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Article

Globalization and the Reconfiguration of Architectural Space and Social Practices

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Abstract: Against the dual backdrop of advancing globalization and the normalization of pandemic prevention and control in the post-pandemic world, the functional requirements of architectural spaces have undergone profound changes. As urban populations grow and environmental challenges intensify, traditional static facades are no longer sufficient to meet the dynamic demands of modern spaces. Consequently, innovative facade design has emerged as a critical breakthrough point for the comprehensive reconstruction of architectural spaces. Building upon existing research on architectural facades and integrating the core needs of post-pandemic spatial environments, this paper explores the fundamental value, underlying design logic, and practical pathways of movable facades in architectural reconfiguration. It systematically analyzes their pivotal role in enhancing architectural adaptability, optimizing the human living experience, and implementing sustainable green development principles. Furthermore, the study investigates how dynamic building envelopes can actively respond to fluctuating climatic conditions and shifting user requirements, thereby reducing energy consumption and improving indoor environmental quality. By examining relevant contemporary case studies and cutting-edge technological applications, the paper identifies emerging trends in movable facade design. Ultimately, this research provides robust theoretical guidance and actionable practical insights for the reconfiguration of contemporaneous architectural spaces, ensuring they remain resilient, flexible, and highly responsive to the evolving socio-spatial paradigms of the twenty-first century.

Keywords: globalization; architectural facades; spatial reconstruction; movable facades; sustainable design

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1. Introduction

With the ongoing processes of globalization and urban renewal, building facades have emerged as a critical medium for shaping the visual and functional aspects of urban environments. They play a pivotal role in enhancing spatial quality, preserving cultural heritage, and contributing to the aesthetic and functional revitalization of urban areas. This is particularly evident in projects aimed at renovating older communities and rejuvenating urban streetscapes. However, traditional methods of surveying building facades often encounter significant challenges, including inefficiencies, incomplete data acquisition, and safety risks. To address these limitations, innovative approaches and advanced technologies have been developed. These include the use of UAV oblique photogrammetry for precise data collection, green facade technologies for sustainable urban design, the integration of regional cultural symbols into architectural elements, and the application of advanced materials such as stone-effect paints [1, 2]. These advancements collectively offer promising solutions for improving the efficiency, accuracy, and overall quality of building facade renovation and maintenance.

2. Core Concepts and Theoretical Foundations

2.1. Developmental Characteristics of Building Facades in the Context of Globalization

Globalization has significantly influenced the evolution of urban building facades, driving them toward a state of diverse integration. This phenomenon has been marked by the rapid adoption of modern materials, advanced construction techniques, and innovative design concepts. These advancements have not only led to continuous innovation in the aesthetic aspects of building facades but have also expanded their functional capabilities. The integration of cutting-edge technologies has enabled facades to serve as more than mere architectural elements, transforming them into dynamic components that contribute to energy efficiency, environmental sustainability, and urban identity. Simultaneously, regional culture and the unique characteristics of urban environments have emerged as pivotal elements in facade design [3]. This focus on local identity helps counteract the homogenization of architectural landscapes often associated with globalization, ensuring that cities retain their distinct visual and cultural identities. Traditional methods of facade surveying and renovation, however, have proven to be inefficient and prone to incomplete data collection. The introduction of advanced technologies, such as UAV oblique photogrammetry and point cloud adaptive segmentation, has revolutionized this process. These tools have significantly enhanced the precision of data collection and modeling, enabling the creation of standardized and refined facade designs. This dual approach allows for adherence to unified design standards while simultaneously emphasizing intricate details, ensuring that facades meet both functional and aesthetic demands in the context of globalization.

2.2. The Relationship between Architectural Space Reconstruction and Facades in the Post-Pandemic Era

In the post-pandemic era, the redesign of buildings emphasizes three fundamental aspects: health and safety protection, functional adaptability, and ecological sustainability. The building facade, as the critical interface between the structure and its external environment, plays a pivotal role in this spatial transformation. Facades must be designed to address evolving health concerns, incorporating strategies such as green retrofitting and enhanced ventilation systems to reduce potential health risks. Additionally, facade renovations should align with urban renewal objectives, tackling practical challenges like the deterioration of aging structures, disorganized utility installations, and suboptimal energy performance. These improvements contribute to the holistic upgrading of architectural spaces and the urban landscape. By integrating advanced materials and technologies, facades can further enhance energy efficiency and environmental harmony, ensuring that buildings meet contemporary standards of sustainability while fostering healthier and more adaptable urban environments. This approach underscores the importance of facades in shaping resilient and future-ready architectural designs [4, 5].

