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Research on Structural Renewal and Renovation Strategies for Industrial Heritage Projects—A Case Study of the Structural Renovation of the "Dahua 1935" Project

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Abstract: The wave of post-industrial evolution has led to the emergence of numerous industrial heritage renovation projects in recent years. The renovation and upgrading of the Dahua 1935 project preserve the memories of the previous industrial age while incorporating modern materials and technologies, resulting in a design that blends traditional and contemporary elements. This has made Dahua 1935 a new intellectual property (IP) symbol of Xi'an, earning praise from both residents and tourists from other provinces. Additionally, to achieve a unity of art and technology, Dahua 1935 underwent structural reinforcement and optimization to enhance its aesthetic appeal. This paper aims to further explore methods for structural optimization in the renovation of Xi'an's industrial heritage projects by conducting on-site investigations, data collection, and structural analysis, building upon the structural analysis of Dahua 1935 in Xi'an.

Keywords: Industrial heritage; Urban renewal; Structural optimization; "Dahua 1935" project; Carbon fiber reinforcement method

Online publication: January 2, 2025

1. Introduction

In the wave of post-industrial evolution, urban renewal—particularly the transformation of industrial heritage—has garnered increasing attention. It not only involves preserving the city's historical memories but also aims to beautify the urban image and enhance the quality of the living environment. A multitude of urban industrial building renovation projects have emerged, like bamboo shoots after a spring rain, providing numerous topics for urban developers and architects to study. Through research and practical investigation, a series of scientific methods have been summarized and applied to collectively advance the renewal and transformation of industrial heritage projects [4,5]. As a representative industrial heritage renovation project in Xi'an, Dahua 1935 has attracted significant attention from researchers in recent years.

For example, Wang's research on the sustainable utilization and transformation of Dahua 1935 and other projects begins with additive and subtractive strategies as well as different functional renovation strategies, proposing a series of renovation plans [1]. Zhao and Yu started the locality study of "Dahua 1935" to create spatial experiences, highlighting its commercial atmosphere within existing industrial buildings to satisfy the spatial experiences of users and consumers [6]. Based on He, using spatial syntax research strategies, evaluated the spatial utilization of Dahua 1935 and provided suggestions on road layout, spatial arrangement, node space settings, exhibition flow lines, safety entrances and exits, and public facilities [7]. Wang analyzed the green technology measures of Dahua 1935, proposing aspects that can be referenced, but do not offer related suggestions or optimization considerations. From the extensive analyses of Dahua 1935 by predecessors, it is evident that the renovation of industrial heritage projects urgently requires scientific and systematic methods to assist.

The main representatives in the research of heritage buildings abroad are as follows. González *et al.* presented detailed examples of structural refurbishment strategies in Madrid, contributing valuable insights into the adaptive reuse of industrial heritage [8]. Huang *et al.* explored the feasibility of using metal-timber hybrid structures for industrial building renewal [9]. With quantitative indicators improving and clearness, Ma *et al.* provided a systematic framework for evaluating district-level industrial heritage renovation strategies [10].

Therefore, under the quantitative analysis and structural technology's background of development, this study will commence with the structural transformation of Dahua 1935, utilizing the original design drawings of Dahua 1935 as well as the Phase I and Phase II structural renovation plans to analyze structural modifications, reinforcement, and form optimization. Moreover, by integrating structural renovation methods (carbon fiber reinforcement method) and application cases of similar types, the study will compare the advantages and disadvantages from various aspects including economic viability, aesthetics, and sturdiness. The goal is to propose structural optimization renovation strategies for industrial heritage projects for collective discussion.

2. Results and discussion

2.1. Structural analysis of the "Dahua 1935" project

2.1.1. Structural selection during the initial construction period

In the early 1930s, against the backdrop of the rapid development of national capitalism and to develop the textile industry in Northwest China, the Xi'an Dahua Yarn Factory was constructed from 1934 to 1936. **Figure 1** shows the initial design by Japanese architects. Most of the factory buildings primarily employed steel structures, supplemented by large-span concrete frame structures and brick-concrete constructions. The office areas and dormitories mainly utilized brick-concrete structures [2].

Figure 1. Initial construction floor plan of Xi'an Dahua Yarn Factory (drawn based on materials)

Table 1. Architectural structure of Xi'an Dahua Yarn Factory

<table>
<tr><th>Building types structural components</th><th>Roof</th><th>External walls</th><th>Interior walls</th><th>Beam frame</th><th>Column</th><th>Structure</th></tr>
<tr><td>Multistory production plant</td><td>steel roof truss, concrete roof truss, rowed single-slope sawtooth roof</td><td>Concrete plaster finish, exposed aggregate finish</td><td rowspan="5">Green wainscot with whitewashed upper section, painted with propaganda slogans</td><td>Concrete Prefabricated Structure beam frame, rectangular long beams joined on both ends to raised basket-shaped end columns, north-south oriented prefabricated</td><td>Basket-shaped columns with protruding corbels at both ends, along with steel i-beam columns</td><td>Steel structure</td></tr>
<tr><td>Single-story production workshop</td><td>Rowed single-slope sawtooth roof</td><td>Red exposed brick wall</td><td rowspan="4">Continuous span single-story sawtooth steel structure beam frame</td><td>Independent prefabricated concrete structure columns, painted green to match the wainscot</td><td rowspan="4">Brick-concrete structure, concrete frame</td></tr>
<tr><td>Warehouse</td><td rowspan="2">Double-slope roof with wooden trusses and steel trusses</td><td>Concrete plaster finish, exposed aggregate finish</td><td>Wooden and stone columns used in coordination with the load-bearing system</td></tr>
<tr><td>Office area</td><td>Gray exposed brick wall, mostly load-bearing walls</td><td rowspan="2">Wooden and stone columns used in coordination with the brick Load-Bearing System</td></tr>
<tr><td>Auxiliary buildings</td><td>Flat concrete roof structure</td><td>Red exposed brick wall</td></tr>
</table>

2.2. Analysis of the initial structure

Most of the workshops use concrete and steel frames, which can provide a large span, high heights, and large stiffness, so the internal space can be operated by large machines (**Figure 2**). Furthermore, the concrete steel frame structure has strong operability, and the beam and plate can be dismantled and strengthened. During the process of transformation, we should pay attention to the unity and stability of the structure.

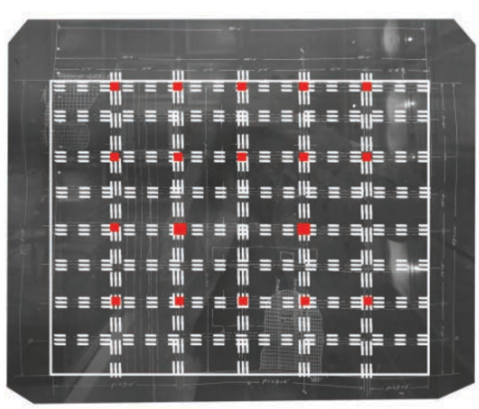

Figure 2. Structural plan of initial construction building (drawn according to data)

2.3. Structure selection after the transformation

The reconstruction involves the selective demolition of landscape structures. For the workshop, the focus is primarily on retention and reinforcement. Regarding the serrated workshop boundary, part of the roof and exterior walls will be dismantled to create gray spaces and corridors on the second floor.

2.3.1. Phase I production plant renovation

In the first phase of the plant renovation, the original workshop serrated single slope roof is simulated to extend, and the metal brown and yellow texture frame material is used to limit the boundary, breaking the original boundary to extend 5–8 m. The internal skylight adds a metal frame grille to avoid large areas of direct light entering the room and create a comfortable light environment (**Figure 3**). The metal frame grille flows like yarn in the horizontal and vertical planes and the extended three-dimensional direction to the new outdoor structures which is shown in **Figure 3** and **Figure 4** respectively. The old buildings are connected with the new buildings, and the new structures are integrated into the 2.2 m high pipeline equipment layer to achieve the traditional and modern interweaving in the structure [1].

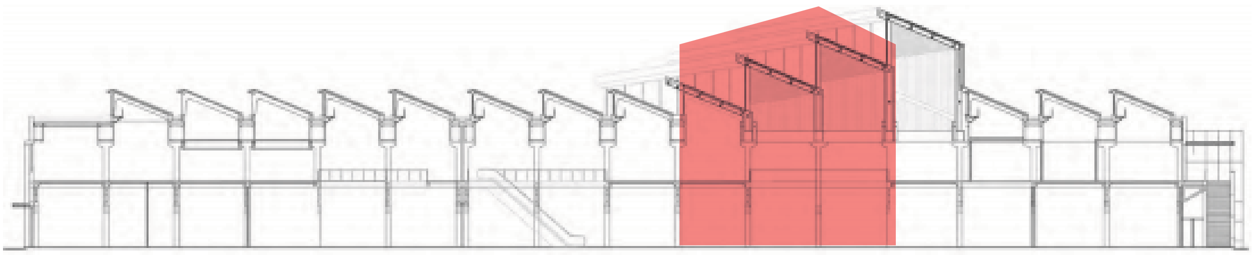

Figure 3. Schematic diagram of phase I production workshop section (modified according to data)

Figure 4. Perspective diagram of phase I plant renovation (sourced from gooood.cn)

2.3.2. Phase II production plant transformation

The original structure of the second phase workshop is a precast concrete assembly large-span structure. In the transformation process, the steel structure for paste node reinforcement is introduced for a four-way hinge, which provides mechanical support and a unified connection [3]. The atrium part completes the height, removes the second-story floor slab, and introduces the light to solve the problem of insufficient lighting of the serrated skylight in the large space, which is shown in **Figure 5**. The first floor of the original building arranged the concrete box main girder in the north and south direction, the concrete box main girder was arranged in the east and west direction of the second floor, and the broken line secondary beams were erected on the main beams. In the process of transformation, because of the force unity of the structure, the beam and plate were not removed, only the second-floor wall was partially removed, and the two-floor corridor was retained. To unify the space, the stairs of the new steel structure are hung on the second floor and beam, and the stairs plus the structures are unified in the overall structure.

