration of Spatial Organization Model

3.1.1. Optimize the Functional Zoning Structure

For the design of functional areas, it is essential to conduct a comprehensive analysis of the existing building's architectural elements, including floor plan configurations, column grid dimensions, depth measurements, floor height conditions, and business load requirements. The introduction of a hybrid business model significantly influences various aspects such as space management, equipment connectivity, operational timeframes, pedestrian density, and volume capacity. Relying on traditional methods of integrated commercial area division may lead to lower levels of spatial integration and increased vacancy rates. To address this, the principle of progressive zoning can be employed, which involves organizing spaces into a "central aggregation zone," a "cross transitional zone," and an "edge service zone." High-traffic and high-consumption intensity stores should be strategically located at primary traffic nodes and areas with significant pedestrian flow. Conversely, stores with higher equipment demands or those requiring greater operational independence can be positioned at peripheral zones or on the uppermost vertical layers of the building. Enhancing the adaptability and spatial compatibility between stores can be achieved by modifying the transparency of store interfaces, adjusting the width ratios of the front and back sections of stores, and optimizing the proportional relationship between the front and rear areas. These adjustments ensure a more efficient and harmonious spatial organization, ultimately improving the overall functionality and utilization of the commercial building space [7].

3.1.2. Strengthening the Connection of Shared Spaces

The fundamental approach to enhancing the connection of shared spaces involves reimagining public areas that were previously limited to single passage functions. These spaces should be transformed into a composite interface system that integrates multiple attributes, including gathering, resting, displaying, transforming, and scene alternation. From a technical perspective, a multi-level public space network must be established, incorporating nodes such as atriums, lobbies, corridors, platforms, hidden areas, and key extension spaces. To achieve this, strategies like optimizing open boundaries, improving visual corridors, implementing boundary retreats, and embedding devices should be employed to foster spatial integration across various business functions. The scale of shared spaces should not be confined to the width of passageways or evacuation routes but should also consider factors such as rest density, load-bearing requirements, display configurations, and adaptable operational models. Interface connections can be enhanced through the use of semi-open isolation layers, movable display walls, and extendable enclosure components, which collectively increase the capacity of shared spaces to host temporary business activities. For instance, in a community commercial renovation project, closed corridors were minimized, intermediate shared nodes were expanded, and diverse activity interfaces were integrated. This approach effectively connected retail,

dining, and service areas within a unified public space system of the same size, thereby creating a more dynamic and versatile environment for users [8].

3.2. Reconfiguration of Traffic Flow Patterns

3.2.1. Coordinate Customer Flow Organization

The reorganization of customer flow lines should transition from a single product-selling format to a design methodology that accommodates diverse purpose-oriented road networks under multiple consumption scenarios. Traditional stores often utilize circular circulation routes or linear series routes, which are effective for layouts focused on selling similar types of goods. However, in complex business environments where destination-type purchases, stay-type purchases, and impromptu-type purchases coexist, existing mobility systems face challenges such as overly concentrated aggregation areas, underutilized marginalized zones, and reduced circulation efficiency. To address these issues and enhance mobility, a three-tier pedestrian space pattern comprising "dominant path - auxiliary diffusion channel - node stay corridor" can be established. This can be achieved through tools such as pedestrian flow heat maps, statistical analysis of pedestrian arrivals, and evaluations of pedestrian influence. Measures like relocating entrances and exits, activating corner interfaces, designing visual nodes, and improving the continuity of flow lines can significantly enhance spatial homogeneity and mobility. For high-end business districts that often suffer from monotony, cross-level popular gathering points and reverse guidance interfaces can be introduced to strengthen vertical pedestrian flow traction. For instance, in a commercial renovation project in a specific city, the addition of two entrance and exit routes, along with return routes, successfully mitigated the issue of reduced pedestrian flow caused by the original single-route design.

The evaluation of flow uniformity can be calculated using a specific formula designed to assess whether the distribution of passenger flow across various areas within a commercial space is balanced. This formula provides a quantitative measure of spatial efficiency and helps identify areas requiring optimization to ensure equitable distribution of pedestrian traffic. By applying this formula, planners can make informed decisions to improve the overall functionality and accessibility of the space.

$$E=1-\frac{\sqrt{\sum_{i=1}^n(Q_i-\bar{Q})^2}}{\bar{Q}} \quad (1)$$

Among them, E represents the index of streamline homogeneity; Q_i denotes the passenger flow volume of the i-th area; \bar{Q} signifies the average passenger flow volume across all areas; n represents the total number of areas [9, 10]. The closer E approaches 1, the more balanced the distribution of passenger flow is across the commercial space. This metric is crucial for evaluating the effectiveness of spatial design strategies and ensuring optimal utilization of all areas within the space.