2.3. Core Definitions, Types, and Fundamental Characteristics of Building Facades

Architected facades represent the building's external visual interface, encompassing all exterior elements such as walls, doors, windows, eaves, and decorative components. These facades serve as a direct reflection of a building's aesthetic appeal, functional purpose, and cultural identity. Depending on the approach to renovation, they can be categorized into types such as surface renewal, functional optimization, and cultural integration [6]. Surface renewal focuses on restoring the visual and structural integrity of the facade, while functional optimization emphasizes enhancing the building's performance, such as improving energy efficiency or structural resilience. Cultural integration, on the other hand, seeks to harmonize the facade with the surrounding cultural and historical context. The fundamental characteristics of architectural facades include practicality, ornamentation, sustainability, and cultural significance. Practicality ensures that facades meet essential functional requirements such as waterproofing, thermal insulation, and safety. Ornamentation contributes to the visual appeal and artistic expression of the structure. Sustainability emphasizes the use of eco-friendly materials and energy-efficient designs, while cultural significance ensures that the facade contributes to shaping the city's unique visual identity. These elements collectively

highlight the multifaceted role of facades in modern architecture, balancing functionality with aesthetic and cultural considerations.

Movable facades represent a unique and innovative form of architectural design, referring to facade structures capable of dynamic changes such as opening, closing, extending, retracting, or rotating through mechanical or manual means. These facades are not the primary form of contemporary architectural design but serve as a supplementary approach to address specific needs in modern urban environments. For instance, they can facilitate dynamic spatial adjustments, allowing buildings to adapt to changing functional requirements. Additionally, movable facades optimize ventilation and natural lighting, contributing to improved indoor air quality and energy efficiency. In the context of health and safety, they can also provide isolation measures, which have become increasingly relevant in post-pandemic architectural considerations. By integrating advanced materials and mechanical systems, movable facades offer a versatile solution for creating adaptable and responsive building exteriors. Their innovative nature not only enhances the functionality of buildings but also introduces new possibilities for architectural expression, making them a valuable addition to the evolving landscape of urban design.

3. Core Demands for the Reconstruction of Architectural Spaces in the Post-Pandemic Era

3.1. Epidemic Prevention and Safety: Health Protection Requirements for Building Facades

In the post-pandemic era, ensuring health protection within architectural spaces has emerged as a fundamental priority. Building facades, as the primary interface between a structure and its external environment, play a pivotal role in mitigating disease transmission risks. Traditional facades often face challenges such as inadequate airtightness, suboptimal ventilation, and a tendency to accumulate contaminants, which compromise their ability to meet modern health protection standards [7]. To address these issues, dynamic facade designs have gained prominence, enabling flexible partitioning between indoor and outdoor spaces. This adaptability enhances the building's capacity to respond effectively to epidemic prevention requirements. Furthermore, the integration of advanced cleaning mechanisms and maintenance protocols into facade designs has become essential for safeguarding the health of interior environments. Features such as self-cleaning materials, pollutant-blocking layers, and enhanced filtration systems are increasingly incorporated to minimize contamination risks. These innovations not only improve the overall hygiene of architectural spaces but also contribute to creating safer and more resilient environments for occupants. Figure 1 illustrates the facade of the Chongqing University of Education Main Teaching Building, showcasing practical applications of these principles.

Figure 1. Chongqing University of Education Main Teaching Building(China)

3.2. Flexible Adaptability: The Need for Dynamic Synergy between Façade Functionality and Space

In the context of urban renewal, architectural spaces are undergoing continuous transformation to accommodate evolving societal needs. Building facades, particularly in older residential areas and bustling city streets, must exhibit adaptability to align with dynamic spatial usage. These facades are required to strike a balance between practicality and flexibility, ensuring the seamless integration of utility lines while optimizing the placement of ancillary facilities [2]. Movable facades offer a versatile solution, enabling the regulation of lighting, ventilation, and spatial openness in response to specific environmental or functional scenarios. This adaptability fosters a dynamic synergy between the exterior facade and the interior space, ensuring that the structure can cater to diverse requirements, ranging from residential to public applications. Such innovations in facade design not only enhance functionality but also contribute to the aesthetic and sustainable development of urban environments, addressing the multifaceted demands of modern cities (As shown in Table 1).