Figure 5. Reinforcement of internal atrium and steel structure node in phase II plant renovation (photographs by the author)

2.4. Analysis of the structure after the transformation

The first phase of the plant is mainly decorative construction, while the second phase of the plant is mainly rigid hinge reinforcement of rigid nodes and demolition of the two-story floor slab to form a high atrium. The advantages and disadvantages of the comparison and summary are shown in **Table 2**.

Table 2. Analysis of the quality of Dahua 1935 plant transformation

Plant types	Advantage	Disadvantage	Summary
Phase I workshop	Structure and form are unified	Scale imbalance, insufficient lighting	Form, structure, and function are dialectically unified
Phase II workshop	Steel structure node reinforcement Atrial lighting	Single space form	Unification of applicability and economy
Prospect	Technology and art are unified, and the transformation should not only start from art but also coordinate from the various aspects of applicability (functional vitality, thermal environment comfort, space interest, space accessibility, etc.)	The transformation of the plant will face the situation that the large functions cannot be effectively replaced, so the structure of the large plant to create more space forms will effectively stimulate the commercial vitality	Combined with the technical means of the structure, different forms of structural models are transformed, the integration and flow analysis of spatial syntax are carried out, and the overall planning from the three perspectives of artistry, adaptability, and technology, to promote further scientific development of the renewal of old industrial buildings

3. Conclusion

3.1. "Dahua 1935" project structural transformation and optimization

In the early analysis and design of the transformation of the "Dahua 1935" project, the structural design has an imbalance in scale, a single space form, artistic atmosphere construction, and economy that need to be improved. Therefore, the author puts forward the idea from the two aspects of carbon fiber reinforcement and bonded steel reinforcement and establishes the corresponding model optimization.

3.1.1. Application principle of carbon fiber reinforcement method

Carbon fiber reinforcement primarily involves two types of materials: carbon fiber boards and carbon fiber cloth.

These materials are easy to cut, simple to use in construction, and can adhere closely to the contact surface, ensuring effective construction coordination. The low reinforcement weight of carbon fiber will not affect the dead weight of the structure. The used materials are more cost-effective, have low construction efficiency and cost, high operability, low construction difficulty, and can be the first choice in the economy.

3.1.2. Design concept of the carbon fiber reinforcement method

The carbon fiber reinforcement method minimizes interference with the original building while occupying minimal space. It is applied primarily to the beams and columns, allowing the design of wall panels to remain diverse and flexible.

For example, the corridor surrounding the atrium in the first phase of the workshop avoids strict linearity, opting instead for varying heights and subtle forward-and-backward shifts to create an engaging spatial experience. The large beams and columns of the workshop are left exposed to foster a sense of openness and familiarity. In some areas, hidden elements or spinning wood grilles are added for visual interest. The independent outdoor corridor incorporates green wall skirts and white walls featuring graffiti, where the graffiti is applied only to the surface, as shown in **Figure 6**.

Inspired by the developmental stages of "Dahua 1935"—from industrial production to the "Great Leap Forward" to the reform and opening-up period—the design integrates different styles and materials. As people move through the space, the walking paths reveal these transitions, gradually unfolding the history and development of the site, evoking resonance among visitors, as shown in **Figure 7**.

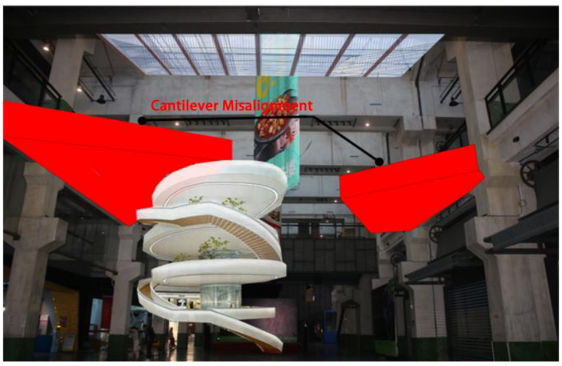

Figure 6. Atrium design (drawn by the author)

Figure 7. Corridor design (drawn by the author)

Firstly, the author identified the separation between the structural and architectural function design in the "Dahua 1935" project. By reviewing references and related literature, the author analyzed the structural changes of "Dahua 1935," examined relevant transformation cases, and summarized a transformation method consistent with the carbon fiber reinforcement approach used in the project. Additionally, based on the characteristics of the carbon fiber reinforcement method and the inherent contradictions of the "Dahua 1935" project, optimization ideas were further developed, and design strategies were simulated to address the corresponding challenges.

However, due to the influence of multiple factors, the business model of "Dahua 1935" has become stagnant and declining. Of course, the author's proposed transformation plan is just one approach. The revitalization of "Dahua 1935" requires multiple, comprehensive, and scientifically grounded solutions that account for its unique characteristics. We look forward to the collaborative efforts of more outstanding researchers to realize its potential.

Disclosure statement

The author declares no conflict of interest.

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Micro-Renewal Design of Typical Public Spaces from the Perspective of Residents' Activity Characteristics and Spatial Needs: Taking Baizhifang Street in Xicheng District as an Example

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Abstract: As China's urbanization development direction has shifted from incremental construction to upgrading existing structures, urban renewal has become an important planning approach, and the gradual micro-renewal model has become a key trend for residential area transformation. Additionally, the local renewal approach focusing on public spaces of residential areas is becoming a new way to enhance the quality of urban public spaces, stimulate urban vitality, and promote sustainable development of regions. Currently, due to the long building years and other factors, old communities have insufficient public facilities, parking difficulties, outdated facilities, and other problems, making it difficult to meet the needs of residents' lives. This paper takes Baizhifang Street in Xicheng District as an example and starts from the meaning of participatory design, respecting the existing environment and policies in China, discussing the public space problems, selecting the renewal area and formulating design strategies, and finally showcases the actual application of the design in public space renovation.

Keywords: Urban micro-regeneration; Urban renewal; Rehabilitation of old neighborhoods

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1. Introduction

In 2016, the "Guangzhou Urban Renewal Measures" first mentioned micro-renovation, based on maintaining the status quo, renewing through partial demolition and construction, functional replacement, repair, and protection, and many others, aiming to improve the living environment, stimulate the vitality of neighborhoods, and pass on the regional culture [1].

In July 2021, the "Small Space, Big Life—Micro Space Transformation for the People" project was completed, with eight pilot micro space projects completed under the leadership of the government, the leadership of think tanks, and public participation, solving practical problems of the residents and promoting grassroots governance and urban renewal. At the moment, the government attaches great importance to the transformation of small and micro spaces and has issued several policies to encourage pilot projects and promote the quality of cities and communities. Localities have responded positively by launching transformation projects and public participation has become an important part of the process. Through the collection of opinions, community discussions, and other means, residents have participated in the development and implementation of transformation programs, which has strengthened their sense of participation and satisfaction with the transformation of their communities. This model of joint consultation and sharing has helped to form a new pattern of community governance [2].

2. Street situation

2.1. Street location overview

(1) Location and area: Baizhifang Street is located in the southwest of Xicheng District, Beijing where the jurisdiction of the maximum distance between east and west is 2.1 km, the maximum distance between north and south is 1.6 km, with a total area of 3.1 km^2.

(2) Administrative divisions: Baizhifang Street is located in the southwest corner of Beijing's old city, adjacent to Ox Street in the north, east of Taoranting Street, west to Guangwai Street, south looking at Fengtai. This street serves as a critical connection between the old city and its periphery, forming an important transportation hub for the southern part of Beijing. Key landmarks include CaiShiKou Street to the east, the Second Ring Road to the southwest, and the Beijing South Railway Station and Yongdingmen Long-distance Coach Terminal to the southeast (see **Figure 1)**.

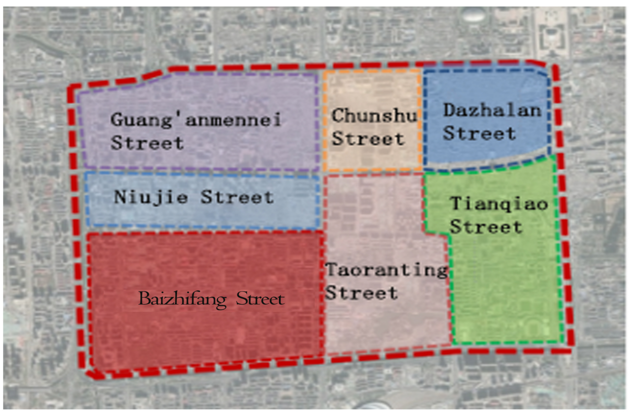

Figure 1. Street location

2.2. Street history

The Baizhifang area has a long history, belonging to the southwestern suburb of Nanjing during the Liao Dynasty, located in the central capital city during the Jin Dynasty, and gradually developed into part of the city during the Ming and Qing Dynasties. After several administrative reorganizations, the current Baizhifang Street was finally formed in 1958 from Baizhifang, Guojiajing, and part of Zixinlu and Zaolinqianjie streets (**Figure 2**).