3.2.2. Improving Vertical Transportation Transitions

The enhancement of vertical transportation transitions within buildings requires comprehensive coverage, optimal accessibility, and sufficient carrying capacity to accommodate diverse user needs. Mixed-use spaces, which integrate functions such as dining, commerce, office work, and exhibitions, demand tailored solutions for internal floor access paths and user movement patterns. Traditional department store designs often face challenges such as inefficient dynamic transportation cores, limited platform connection points, and suboptimal transfer systems. To address these issues, the reorganization of escalator layouts, elevator service radii, and stair lobby configurations should be strategically planned. This optimization must consider the functional attributes of each floor, peak flow distribution patterns, fire evacuation routes, and the spatial constraints of equipment shafts. For atrium-style commercial spaces, the installation of multiple elevators can significantly improve visibility and directional guidance for users. In areas where vertical connections are insufficient, the transfer experience can be enhanced by introducing transfer stations, expanding inter-floor entrances, and renovating transportation vestibules. These measures aim to streamline movement,

improve accessibility, and ensure safety while accommodating the unique requirements of each space type.

3.3. Reconfiguration of the Facility System Model

3.3.1. Verify the Capacity of the Mechanical and Electrical System

The volume prediction of mechanical and electrical engineering plays a pivotal role in the secondary renovation of complex mixed-type business scenarios. This process involves numerous subsystems, including HVAC, water supply and drainage, waste discharge, air supply and suction, fire protection, and intelligent management systems. Typically, the original mechanical and electrical facilities of commercial complexes are configured based on pre-leased customer requirements and stable operational conditions. However, the introduction of new business forms, such as high-end restaurants, long-stay meeting areas, or high-density offices, necessitates significant adjustments to load characteristics, peak periods, and terminal allocation zones. Capacity planning must not only verify the total load but also conduct detailed designs focusing on load volume, utilization rates, shaft transmission capacities, and terminal redundancies for each area. This ensures the determination of capacity expansion limits, pipeline occupation standards, and expansion routes for terminal equipment. For renovation projects with restrictions, adopting a partition-based independent strengthening approach and dispersing terminal areas can enhance adaptability. For instance, in a specific office building, changes in cooling demand, power supply demand, and exhaust air demand were addressed by adjusting the load of electrical boxes and designing the new air system in stages. This approach successfully avoided overall system overload operation. The comprehensive load of each partition can be calculated using the following formula.

$$L_i = \sum_{j=1}^n q_{ij} \cdot A_{ij} \cdot \mu_{ij} \quad (2)$$

In the formula, L_i represents the comprehensive load of the i -th zone; q_{ij} denotes the unit area load index of the j -th type of business within the i -th zone; A_{ij} signifies the area of the j -th type of business within the i -th zone; μ_{ij} indicates the usage coefficient of the j -th type of business; and n represents the number of business types. This calculation method provides a systematic approach to evaluating the load distribution across various business types and zones, ensuring that the mechanical and electrical systems are adequately prepared for diverse operational demands. The system peak load verification is calculated using the following formula:

$$L_{max} = \sum_{i=1}^m L_i \cdot \eta_i \quad (3)$$

In this formula, L_{max} represents the peak total load of the system, while L_i denotes the comprehensive load of the i -th zone. Additionally, η_i signifies the peak simultaneous coefficient of the i -th zone, and m represents the number of zones. This calculation method is essential for verifying the peak load capacity of the system, ensuring that it can handle simultaneous operational demands across multiple zones without compromising efficiency or safety. By employing these formulas, planners can optimize the mechanical and electrical systems to accommodate varying load requirements and peak usage scenarios effectively.

3.3.2. Integrate the Overall Pipeline Layout

The integration of comprehensive pipeline layouts is essential for addressing challenges such as pipeline constraints, path conflicts, and maintenance inefficiencies, especially when multiple specialties are simultaneously updating systems. Commercial buildings often require the renovation of various pipelines, including air conditioning ducts, water supply and drainage systems, power and weak current networks, fire water pipes, fire hydrant pipes, and ventilation and exhaust ducts. If the traditional approach of separate construction by each specialty is maintained, it can lead to overcrowding in ceiling spaces, a sense of spatial oppression on floors, and obstructed maintenance pathways. To mitigate these issues, the principle of "concentrating the main roads - dispersing the branch roads - separating power and weak current - facilitating maintenance" should be adopted. This principle must align with the building framework, equipment terminal positions, inspection distances, and management requirements.