Table 1. Content and Form of Different Facades

Type	Main Content	Style
Mechanical Systems	Application of gear drives to achieve opening and closing control through precise meshing characteristics	High-end Office Building Curtain Walls
	"Unit Box" translation modules, with synchronous belt drives ensuring precise translation adjustments	Commercial Spaces
Intelligent Systems	Sensor system that collects data to drive facade responses	Daylighting Curtain Walls for Office Spaces
	Design fast-response logic to enable the movable facade to adjust in real time	Dynamic Curtain Walls for Public Spaces
Materials Systems	Research the application of aluminum alloy in community facade renovations, highlighting its suitability due to lightweight, corrosion resistance, and ease of fabrication	Manual/Motorized Louvers for Residential Communities
	Application of carbon fiber composite materials in large-span movable skylights, leveraging their high strength and low self-weight advantages	Movable Skylights for Industrial Parks

3.3. Eco-Friendly and Low-Carbon: Green Energy-Saving Requirements for Building Facades

Eco-friendly and low-carbon design represents a pivotal direction for architectural development in the context of globalization and the post-pandemic era. Energy-efficient retrofitting of building facades has emerged as a critical strategy for reducing energy consumption in buildings. Traditional and aging facades often exhibit poor thermal insulation, insufficient heat resistance, and reliance on non-environmentally friendly materials, all of which contribute significantly to energy inefficiency. Green building facades, incorporating vertical greening and advanced energy-efficient materials, offer a multifaceted solution. These facades not only enhance energy efficiency but also mitigate the urban heat island effect, absorb air pollutants, and contribute to improving the urban microclimate. In the process of facade renovation, the selection of durable and eco-

friendly finishing materials, such as stone paint, combined with thermal insulation structures, plays a crucial role. This approach reduces energy consumption and minimizes long-term maintenance costs, aligning with the ecological imperatives of sustainable urban development [8]. By integrating these strategies, buildings can achieve enhanced environmental performance while supporting broader goals of urban sustainability and resilience.

3.4. Cultural Integration: The Need for Facade Expressions That Balance Globalization and Local Character

Globalization has significantly influenced architectural styles, often leading to a homogenized aesthetic that diminishes the unique cultural identity of urban spaces [9]. In the post-pandemic era, there is a growing emphasis on preserving and showcasing local culture through architectural design. Urban street facades, older residential neighborhoods, and tourist buildings play a crucial role in reflecting and transmitting regional heritage. However, many facades currently lack distinct cultural elements, displaying stylistic inconsistencies that fail to honor the historical and cultural legacy of their surroundings. To address this, architectural facade design must carefully extract and incorporate symbols of regional culture. This can be achieved through the thoughtful use of colors, materials, and decorative elements that resonate with local traditions while aligning with modern global aesthetics. Such an approach not only enhances the visual appeal of urban spaces but also fosters a stronger sense of cultural identity and belonging among residents. By integrating regional characteristics into facade design, cities can create spaces that are both culturally distinctive and visually harmonious, contributing to a richer urban experience.

4. Design Principles for Contemporary Building Facades in a Globalized Context

4.1. Health-First Principle

Prioritizing health is a fundamental aspect of building facade design in the post-pandemic era, addressing two critical requirements: adaptation to epidemic prevention measures and the healthiness of materials. As the interface between the building and its external environment, facades must incorporate essential health protection capabilities to safeguard occupants. Movable facades offer a dynamic solution, enabling flexible adjustments to indoor and outdoor ventilation and isolation. These adjustments can be achieved through mechanisms such as opening, closing, and partitioning, which are essential for meeting public health protection needs during emergencies or routine operations. Regarding material health, the selection of environmentally friendly materials is paramount. Facades should utilize materials that are free from harmful substances to ensure safety and sustainability. For instance, stone-effect water-based coatings, commonly applied in the renovation of older residential communities, exemplify this approach. These coatings combine environmental friendliness with stain resistance, effectively reducing pollutant adhesion and enhancing the durability and safety of building surfaces. Such innovations contribute to healthier living environments while aligning with contemporary design principles for sustainable urban development.