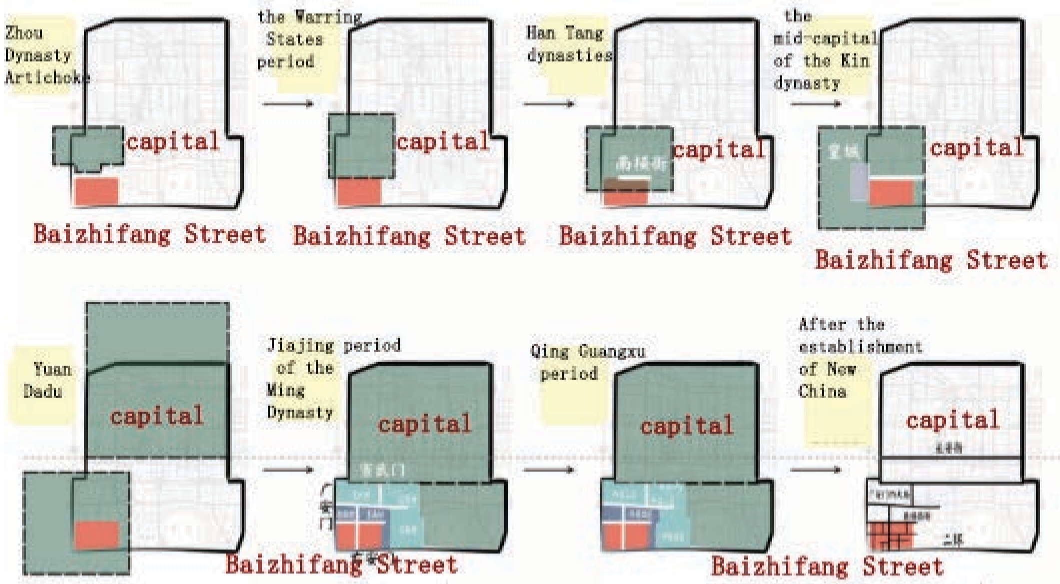

Figure 2. History of Baizhifang Street

2.3. Street characteristic culture

Since the Jin Dynasty, Baizhifang Street has served the important function of serving the central government and is the only street in Beijing that continues to bear the name of "Fang" reflecting its historical association with paper production. As a model for the planning of Beijing's old city after the founding of New China, it is also an area where the development of modern education has come to fruition. Deeply rooted in the multi-cultural hinterland of Xuannan, Baizhifang Street is home to representative non-legacy programs such as "Baizhifang Tai Lion" and "Baizhifang Satchel Drums" which are not only of deep cultural heritage and high artistic value but have also become the street's unique cultural card, which the street is actively protecting and passing on to provide new vitality to the area's cultural endeavors. These projects not only have deep cultural heritage and high artistic value but also become the unique cultural card of the street [3].

2.4. Research on the characteristics of residents' activities and spatial needs

The daily activities of the residents of Baizhifang Street are primarily influenced by the age structure of the population. According to preliminary research statistics, the main activities of residents in the Baizhifang community include living, working, and leisure. Due to the large proportion of elderly residents, the community's current activities are predominantly geared toward the elderly (see **Figure 3**).

Population by age	
0～14	3152
15～64	6115
65 and above	5068

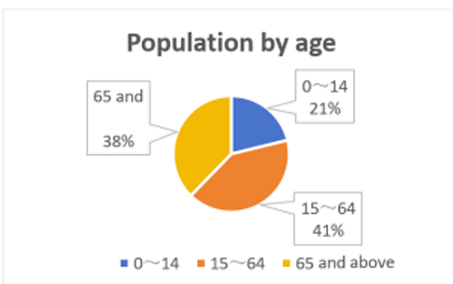

Figure 3. Demographics of the Baizhifang community

The community offers a wide range of activities, including various sports, cultural events, and multiple types of elderly services. Most activities are developed based on the community's existing resources, ensuring they are tailored to the needs of the residents. This approach has allowed for the effective and innovative use of original community resources. To address residents' demand for activity spaces, the street has implemented a "2 + 5 + 2N" model for its elderly service consortium. This model includes two elderly care centers, five elderly service stations, and several self-managed organizations and service resources for the elderly [4].

3. Selection of design site

With the acceleration of urbanization, the aging infrastructure in older communities—an integral part of the city—is becoming increasingly problematic. As a critical facility for parking and charging non-motorized vehicles, the condition of old carports directly affects the safety and convenience of residents. In response, the team chose the carport space, which has been a longstanding issue for residents, in the Pingyuanli sub-district of Baizhifang Street to implement a micro-renewal design [5].

3.1. Site condition

With the assistance of the street office staff, the team visited 19 communities to understand their basic situations and challenges in community governance. During these interviews, common issues in older neighborhoods were identified, such as parking difficulties, poor environmental conditions, and inadequate property management. Additionally, some community leaders and residents highlighted specific problems and suggestions unique to their communities.

Based on an analysis of the conditions in each community within Baizhifang Street, the team ultimately chose the Pingyuanli Community for transformation. Established in September 2018, the Pingyuanli Community is "young" in terms of its founding date but "old" regarding its facilities. As a relocated neighborhood built in the 1990s, it has a high population density and numerous resident demands [6].

3.2. Problem identified

The pre-design team conducted in-depth research and a comprehensive survey using methods such as questionnaires, on-site observation, and resident interviews. The following issues were identified regarding the use of carports, safety conditions, and management status.

(1) Safety hazards

- (a) Fire safety issues: Aging wires and private charging setups in the old carports pose significant fire risks. Additionally, the accumulation of debris in the carport obstructs fire escape routes, which could lead to catastrophic consequences in case of a fire.
- (b) Structural safety issues: The carports, built long ago, suffer from roof damage and are at risk of collapse. Narrow entrances and exits hinder vehicle parking and resident movement.
- (c) Lack of security awareness: Residents exhibit unsafe behaviors such as improper charging and haphazard parking of vehicles, increasing security risks.

(2) Management deficiencies

- (a) Inadequate maintenance: Lighting facilities in the carports are either missing or damaged, making night-time parking inconvenient and unsafe.

(3) Residents' demand

(a) Parking difficulties: The increasing number of non-motorized vehicles has exceeded the parking capacity of the old carports.

(b) Charging challenges: Residents resort to private wiring from windows, creating hazardous "sky nets" that pose significant safety risks.

(4) Lack of vitality:

(a) Unattractive appearance: The carports are poorly designed, negatively impacting the neighborhood's aesthetics.

(b) Limited functionality: The carport spaces lack versatility and fail to contribute to the community's vibrancy.

3.3. Program strategies

In response to the problems identified in the research, we have developed targeted solution strategies for the micro-space, categorized into the following five areas.

(1) Intelligent equipment addition: Increase the power exchange station in Carport 1 and simultaneously set up a monitoring system and an intelligent charging system in all three carports to facilitate their management [7].

(2) Rational planning and utilization of space: Redelineate the parking space lines, ensuring a strict division between non-motorized and motorized vehicle parking areas. Additionally, allocate a 6.4 m × 1.5 m space in the carport for parking "zombie cars" to address parking difficulties and other issues (see **Figure 4**) [8].

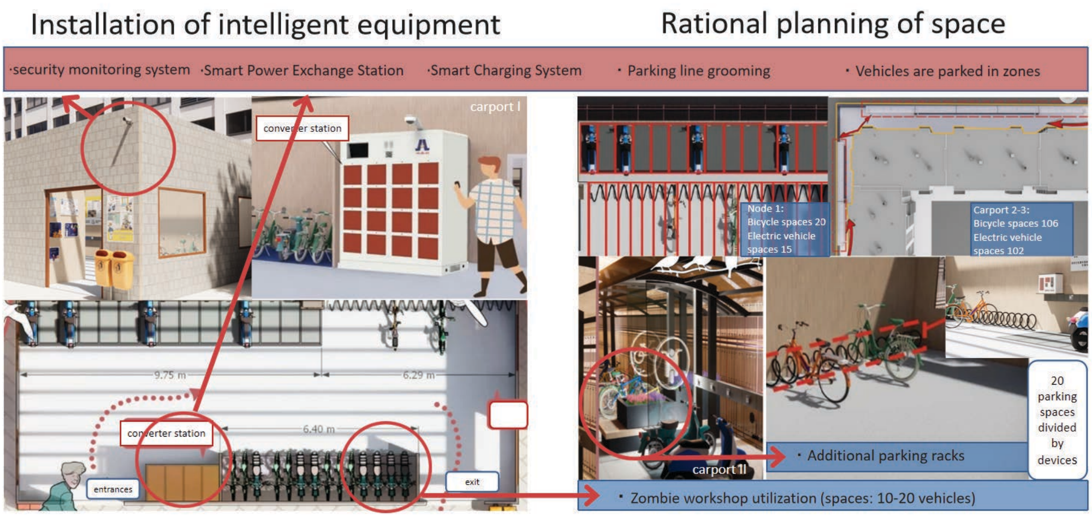

Figure 4. Program Introduction I

(3) Infrastructure improvement: The old lamps and lanterns will be updated, and an acrylic baffle with a light-emitting diode (LED) strip will be used to separate the motorized and non-motorized parking areas. This will provide soft lighting for residents returning home at night while also helping to regulate the parking area. Moreover, the carport, which originally had poor lighting due to its closed design, will have its roof transformed using polycarbonate panels and other materials. This will provide shading from the sun while also enhancing lighting, as shown **Figure 5**.