Additionally, the elevation relationships, intersection areas, and turning radii between various systems should be carefully coordinated. For areas with limited clearance, the use of lightweight ducts, combined supports, and modular equipment interface settings can enhance space utilization efficiency. Furthermore, the application of BIM conflict detection and comprehensive pipeline layout models can provide early warnings and optimize installation procedures. For instance, in a specific renovation project, smoke exhaust, electrical, and fire hydrant pipes were reorganized into distinct layers. This integration resolved previous incompatibilities, significantly reducing on-site disassembly and secondary operation time costs. Such measures not only streamline the construction process but also ensure that maintenance and future upgrades can be conducted more efficiently, thereby improving the overall functionality and sustainability of the building's infrastructure.

3.4. Reconfiguration of Space Vehicle Mode

3.4.1. Optimize Structural Interface Conditions

For the reuse of commercial buildings, managing structural interface conditions during renovation is a critical task that directly impacts the scope of space reconfiguration and the safety parameters of construction activities. When adapting buildings for multiple uses, several challenges may emerge, including the need for large-span structural modifications, accommodating increased localized loads, addressing structural perforations, integrating glass curtain walls, and expanding mechanical and electrical capacities [9, 11]. In some cases, the original building foundation may prove inadequate for the new functional requirements. Prior to initiating renovations, it is essential to conduct a comprehensive assessment of factors such as column grid dimensions, beam and slab load-bearing capacities, ground live load tolerances, potential for structural openings, reinforcement needs, and the stability of the building's enclosure. This evaluation helps identify which components can be modified or removed and which must remain intact. Optimization of the structural interface extends beyond ensuring safety; it also encompasses considerations like natural lighting, ventilation, visibility, exhibition coherence, and the seamless integration of internal and external interfaces. For projects aiming to enhance commercial visibility, modifications such as enlarging openings while maintaining electrical and fire safety systems can be implemented. Additionally, window openings may be redesigned, and the first-floor interface reorganized to improve transparency and visual appeal, thereby aligning the building's design with its intended commercial objectives.

3.4.2. Enhancing the Level of Spatial Flexibility

The objective of enhancing spatial flexibility is to improve the adaptability of existing commercial buildings to accommodate future changes in business operations, tenant replacements, and evolving strategies, while avoiding rigid constraints introduced by one-time renovations. This approach involves establishing an adaptive framework through modular planar combinations, separable space units, reserved equipment interface positions, distributed load distribution designs, and shared area layout planning [12–14]. Expanding the span scale of standard rooms and separable units facilitates more flexible rental arrangements. Pre-designed openings for water, electricity, and ventilation ducts can significantly reduce the time required for subsequent functional conversions. The use of movable wall panels, detachable ceilings, and suspended floors minimizes disruptions caused by secondary renovations. For shared spaces, incorporating foldable equipment, color-changing lights, and movable desks and chairs enhances the efficiency of space conversion across various scenarios. For instance, in a street area renewal project, exhaust vents and mixed power sockets were reserved for catering businesses. This allowed the rapid transformation of spaces to accommodate catering establishments, shops, exhibition galleries, and offices, demonstrating the technical value of flexible design in promoting sustainable space reuse. By integrating these adaptive measures, commercial buildings can achieve greater resilience and sustainability, ensuring their long-term viability in dynamic urban environments.

4. Conclusion

Under the drive of the complex operation model, the reuse of commercial building spaces is not merely a simple renovation and update; it involves a comprehensive recreation of various interconnected systems, including spatial forms, pedestrian and vehicular traffic flows, mechanical and electrical systems, and the structural framework. For existing commercial buildings, addressing the incongruous factors that emerge in diversified business operation environments requires a systematic approach. This includes analyzing and restructuring business zoning, optimizing the connection of shared surfaces, reorganizing movement paths, enhancing vertical transportation systems, recalculating power capacity, integrating pipelines, expanding structural boundaries, and improving spatial flexibility. Such measures collectively enhance the multi-functional adaptability, precision, and sustainable operational capacity of these spaces. Looking ahead, the reuse of commercial building spaces is expected to increasingly incorporate advanced technologies such as digital measurement equipment, Building Information Modeling (BIM) for collaborative workflows, real-time data feedback systems, and flexible update plans. These advancements will provide robust technical support for achieving high-quality renovations, ensuring that commercial spaces remain adaptable to evolving demands while promoting sustainability and operational efficiency in the long term.

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