4.2. Principle of Flexibility and Adaptability

The principle of flexibility and adaptability emphasizes the need for building facades to respond effectively to evolving spatial functions and diverse usage requirements within a globalized framework. Traditional static facades often struggle with issues such as functional clutter and limited adaptability, particularly in aging structures. To address these challenges, it is essential to optimize the layout of ancillary facilities, ensuring that components like air conditioning units, exposed piping, and balconies are seamlessly integrated into the design. This approach not only enhances functionality but also improves the aesthetic coherence of the facade. Furthermore, during the design process, identifying and incorporating regional cultural symbols, such as traditional architectural elements, colors, and materials, plays a crucial role in preserving the historical and

cultural heritage of a city. By blending these traditional elements with modern design concepts and advanced material technologies influenced by globalization, it becomes possible to create facades that harmonize local cultural identity with contemporary aesthetics. This fusion ensures that building facades remain relevant to current trends while maintaining a distinct regional character, ultimately contributing to the architectural and cultural richness of urban environments (As shown in Table 2).

Table 2. Classification of Multidimensional Studies on Movable Facades

Primary	Content	Format
	Application Scenarios	
Office Buildings	Dynamic switching between "healthy office" and "pandemic quarantine" modes	A smart office building in Milan
Business Buildings	Quickly switch between "retail displays and event spaces" to enhance the flexibility of commercial spaces	Facade of the Shenzhen Longhua Industrial Park
Community Buildings	Movable grilles redefine the boundaries of community public spaces, balancing the needs of daily activities with emergency disease prevention requirements	Facade of the Fengyang No. 1 Village community in Hefei
Healthcare Buildings	Modular ward units can be converted from a "health complex" to an "isolation facility" within a matter of hours	Patient ward area of a medical building in Changsha
	Cultural Strategy Dimension	
Place Translation	Drawing inspiration from the woven bamboo texture of Yuelu Academy, we have translated it into the formal language of movable louvers to reinforce a sense of regional cultural identity.	"Eye of the Xiang River" Cultural Building
Place Memory	Transform the community's historical and cultural wall into an interactive, movable lattice that residents can manually adjust to help create cultural scenes	Hefei Fengyang Village Community Renovation

4.3. Facade Design Focused on Infection Prevention

In the post-pandemic era, building facades must prioritize health protection as a fundamental objective, ensuring the creation of safe and effective interfaces between indoor and outdoor environments. The design approach should emphasize optimizing facade ventilation structures to enhance natural airflow. By strategically arranging windows and ventilation components, the efficiency of natural ventilation can be significantly improved, thereby mitigating health risks associated with confined indoor spaces. Movable facades represent an innovative supplementary design strategy, particularly suitable for public buildings and street-facing structures. These adaptable facades can dynamically open and close, allowing for flexible transitions between spatial isolation and ventilation. This adaptability ensures that facades can meet varying requirements for epidemic prevention while maintaining functionality. Additionally, incorporating advanced materials and technologies into facade design can further enhance their performance, ensuring a balance between health protection, energy efficiency, and aesthetic appeal [5].

4.4. Facade Design with Spatial Flexibility

Flexible spatial adaptation emphasizes resolving challenges associated with functionally monotonous building facades and disorganized external facilities. This approach is particularly advantageous for the renovation of aging urban neighborhoods and street-level structures, where aesthetic and functional improvements are critical. The design process involves integrating ancillary facade elements and systematically organizing modules such as air conditioning units, exposed piping, and balconies to achieve a cohesive and visually appealing facade layout [10]. Additionally, the functional configuration of the facade is optimized by considering the building's usage scenarios. For instance, balconies can be expanded to serve multiple purposes, such as recreational spaces or storage areas, while exterior decorative elements are standardized to ensure uniformity. These measures enhance the practicality and adaptability of the space, contributing to a more harmonious urban environment and improving the overall user experience.