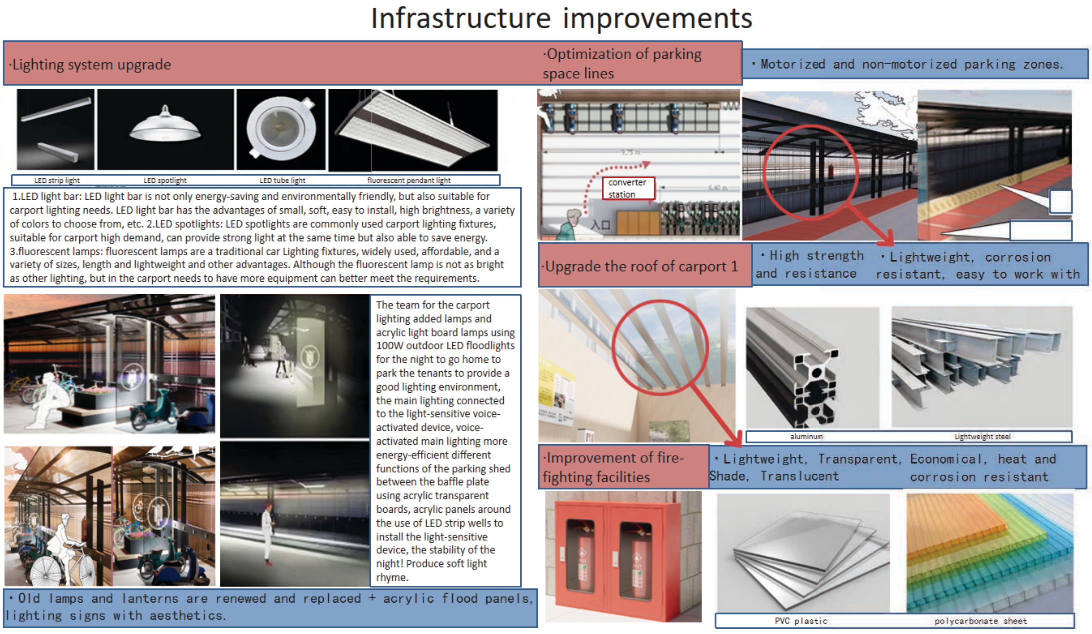

Figure 5. Program Introduction II

(4) Environmental beautification and functional revitalization: The core highlight of the program is the division of the parking area using green flower beds. The flower bed platforms, which also function as seating areas, meet the needs of community residents who wish to rest. The seats are designed at an appropriate height, making them particularly accessible and comfortable for the elderly. In addition to beautifying the environment, the flower beds also enhance the vitality of the space, as shown in **Figure 6**.

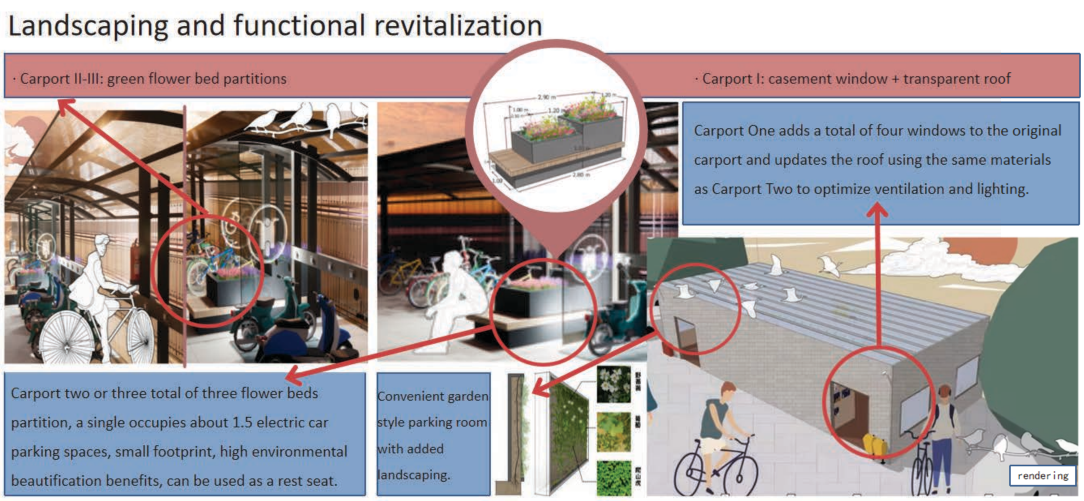

Figure 6. Program Introduction III

(5) Residents' needs: We produced a variety of guide signs, charging station guidelines, graphic maps, and more. Furthermore, we utilized the street property's intellectual property (IP) image, "Xiaobai," to create safety posters aimed at raising residents' safety awareness. Moreover, we formulated a set of community policies that use rewards and penalties to encourage residents to regulate their parking behavior [9].

4. Conclusion

Using Baizhifang Street in Xicheng District, Beijing as a case study, this article explores the importance of the urban micro-renewal model in settlement renewal within the context of urbanization. The investigation focuses on the micro-space of the Pingyuanli Community in Baizhifang Street, following the "people-oriented" concept to optimize the design of carport spaces based on residents' activity patterns and spatial needs. The renewal of public spaces in Baizhifang Street is a long-term and complex process requiring the joint efforts of the government, community, and residents. As one of the typical communities in Baizhifang Street, the Pingyuanli Community serves as a valuable model for micro-renewal projects, particularly through its carport micro-renewal initiative. It is believed that with continuous optimization, innovative approaches, and the integration of historical and cultural characteristics, Baizhifang Street can evolve into a modern community model featuring well-functioning infrastructure, a beautiful environment, and satisfied residents.

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Research on the Optimization Control Method of Inbound Traffic Flow on On-ramp

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Abstract: This study aims to optimize the inbound traffic flow on on-ramps by considering low time costs, good speed stability, and high driving safety for mixed traffic flow. The optimal inlet gap is identified in advance, and trajectory guidance for vehicles entering the gap is determined under safety constraints. Based on the initial state and sequence of vehicles entering the merging area, individual vehicle trajectories are optimized sequentially. An optimization model and method for ramp entry trajectories in mixed traffic flow are developed, incorporating on-ramp vehicle entry sequencing and ordinary vehicle trajectory prediction. Key performance indicators, including driving safety, total travel time, parking wait probability, and trajectory smoothness, are compared and analyzed to evaluate the proposed approach.

Keywords: Traffic flow; Optimization control method; On-ramp vehicle

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1. Introduction

With the implementation of intelligent bicycle systems, highways and urban expressways exhibit characteristics such as fewer nodes, continuous traffic flow, and simplified path selection behavior. Additionally, the cost of roadside network connection equipment is relatively low, and many cities have initiated pilot studies in specific areas. Therefore, studying the laws of traffic flow and developing control measures under intelligent network-connected scenarios hold significant practical value. This represents a necessary stage in achieving coordinated traffic management from localized points to broader areas [1]. Intelligent collaborative control of continuous traffic flow on highways is influenced by factors such as traffic flow guidance, lane selection at entry points, and on-ramp merging and exiting. The networking and communication capabilities between vehicles enable collaborative control and optimization of the vehicle flow system.

Currently, research on connected vehicles primarily focuses on technical aspects such as vehicle-road communication, lateral trajectory control, traffic flow parameter characteristics in connected environments, driving behavior, and traffic flow feature extraction. However, from a management perspective, studies on travel behavior are mainly limited to operational rules and control methods for single road sections or individual intersections, resulting in a relatively narrow research scope. Building on existing research, this paper uses expressways as the research setting, focusing on regional traffic flow optimization and achieving collaborative management.

Traffic flow organization in ramp merging areas plays a crucial role in improving the traffic efficiency of both the main road and the ramp. The on-ramp vehicle optimization method involves signal control and optimization algorithms to organize the merging sequence and trajectories of on-ramp vehicles. By projecting on-ramp vehicles onto the main road, the required gap is calculated in advance, determining the merging point and time intervals for vehicles. A speed adjustment strategy is then proposed to ensure that on-ramp vehicles reach the merging point smoothly and complete the merging process seamlessly [2]. The longitudinal control of on-ramp vehicles was designed using a fuzzy controller. By adjusting the speed of on-ramp vehicles, the controller ensures they enter the main road smoothly and stably, thereby avoiding traffic congestion [3]. To ensure on-ramp vehicles enter the main road smoothly, vehicles on the main road can create appropriate gaps in advance by adjusting their speed through acceleration, deceleration, or lane changes. A novel merging strategy is proposed, leveraging the communication capabilities of intelligent vehicles [4].

In this method, the speed and trajectory of the connected vehicles on the main road are adjusted by the cooperation of the connected vehicles to generate a safe inbound gap, and the inbound trajectory of the on-ramp vehicles is calculated during the traffic time released by the traffic light. The collaborative optimization algorithm of on-ramp and trunk road vehicles can be further divided into optimal control and feedback control [5]. The objective of the optimal control is to optimize the parameters of the total passing time, average speed, acceleration, fuel consumption, and so on. A vehicle longitudinal trajectory optimization model was established to deal with maximizing energy efficiency and driving comfort and achieve optimal speed organization by minimizing the first and second derivatives of acceleration and speed [6]. Therefore, the on-ramp vehicle merging organization can be transformed into a vehicle following problems with safety and kinematics constraints.

This paper presents a collaborative optimization method for mixed flow at the on-ramp. The on-ramp driving rules and driving models of ordinary vehicles and connected vehicles are given respectively, and a speed guidance method to ensure the smooth entry of on-ramp vehicles is proposed, which realizes the safe and efficient entry of on-ramp vehicles under a connected environment. The ramp inlet optimization algorithm is based on the driving model to generate mixed traffic flow and plan the trajectories of the vehicles on the ramp one by one. Based on the principle of safe and efficient import, the import gap on the main road is sorted, and collaborative trajectory optimization is given to verify the import feasibility of alternative gaps. The uncertainty of the import point of each vehicle is considered in the model, and the import time breaks the first-in-first-out rule. The overall framework calculation method of on-ramp traffic import is constructed, which can be used for the centralized management of traffic flow under the intelligent network.

2. Ramp inbound optimization algorithm

The on-ramp inbound scenario considered in this paper includes an inlet on-ramp, on which there is a side road. The traffic flow on the main road and on-ramp is mixed, and the vehicle types include ordinary vehicles, single-car connected vehicles, and Cooperative Adaptive Cruise Control (CACC) vehicles in the fleet. On-ramp traffic merging is a process in which the vehicles on the on-ramp seek to merge into the gap or communicate with the vehicles on the main road to obtain a safety gap, to enter the main road before the end of the service road. For traditional roads and vehicles, the ramp merges into the distance and speed observations within the field of view to artificially adjust the speed and obtain a safe distance before entering. Due to the asynchronous decision-making and lack of communication, it is difficult to ensure that the vehicles do not experience delays, do not collide, and smoothly merge onto the main road.

(1) Step 1: The purpose of this step is to determine whether the current vehicle can successfully merge into the selected gap before reaching the end of the auxiliary lane, without requiring a speed adjustment. If the gap is suitable for the vehicle to merge without adjusting its speed, the vehicle's position at that moment must be precisely mapped to the gap on the main road, and the vehicle distance must meet safety requirements. Additionally, the vehicle is restricted to the auxiliary lane, and exiting is prohibited. Therefore, if the gap can be entered onto the main road without speed adjustment, the following constraints must be satisfied:

$$x_i(t') + h_s(t') \le x_j(t') < x_{i-1}(t') - h_s(t') \quad (1)$$

$$2 \times L_c < x_j(t') < 2 \times L_c + L_a \quad (2)$$

(2) Step 2: Based on the mapped position and spacing of vehicle j on the main road, it is further divided into the following subsets.

$$G_s(t) = \{G_{sf}(t), G_{sb}(t)\} \quad (3)$$

$$G_u(t) = \{G_{uf}(t), G_{ub}(t)\} \quad (4)$$

$$G_{sf}(t) = \{g_i(t) | g_i(t) > g_m(t) \& x_i(t) > x_j(t)\} \quad (5)$$

$$G_{sb}(t) = \{g_i(t) | g_i(t) > g_m(t) \& x_i(t) < x_j(t)\} \quad (6)$$

$$G_{uf}(t) = \{g_i(t) | g_i(t) \le g_m(t) \& x_i(t) > x_j(t)\} \quad (7)$$

$$G_{ub}(t) = \{g_i(t) | g_i(t) \le g_m(t) \& x_i(t) < x_j(t)\} \quad (8)$$

(3) Step 3: When none of the intervals within the detection area can be successfully entered without a speed adjustment, the algorithm will be activated to achieve the necessary conditions through coordinated speed adjustments between the main road and on-ramp vehicles. It will then publish details to the side unit, including the merge location, merge time, and speed. The basic idea is to verify the feasibility of each interval in order of distance. Once verified, the relevant main road vehicle i and ramp vehicle j will receive speed guidance, while other vehicles will maintain their natural behavior and follow.

3. Examples and analysis of results

The algorithm was experimentally validated in a highway scenario with on-ramps, as shown in **Figure 1**. To ensure generality, it is assumed that the traffic flow of drivers arriving at the entrance of the inbound area follows a Poisson distribution, with an average interval time of three seconds on the main road and five seconds on the on-ramp to generate random traffic flow. Specifically, if a steady flow has formed on the main road at the entrance of the ramp, it can be assumed that the vehicle interval on the main road is constant. In this experiment, vehicles are assumed to enter the road according to a Poisson flow from the detection point. The proportion of connected vehicles on the main road and on-ramp is set as =70% and =40% respectively. The distribution and arrangement of different models on the main road and on-ramps are randomly generated. The simulation duration is 120 seconds, and the time range is divided into 120 sections.

In the example, the trajectory and speed changes of the vehicle at the ramp inlet are shown in **Figure 1** and **Figure 2**. The horizontal axis indicates the travel time, the vertical axis indicates the location of the vehicle, and the main road and ramp are calculated from the monitoring point. A total of 72 vehicles entered, including 48 vehicles on the main road and 24 vehicles on the on-ramp. Among them, the red, blue, yellow, and green lines respectively represent the driving tracks of connected vehicles on the main road, ordinary vehicles on the main road, connected vehicles on the on-ramp, and ordinary vehicles on the on-ramp. In **Figure 1**, the trajectory line with a constant slope indicates a direct import process with no velocity change. Some vehicles on the main road must slow down to widen the gap and allow on-ramp vehicles to enter, such as some track lines with small amplitude track shocks.

Another phenomenon that oscillates even more strongly is that associated vehicles cooperate with other vehicles following an optimized trajectory, which is achieved by adjusting the speed of multiple vehicles in front of the speed. Additionally, in this example, no vehicles were observed stopping for inbound traffic, and none of the vehicles slowed to zero. Simultaneously, it can be seen that the rear vehicles join in advance and then move to the front, and the connected vehicles on the ramp (yellow curve) can merge with the main road-connected vehicles to form a team. **Figure 2** shows the speed change of vehicles. It can be observed that on the corresponding main road, connected vehicles and ordinary vehicles on the on-ramp, a small number of vehicles accelerate directly to a comfortable speed and then drive at a constant speed, and some vehicles need to adjust their speed but the changes are relatively gentle, with no instances of prolonged stopping or waiting.

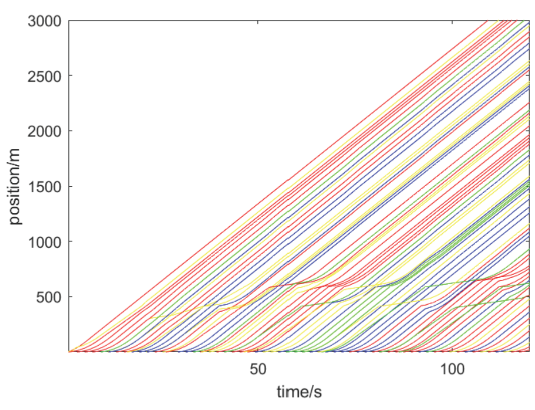

Figure 1. Vehicle track at ramp entry

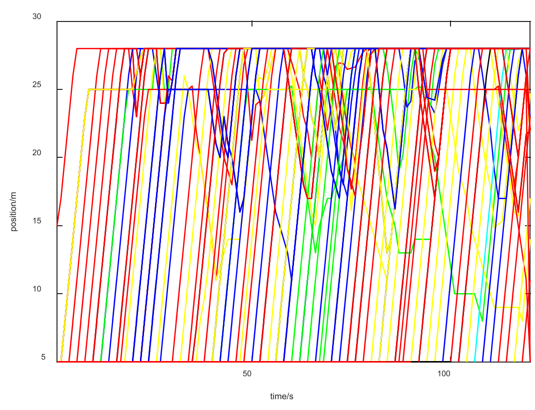

Figure 2. Vehicle speed at ramp entry

Figure 3 and **Figure 4** show the total capacity of the road network under different inbound traffic volumes of the main road and on-ramp. In the experiment, the number of driving hours is first converted to the average time between vehicles. As can be seen from **Figure 3**, in the case of low ramp flow (as shown on the left side of the figure), the total capacity on the main road increases rapidly with the increase in traffic. It can be seen that in this case, the impact of vehicles on the on-ramp on the main road is small, and the speed change of vehicles is also small. With the increase of ramp flow, the increase or decrease of capacity is slow and presents an irregular trend. Concurrently, the traffic flow of the main road is severely affected, and the merging of vehicles can lead to dramatic speed fluctuations and unsmoothness of the track. When the traffic flow of the main road increases to 1,800 veh/h, and the traffic flow of the on-ramp is 500 veh/h to 1,000 veh/h, the traffic capacity decreases due to the high traffic density and is accompanied by congestion. As shown in **Figure 4**, the total number of outgoing vehicles always increases with the increase of the number of incoming vehicles on the main road, and when the on-ramp traffic is large, the incremental rate gradually slows down. It shows that due to the high speed and driving priority on the main road, the main road flow is the key factor affecting the traffic capacity, and too much on-ramp flow will lead to congestion, speed deceleration, and traffic capacity reduction, and vice versa.

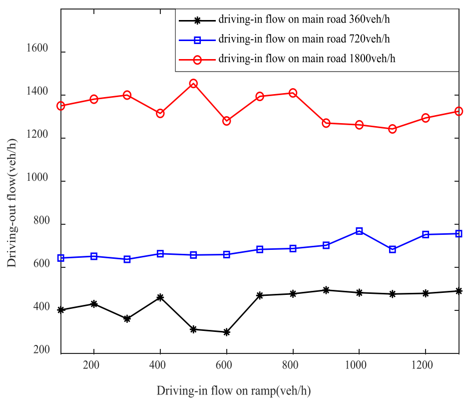

Figure 3. Impact analysis of ramp flow

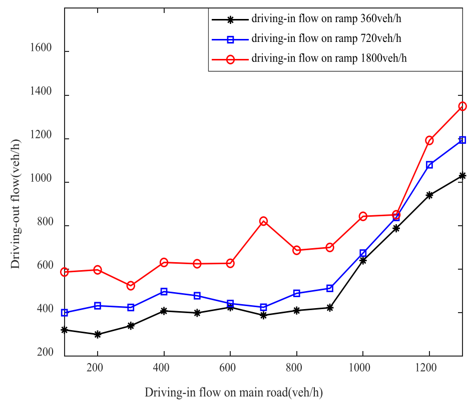

Figure 4. Impact analysis of main traffic

4. Conclusion

This paper presents a trajectory optimization algorithm for ramp entry of mixed traffic in a networked environment. Considering constraints such as vehicle safety distance, kinematic characteristics, and driving performance, Vehicle-to-Everything (V2X) communication is used to stabilize the speed of on-ramp inbound traffic and increase the total number of off-ramp vehicles. In the proposed method, the trajectories of connected vehicles are optimized based on the arrival order of on-ramp vehicles. The optimization plan for the vehicle in front is stored and used as input for the following vehicle, while the trajectory of ordinary vehicles is predicted using a driving model. For each vehicle, the process involves first identifying an appropriate gap and determining priority, then verifying the feasibility of the gap based on constraints and calculating the driving trajectory. The vehicle entry point in the algorithm is not fixed, and the entry time of the rear vehicle can be earlier than that of the front vehicle. Additionally, the rear vehicle is allowed to move ahead and become the leading vehicle once it merges into the main road. The model and algorithm are validated through numerical examples and comparative experiments. The results show that the method achieves relatively smooth vehicle trajectories, ensures safe distances, and improves entry efficiency. On-ramp vehicles are allowed to merge into the main road before reaching the auxiliary lane exit, avoiding stops and delays, while keeping speed fluctuations minimal.