5. Case Study Analysis

5.1. International Case Study: Bosco Verticale in Milan, Italy

The building facade is designed around staggered cantilevered balconies, which are integrated with a modular arrangement of vertical greenery. A diverse array of trees, shrubs, and herbaceous plants is strategically planted on the exteriors of the twin towers, forming a comprehensive vertical ecological facade system. This innovative design prioritizes ecological functionality, allowing the vegetation to transform the facade's appearance as it adapts to seasonal changes. By leveraging the natural processes of transpiration and shading, the facade contributes to reducing energy consumption within the building, while also absorbing airborne particulate matter and alleviating the urban heat island effect. Additionally, adjustable shading elements are incorporated in specific areas as lightweight, movable facade applications. These elements enhance the regulation of indoor lighting and ventilation, ensuring optimal conditions for healthy living environments. The project exemplifies the evolution of green facades from mere decorative features to integral components of urban ecological infrastructure, setting a benchmark for ecological building designs on a global scale. This approach underscores the potential of architecture to harmonize with environmental sustainability while addressing urban challenges.

5.2. Typical Domestic Case Study: Comprehensive Façade Renovation Project for the Xi'an Small Wild Goose Pagoda Historical and Cultural District

This project exemplifies a national model for integrating regional culture, ecological sustainability, and functional renovation within the framework of urban renewal and cultural heritage preservation. By prioritizing the conservation of local historical elements, the initiative incorporates innovative design strategies to enhance both aesthetic and environmental performance. Small-scale vertical greening modules are strategically implemented to improve ecological functionality, contributing to urban biodiversity and reducing the heat island effect. Additionally, movable ventilation louvers are selectively applied to specific areas of public buildings, ensuring optimal airflow and energy efficiency while maintaining the static facade's visual integrity. This approach achieves a seamless balance between preserving cultural identity, promoting ecological sustainability, and addressing modern functional requirements, making it a benchmark for similar urban renewal projects across the nation.

5.3. Case Comparisons and Lessons Learned

Against the backdrop of globalization, these two projects illustrate two key trends in architectural facades. Overseas cases emphasize the integration of global ecological technologies, focusing on the ecological benefits and innovative forms of green facades. These projects also incorporate movable facades as dynamic functional modules, albeit to a moderate extent. In contrast, domestic cases prioritize localized cultural expression and

the renewal of existing architectural stock. This approach emphasizes the preservation of regional cultural heritage while addressing the renovation of aging facades and ecological optimization. Such a strategy aligns more closely with the practical needs of residents and the realities of urban development. Table 3 provides a comparative overview of these architectural projects, highlighting the distinct approaches adopted in different contexts. By balancing ecological considerations with cultural and practical imperatives, domestic projects demonstrate a nuanced understanding of local urban dynamics, which is essential for sustainable development in rapidly evolving urban environments.

Table 3. Comparison of Architectural Projects

Dimensions of comparison	Milan Vertical Forest Tower	Little Wild Goose Pagoda Cultural District
Core Philosophy	Prioritizing Ecology	Local Cultural Heritage
Core Characteristics	Focusing on vertical greening with high plant coverage	Tang Dynasty-inspired design + stone-effect finish, creating a cohesive and uniform exterior
Technological Applications	Modular green facade technology	Standardized construction techniques for drones and stone-effect finishes
Facade Applications	Emphasizing dynamic adjustment of natural lighting and ventilation	Movable ventilation louvers incorporated into specific building sections
Key Focus Areas	Innovative ecological benefits	Cultural Heritage + Functional Renovation
Common Characteristics	Focusing on ecological energy efficiency	With a static facade as the main feature

In terms of practical outcomes, the value of green technologies and digital surveying in facade design has been validated in both cases. International projects place a stronger emphasis on cutting-edge ecological innovations, showcasing advanced technologies and experimental designs. Domestic projects, however, focus on practical implementation and cultural significance, ensuring that the designs resonate with local communities and address immediate urban challenges. Both types of projects treat static facades as the primary focus, with movable facades serving as a niche supplementary form. This trend underscores the continued importance of optimizing static facades as the core direction in contemporary architectural development. Table 3 further illustrates these distinctions, offering insights into the varying priorities and methodologies employed. By leveraging both technological advancements and cultural considerations, these projects collectively contribute to the evolution of facade design, balancing innovation with practicality to meet diverse architectural and urban needs.