Disclosure statement

The authors declare no conflict of interest.

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Design Strategies for the Renewal of Public Space in Chongming Countryside from the Perspective of Cultural Heritage

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Abstract: Cultural heritage and protection is an important part of rural revitalization. Chongming district is a place with special geographical advantages and historical and natural resources in Shanghai. However, after recent investigations, it is found that the cultural heritage and protection of local traditional architecture in Chongming has not been adequately researched. This paper is based on the analysis and abstract of the traditional architectural design elements of Chongming, combined with renewal design projects, hoping to summarize the public space renewal design strategies in Chongming countryside with the characteristics of Chongming, and providing certain reference value to relevant research or design projects in the future.

Keywords: Environmental design; Public space design; Cultural heritage

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1. Introduction

Chongming district, Shanghai City is located at the mouth of the Yangtze River, with a unique geographical location and natural resources, and has great economic development potential. Chongming's agriculture has gradually developed since the Tang and Song dynasties, and its financial and social status has thus steadily improved, the material and cultural life for local people has also been improved, it has laid the solid foundation for Chongming's rich historical and cultural resources in terms of intangible culture heritage and architecture.

Cultural heritage reflects local culture and tradition and is the basis for building local characteristics and enhancing local identity. However, many projects carried out in Chongming in recent years have not paid enough attention to the cultural heritage and protection. Chongming is important to Shanghai as it has a special location and rich history, but the socio-economic development is falling behind other districts in Shanghai. Shanghai needs to promote and activate the development of Chongming.

This paper is based on architectural and environmental design perspectives, studies the characteristics of architectural planning and design elements in Chongming, and combined with renewal design projects, trying to explore the design strategies for the renewal of public space in Chongming countryside under the context of culture heritage and protection, hoping to activate the development of Chongming and protect its historical and cultural at the same time, as well as providing certain research value for relevant researches and design projects in the future [1].

2. Analysis of planning and design elements of Chongming traditional buildings

2.1. Planning

The planning of traditional courtyard houses in Chongming is divided into one-tier type, two-tier type, three-tier with two atriums type, and four-tier with three atriums type [2]. Such as Shanghai's outstanding historical building, Ni Baosheng's residence and Chongming Confucius Temple which was built in the Yuan Dynasty, were both four-tier with three atriums type planning. These are the most representative buildings in Chongming and reflect the characteristics of the traditional courtyard house planning in Chongming.

The representative planning of the four-tier with three atriums is made of four layers of houses and three enclosed atriums, which are enclosed by the surrounding houses to form a wellhead space for natural lighting, ventilation, and drainage [3]. By the traditional concepts of "Heaven and man are united as one" and "water resembles wealth," the sloped roofs around the atriums are gradually developed into the form of sloping to the atriums more and sloping to the outside less, which introduces more rainwater into the atrium, and then placed water collection devices in the atrium to fulfill the traditional concepts. This kind of traditional courtyard house planning is called "Sishuiguitang" which means water from four directions returns to the middle of the courtyard house, and it has been widely applied in recent Neo-Chinese style buildings [4].

2.2. Design elements

Traditional design elements have their characteristics that reflect the development and environment of society at that time. Due to geographical differences, the same region may show different expressions in the use of traditional design elements [5]. For example, many fishermen lived in Chongming, while they tended to live by the river because of the convenience of fishing, and they began to build houses to protect themselves from the storm by using local and easy-to-get materials and in the shape of arches. As a result, a kind of traditional dwelling "Huandongshe" was gradually formed and reflected the way of life of the local fishermen in Chongming in the last century.

In addition, the textile industry is well-developed in Chongming, and the textile households need their dwellings to be open and well-displayed because they live and produce in the same space. Whereas Chongming is windy and rainy, the textile household designed a kind of door and window form in order to avoid the bad weather, "Yichuangyita" was therefore formed, and also reflects the way of life of the textile households in Chongming.

3. Abstract of the planning and design elements of Chongming traditional buildings

3.1. Abstract of the planning elements

With the development of the ages, the traditional courtyard house planning "Sishuiguitang" has evolved a lot of new expressions, the spatial combination and the material application have also changed a lot compared with the past. However, the core design elements that constitute its special space feel remain the same [6]. In this paper, the author extracts the core design elements that comprise the planning of "Sishuiguitang" as follows.

3.1.1. Atrium

The atrium often lays in the central axis of the entire courtyard house, surrounded by the houses and enclosed to be a wellhead space. The wellhead shape is diverse, like rectangular or round shapes, even in irregular shapes, and the atrium is an open, transition leisure space in the courtyard house [7]. Water collection devices, waterscapes, or pools can be placed in the middle of the atrium to fulfill the concept of "Sishuiguitang" and "Heaven and man are united as one," therefore, the water-relevant devices are the core design elements during the design process of the atrium.

3.1.2. Surrounded constructions

In a traditional courtyard house, the atrium space is usually formed with three sides of surrounded buildings, and the sloped roof of the surrounding buildings guides rainwater into the atrium, combined with the water collection devices in the atrium to build a space under the concept of "Sishuiguitang" [8]. Recently, besides using buildings to enclose the atrium, other design cases also trying to use corridors or connecting hallways to form the atrium space, building a semi-open and circle traffic flow to provide a sense of leisure and tranquility, which is especially common in the new design projects.

3.1.3. Decorated components

Decorated components such as openwork designed windows, which are used for natural lighting, ventilation, and wall decoration, tiles, and eave tiles for guiding rainwater, paving stones, and decorative ceilings, beams, pillars, and columns, all together form a courtyard house space with traditional Chinese characteristics [9].

3.2. Abstract of the traditional design elements

3.2.1. Traditional dwelling "Huandongshe"

Chongming Island is located at the mouth of the Yangtze River, and along the river, reeds are easier to find than wood. Thus, local fishermen tend to use local materials like reeds to build their shelters. They tied reeds into bunches, bent the bunches to semi-circular, and inserted both ends into the ground to build an arch or dome-shaped structure and then covered reeds and waterweeds onto the top of the structure as the roof [10]. From this, the semi-circular, arch-shaped architectural form of the traditional dwelling "Huandongshe" was designed. It is not only a result of the theory "round sky and square earth" but also due to the weather in Chongming, where streamlined structures can better cope with the storm [11]. From the above analysis, it can be seen that the typical design elements of the traditional dwelling "Huandongshe" are arch-shaped structures, bunch-shaped façade, native materials, and many more.

3.2.2. The door and window form of "Yichuangyita"

In the countryside of Chongming, most of the habitants make their living in the textile industry, and their houses are relatively small with windows that lead to the natural lights being relatively small too and with single lighting direction, and are often in the bedroom-kitchen layout. Due to the stormy weather in Chongming island, they tend to place the looms or other textile machines in the kitchen, while moving the machines outdoors when cooking. From this, the textile households designed a kind of door and window form called "Yichuangyita" to meet their needs of easily carrying things indoors or outdoors [12]. In their design, the door frame is divided into two parts: one is a door, and the other one is a half window on the upper side and half still board like a small door on the lower side. The door part and the window-board part can be opened together to provide a large doorway for carrying equipment, while on stormy days, it can be closed together with only the upper window part opened to ensure the natural light and prevent the wind and rain at the same time. This kind of door and window form was still in use in Chongming until the 1980s [13].

4. Application of the planning and design elements of Chongming traditional buildings

The traditional courtyard house planning of "Sishuiguitang," especially the typical atrium design is widely applied in Chongming in both historical buildings and new-designed buildings. The traditional dwelling "Huandongshe" and the door-window form "Yichuangyita" are unique design elements that characterized Chongming, but the "Huandongshe" was almost extinct in the 1950s, and the "Yichuangyita" can rarely be seen due to the impact of modern design styles, although it still existed until the 1980s. Also, the academic fields and design fields paid inadequate attention to these two elements and have little research achievements. Based on the design strategy of cultural heritage, this paper expects to build a diversified and unique architectural space with Chongming's characteristics through in-depth study, detailed analysis, and design application attempts [14]. The following projects are based on the current building in Yuxi Village, Chenjia Town, Chongming District.

4.1. Project 1: application of the planning elements

This project is an attempt to apply the atrium design concept of "Sishuiguitang" to the redesign process of the current building to create a modern courtyard-house-like villagers' center. In the planning design, more attention has been paid to the design process of the atrium. Typical design elements like connecting corridors have been applied to create the semi-open atrium space, a square waterscape has been placed in the central axis of the atrium to build a tranquil transition space, and the sloped roofs of the corridors are designed under the concept of "Sishuiguitang," which both ensure the atrium to be designed with traditional characteristics as well as in a modern way. During the design process of courtyard walls, native materials that have often been used in traditional Chongming buildings like tiles and lattice were also been applied to fulfill the feelings. Openwork window is a typical traditional design element in Chongming and even in the whole Yangtze River Delta, this kind of decorative window has been designed into a plum blossom shape and applied in this project to beautify the wall as well as improve natural lighting and ventilation. Columns, beams, and pillars were well-considered too, using different materials and details to show both modern and traditional design styles (see **Figure 1**).

Figure 1. The atrium and the connecting corridor (author's design)

This project discussed the combination of "Sishuiguitang" and the villagers' public center, using native materials and special design elements that are based on traditional concepts to create a unique local public space.

4.2. Project 2: application of the traditional design elements

This project is trying to re-design the current buildings into villagers' centers and combine the traditional design elements that were studied above to create a unique public space with Chongming characteristics. Yuxi Village, Chenjia Town is on the east side of Chongming Island, close to the East China Sea, where the local inhabitants are mostly fishermen. Accordingly, the design elements of traditional fishermen's residence "Huandongshe" have been taken into the façade design process, such as the application of an arch-shaped structure, creating a visual center of the whole community as well as different from the surrounding residential buildings, and also awaking the memory of the fishermen to enhance the sense of belonging (see **Figure 2**).

Figure 2. Main elevation (author's design)

During the façade design process, the concept of continuing the texture of the old dwellings was taken into account, while considering the durability of reeds and waterweeds, native materials like bamboo material which also represents Chongming and is bunch-shaped is more appropriate. Bamboo weaving façade in the same traditional tone and texture, combined with the arch-shaped architecture, brings the feeling of "Huandongshe" to the fishermen in a modern design way. At the entrances of the building, the door-window form "Yichuangyita" has been applied as the doorway. Replacing the original wooden door-window frameworks with metal frameworks, and enlarging the width of the window by using a triple-folding window structure, introducing more natural lights as well as remaining the original design purpose. Moreover, several arch-shaped glass curtain walls have been applied to continue the overall design element, to make the whole building in a harmony and unified design language (see **Figure 3**).

Figure 3. Façade details and door-window details (author's design)

This project discussed the attempt to create a public space that characterized Chongming by combining "Huandongshe" and "Yichuangyita" design elements, hoping to provide certain references to the local inhabitant-oriented design projects.

5. Conclusion

Chongming is an important part of Shanghai in terms of economic, cultural, and agricultural. However, during the investigation and research process of Chongming's traditional architecture and cultural heritage, it is found that a lot of precious traditional buildings, culture, and design elements are gradually disappearing from people's lives [15]. At present, China attaches great importance to rural revitalization and cultural heritage as well as historical protection, and remaining loyal to cultural heritage and historical protection in innovation has become an important issue to the design field in the new era. Thus, the inheritance, protection, and development of Chongming's characteristics in terms of environmental design and architectural design should be carried out promptly [16].

This paper analyzes and abstracts the unique design elements in Chongming, and summarizes the core design elements that consist of courtyard house planning "Sishuiguitang," traditional dwelling "Huandongshe," and door window form "Yichuangyita" combines two redesign projects towards a current building in Yuxi Village, Chenjia Town, trying to explore the public space design strategy based on the studies of Chongming characteristics thought the reapplication and integration of the design elements. Therefore, hoping to provide a certain research basis for relevant design projects and research as well as protect the local history and culture, and finally promote the development of Chongming.

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Research on Intelligent Application of Construction Project Management Method in the New Era

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Abstract: Intelligence has penetrated all walks of life with the rapid development of information technology. In the field of construction management, the application of intelligent technology is also increasingly extensive. Intelligent management methods can not only improve the efficiency and quality of construction projects but also reduce costs and waste of resources. This paper focuses on the intelligent application of construction project management methods in the new era. By analyzing the problems existing in the current construction management, the application of intelligent technology in every link of project management is expounded, including construction site management, material and equipment management, schedule control, quality supervision, and so on. At the same time, the paper also puts forward relevant suggestions on the popularization and application of intelligent management methods, which provides a reference for the innovative development of construction project management.

Keywords: Construction engineering; Management method; Intelligent; Apply

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1. Introduction

The construction industry is one of the pillar industries of the national economy, which plays an important role in promoting social development and improving the living environment. In recent years, the construction industry in China has shown a good situation of expanding scale and improving technology day by day. Simultaneously, the construction project is becoming more and more complex, and the traditional management mode has made it difficult to adapt to the requirements of the new situation. To further improve the management level of construction projects and achieve cost reduction and efficiency, it is urgent to introduce advanced concepts and technologies. With the rise of modern information technologies such as big data, cloud computing, the Internet of Things (IoT), and artificial intelligence, a new round of scientific and technological revolution characterized by intelligence is sweeping the world. The application of intelligent technology to construction project management can effectively solve the problems of low efficiency and serious waste of resources in traditional management methods [1]. With the advantages of informatization, automation, and intelligence, intelligent management methods have shown great potential in optimizing processes, improving refinement levels, and ensuring project quality and safety. Therefore, actively exploring the application of intelligent technology in construction project management is of great significance for enhancing the core competitiveness of the construction industry and promoting the transformation and upgrading of the industry.

2. Intelligent requirements in construction project management

2.1. Construction project management status and challenges

China's construction industry after many years of rapid development, both in the scale of engineering and technical level, has made great progress. However, there are still some problems to be solved in current construction project management.

Firstly, many construction enterprises follow the traditional management mode and rely on manual operation and experience judgment. The degree of information is not high and it is difficult to adapt to the increasingly complex engineering needs. Secondly, the construction project involves many links and a wide range of participants, and there are difficulties in coordination and cooperation at various stages, which affects the progress and efficiency of the project.

Additionally, due to the lack of scientific planning and effective supervision, a large amount of construction materials, equipment, energy, and so on, is wasted, which not only causes economic losses but also brings negative impacts on the ecological environment. Finally, engineering quality and safety risks cannot be ignored. Some projects have common quality problems and safety accidents, which reflect the loopholes and shortcomings in management. Facing the challenge of the new era, construction management needs to change and innovate. The introduction of intelligent management methods and the full use of advanced technological achievements can effectively crack the current management problems and promote the high-quality development of the construction industry.

2.2. Development and application prospects of intelligent technology

In recent years, the new generation of information technology represented by artificial intelligence, big data, and the Internet of Things has developed rapidly and been widely used in various industries, which has greatly changed the traditional way of production and life. As an important part of the national economy, the construction industry is also facing a wave of technological change.

At present, building information model (BIM), radio frequency identification (RFID), virtual reality (VR), drones, robots, and other intelligent technologies have emerged in the design, construction, operation, and maintenance of construction projects. The application of these advanced technologies makes engineering information more transparent, management processes more efficient, and quality and safety more guaranteed [2].

Taking BIM technology as an example, it realizes the information integration and sharing of the whole life cycle of buildings through digital models. Using the BIM platform, it is possible to optimize the design scheme, simulate the construction process, and conduct collision inspection, thereby improving the quality and efficiency of the project. Another example is unmanned aerial vehicle (UAV) technology, which obtains engineering image data through aerial inspection and combines it with an intelligent analysis algorithm to find quality defects and safety risks in construction in time.

In general, intelligent technology has the characteristics of accurate information collection, efficient data processing, and wide application scenarios, which can well meet the needs of construction project management. In the future, with the further development and integration of 5G, artificial intelligence, and other technologies, intelligent management methods will be more widely applied in the construction field and become the core driving force leading the industry change.

3. Application of intelligent technology in construction project management

3.1. Intelligent construction site management

A construction site is the core area of construction project management, which is directly related to the achievement of project quality, schedule, cost, safety, and other indicators. Traditional construction site management mainly relies on manual inspection and paper ledger, and there are some problems such as inadequate supervision and lagging information. The introduction of intelligent management methods can effectively improve the efficiency and level of construction site management.

Among them, the application of Internet of Things technology makes construction site management more intelligent. By deploying various sensors on the construction site, such as temperature and humidity sensors, noise sensors, PM2.5 sensors, and many more, environmental data can be collected in real-time and uploaded to the management platform. Through the visual interface, managers can intuitively grasp the working conditions of the construction site and optimize the construction organization plan in time.

Moreover, the use of drones, laser scanning, and other equipment has also greatly improved the digitization level of site management. The UAV is equipped with high-definition cameras to take aerial photos of the construction site, and through intelligent algorithm processing, three-dimensional point cloud models can be quickly generated for engineering volume statistics and progress tracking. By scanning the construction site, the laser scanner generates an accurate three-dimensional model to provide data support for site layout and program optimization. Smart wearable devices such as smart helmets and smart work clothes have also begun to appear at the construction site. Through the built-in chip, these devices can locate the location of workers in real-time, monitor the vital signs of workers, and promptly warn and take emergency measures once dangerous situations are found.

3.2. Intelligent material and equipment management

The material cost accounts for a large part of the project cost, and the quality of the material directly affects the quality of the project. Equipment is an important tool for construction production, and its state is directly related to construction efficiency and cost. Therefore, strengthening the management of materials and equipment is an important part of construction project management. RFID technology is an effective means to realize intelligent material management. By pasting electronic labels on building materials and using radio frequency communication, the whole process of material procurement, transportation, storage, and use can be traced in information management. Once the problem material is found, the source can be queried in time to prevent quality accidents.