6. Existing Issues and Optimization Pathways in Contemporary Architectural Façade Design

6.1. Existing Issues

Current architectural facade design and renovation practices continue to face numerous challenges, which hinder their ability to fully address the evolving demands of the globalized and post-pandemic era. In many older residential communities, facade renovations are often limited to superficial cosmetic upgrades. These projects tend to prioritize aesthetic enhancements while neglecting critical functional improvements such as thermal insulation, energy efficiency, effective ventilation for pandemic prevention,

and the organization of utility lines. This imbalance results in facades that fail to achieve their full practical potential. Furthermore, small- and medium-scale renovation projects frequently rely on traditional manual surveying methods, which are characterized by low efficiency, incomplete data collection, and insufficient accuracy. These limitations significantly impede the progress and effectiveness of such projects.

From a cultural perspective, architectural facade design often suffers from homogenization, where regional cultural characteristics are inadequately explored. This leads to a superficial application of cultural elements that are poorly integrated with architectural functions and contexts, resulting in a fragmented and incoherent stylistic outcome [11]. Additionally, the adoption of eco-friendly and energy-efficient designs has shown limited success. Green facades and energy-saving materials are frequently implemented as superficial decorative elements rather than as integral components of sustainable design. Without comprehensive planning for full-cycle operation and maintenance, issues such as plant withering and material degradation commonly emerge during later stages, undermining the long-term viability of these solutions. Movable facades, which are intended to serve as dynamic supplementary features, face significant challenges, including high construction costs, complex maintenance requirements, and limited applicability to diverse architectural contexts. These factors collectively restrict their broader adoption and effectiveness in addressing contemporary architectural needs.

6.2. Path Optimization

In terms of cultural expression, it is essential to transcend the superficial use of symbols and instead focus on uncovering and integrating the fundamental elements of regional culture. These elements should be thoughtfully reinterpreted within a contemporary framework, ensuring alignment with the functional requirements of the building. This methodology allows the facade to achieve a harmonious balance between a modern, global aesthetic and a unique regional identity. Furthermore, ecological and energy-efficient design must be approached with a comprehensive and systematic strategy. This includes the careful selection of durable, low-maintenance green materials and facade systems that are capable of withstanding long-term use. Additionally, it is crucial to establish robust mechanisms for the ongoing operation and maintenance of these systems. Such measures ensure that green facades continue to provide ecological and environmental benefits over extended periods, contributing to sustainable urban development and environmental conservation [12].

7. Future and Outlook

In the future, building facade design is anticipated to undergo significant advancements, driven by the increasing adoption of digitalization, ecological sustainability, lightweight construction, and cultural localization. Digital surveying and modeling technologies are expected to become indispensable tools in both the design and renovation of facades, enabling architects and engineers to achieve unprecedented levels of precision and efficiency in construction processes. These advancements will likely lead to the standardization of such technologies across the industry, fostering a new era of innovation. Furthermore, eco-friendly and energy-efficient facades are projected to transcend their traditional role as aesthetic enhancements, evolving into integral components of urban ecological systems. By incorporating green materials, vertical greening techniques, and energy-saving structural elements, facades will contribute to reducing urban heat islands, improving air quality, and promoting sustainable urban living. This transformation will position facades as not merely architectural features but as critical elements of urban ecological infrastructure, capable of addressing pressing environmental challenges while enhancing the quality of life in cities.

The integration of regional culture with global design principles is expected to deepen, positioning building facades as pivotal mediums for expressing urban identity and countering the homogenization of architectural styles. This trend will likely result in facades that reflect the unique cultural and historical contexts of their locations, fostering

a sense of place and community. Additionally, the development of movable facades is anticipated to focus on achieving cost-effectiveness, ease of maintenance, and lightweight construction. These innovations will prioritize essential functionalities such as ventilation, disease prevention, and shading, making them particularly suitable for widespread application in residential and public buildings. By addressing these fundamental needs, movable facades will not only enhance the adaptability and resilience of structures but also contribute to improving indoor air quality and thermal comfort. As these technologies mature, they are expected to play a crucial role in advancing sustainable urban development, offering practical and scalable solutions for diverse architectural contexts.

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