Furthermore, automation equipment such as storage robots and intelligent forklifts are also gradually applied to material management. For example, the automatic guided transport vehicle can realize the automatic distribution of materials between the warehouse and the construction site according to the preset route. Loading and unloading robots can replace workers to complete the loading, unloading, and stacking of materials, improving efficiency and improving the working environment.

In terms of equipment management, intelligent technology is also promising. The combination of IoT technologies such as sensors and quick-response (QR) codes with equipment management systems can realize the digital collection and condition monitoring of equipment information. Through big data analysis, it is possible to predict the health status of equipment, develop scientific maintenance plans, and reduce unplanned downtime.

Additionally, remote fault diagnosis, intelligent scheduling, and other technologies have broad application prospects in equipment management. Once the equipment fails, the management personnel can remotely analyze the cause and guide the maintenance without going to the site. According to the construction task and platform schedule, the intelligent scheduling system can optimize the use of equipment and reduce standby waste. Intelligent material and equipment management makes full use of information technology to realize the closed-loop management of the whole life cycle of materials and equipment, which plays an important role in reducing costs, ensuring quality, and improving efficiency.

3.3. Intelligent schedule and cost control

Project delay and cost overruns are common problems in project management, and their root causes are unreasonable planning, asymmetric information, and inadequate management and control. The application of intelligent management methods can solve these problems from the source and achieve fine and dynamic schedule cost control. Through the BIM platform, the design drawing, bill of quantities, construction schedule, cost budget, and other data are integrated into a three-dimensional model. The virtual construction simulation technology can simulate the progress of the project and optimize the construction scheme. By conducting a comparative analysis with the actual progress, timely deviations can be identified, allowing for adjustments to the construction plan.

Based on the project's actual progress and market information, resources can be dynamically optimized, and costs effectively controlled. Big data analysis technology has also created conditions for intelligent schedule cost control. By aggregating all kinds of data such as owners' needs, design requirements, construction logs, material utilization, and mechanical platform shifts into the management platform, and using big data algorithms for association analysis, the project progress law can be revealed and resource allocation optimized. Machine learning algorithms can also train historical data to form cost prediction models to provide accurate support for engineering costs [3].

Moreover, emerging technologies such as smart contracts and blockchain also have broad application prospects in engineering payment settlement and supply chain finance. The smart contract can automatically settle the project payment according to the contract agreement and the project progress, reducing the risk of bad debts. Linking construction process data can realize information sharing and transaction traceability, and provide financing convenience for upstream and downstream enterprises in the supply chain. Intelligent schedule cost management and control uses information technology to open up the data barriers of design, procurement, construction, settlement, and other links, to achieve collaborative management of the whole life cycle of the project, and to improve management efficiency, but also to better control the project cost [4].

3.4. Intelligent quality and safety management

Engineering quality is related to the use function and safety performance and affects the durability and aesthetics of the building. Construction safety is related to life and property, once there is an accident, the consequences are unimaginable. Strengthening project quality and safety management is the bountiful responsibility of each construction participant [5].

In terms of quality management, BIM technology has become the industry standard. Using BIM, virtual inspections can be carried out before construction to identify design defects and construction difficulties and formulate targeted quality control measures. In the construction process, entity information is collected by laser scanning and other technologies and compared and analyzed with BIM. Quality deviation can be found in time and accurate quality control can be achieved. Non-contact detection techniques such as infrared thermal imaging and X-ray flaw detection are also popularized in engineering quality inspection. Using these technical means, the quality problems inside the building components can be probed without damage, and the quality hidden dangers can be disposed of in time. In the face of increasingly complex construction projects, it is difficult to detect quality defects by manual sampling alone, so it is imperative to introduce advanced detection technology [6].

In terms of security management, intelligent technology has also played a role. Traditional safety management mainly focuses on civil air defense, which has many loopholes and low efficiency. By arranging an intelligent monitoring system on the construction site and using a computer vision algorithm, it can automatically identify all kinds of unsafe behaviors and linkage alarm equipment for a timely warning. Training platforms such as virtual reality/augmented reality (VR/AR) are also widely used in safety education [7]. Using VR/AR technology, safe operation training and emergency drills can be conducted in the virtual construction environment, so that workers can feel various risks in the scene, thereby improving safety awareness and practical operation ability [8].

The smart site, smart helmet, and other system platforms realize the all-around intelligent supervision of the construction site. Integrating video surveillance, behavior recognition, positioning tracking, big data analysis, and other functions. The smart site platform can realize the visualization, digitalization, and intelligence of site management. Through the built-in sensor, the smart helmet can accurately locate the position of the worker, monitor the vital signs of the worker, and timely alarm and take measures when encountering dangerous situations [9].

Intelligent quality and safety management starts from two aspects of technology and management, uses advanced digital means and intelligent equipment to realize the dynamic control of the whole process of project quality and safety, prevents common quality problems and safety accidents from the source, and escorts the high-quality development of construction projects.

4. Suggestions for promoting the application of intelligent management methods

As a new modern management concept and method, intelligent management needs to be widely and deeply applied in the field of construction engineering. Combining the status and development needs of the construction industry in China, the following suggestions are put forward.

4.1. Strengthen top-level design and improve standards and specifications

The implementation of intelligent management first requires competent government departments to strengthen top-level design and policy guidance. Formulate medium and long-term development plans for intelligent management, and elevate intelligent construction to a national strategic height. Research and promulgation of policies to support the development and application of intelligent technology, and give preferential treatment in terms of capital, tax, land, and many more. Accelerate the preparation and revision of BIM, Internet of Things, big data, and other related standards and specifications to provide a basis for the implementation of intelligent management norms. Encourage local governments to try first, summarize, and promote the experience of intelligent construction pilots, and create a good intelligent application environment [10].

4.2. Vigorously cultivate talents and improve management ability

Intelligent management puts forward higher requirements for the professional quality of employees. On the one hand, it is necessary to strengthen the training of compound management talents, explore the new model of school-enterprise joint, production-education integration, and build several high-level intelligent construction talent training bases. On the other hand, it is necessary to increase the training of front-line managers and improve the ability of project teams to use intelligent technology. Introduce and train a group of leaders who understand both management and technology and play a leading role in the demonstration. Simultaneously, scientific research institutes, software companies, and other subjects are encouraged to participate in the training of intelligent talents to deliver new forces for the industry [11].

4.3. Focus on integrated innovation and build an industry platform

Intelligent management involves multiple dimensions such as technology, management, and business, and requires system integration and collaborative innovation of management concepts, technical means, and business processes. All parties involved in industry, university, and research should strengthen cooperation, focus on key common problems in project management, and carry out key technology research and achievement transformation of intelligent management. Build an industry-integrated service platform for intelligent management, realize the convergence and sharing of various data resources, and provide enterprises with intelligent solutions for the whole life cycle of design, construction, operation, and maintenance [12]. Strengthen the publicity and promotion of intelligent management, hold high-level forum meetings, build platforms for the exchange of experience, and create a development atmosphere of open sharing and collaborative innovation [13,14].

4.4. Strengthen demonstration and guidance and promote the deepening of application

Select leading enterprises and major projects with foundation and conditions to carry out pilot demonstrations of intelligent management, and play a leading role. Encourage large building central enterprises, design institutes, and other units to actively adopt intelligent management mode, and form many intelligent application models that can be copied and promoted. Support powerful enterprises to build intelligent management platforms, and provide professional technical services for small, medium, and micro enterprises. Improve the evaluation mechanism of intelligent management applications, strengthen process supervision and performance assessment, and strengthen the application effectiveness. At the same time, increases the intelligent transformation efforts, extends the intelligent management to the existing buildings, further expands the application scenarios, and promotes comprehensive intelligent construction management [15].

5. Conclusion

Construction project management in the new era is facing new opportunities and challenges. The introduction of intelligent concepts and technologies into the whole process of management and the use of information technology to optimize business processes is not only an inevitable choice to conform to the trend of modern times, but also the only way to achieve high-quality development of the construction industry. With the increasing maturity of

BIM, the Internet of Things, big data, artificial intelligence, and other technologies, intelligent management will be more widely and deeply applied in the field of construction engineering. Construction enterprises should take the initiative to adapt to the new round of scientific and technological revolution and industrial change trends, accelerate the pace of digital transformation, arm project management with intelligent means, and strive to improve the level of fine management. Concurrently, industry authorities, scientific research institutions, universities, enterprises, and other parties should also work together to take multiple measures in intelligent talent training, key technology research and development, standard formulation, typical demonstration, and other aspects, to jointly promote innovative development of intelligent construction project management, and contribute wisdom and strength to the high-quality development of the construction industry.

Disclosure statement

The authors declare no conflict of interest.

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Exploration and Example of the Bauhaus Concept of "Integration of Technology and Art" in China's Architectural Education System

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Abstract: The Bauhaus School of Design is the most influential art school of the 20th century and the first higher design school in the world. Its unique educational model also provides a reference example for modern design education and also promotes the development of modern design to a certain extent. Since the Bauhaus design concept was introduced to China in the early 20th century, it has been widely studied and applied in China. This article mainly expounds on the different expressions of the idea of "skill integration" in the Bauhaus education concept in China's architectural education system from the aspects of basic education and architectural design achievements. By promoting the comprehensive and open development of architectural design disciplines, and cultivating "theory and practice" and "technology and art" together, it creates an architectural design education and training system with Chinese characteristics, provides theoretical guidance for Chinese architectural education, and promotes the innovative development of China's education system and talent training in the new era.

Keywords: Bauhaus; Design; Education; Expression

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1. Introduction

Bauhaus is the first design school in the world to propose the concept of modern design education. Its theory has a very important influence and role in art, architecture, design, and other disciplines. There are many design education concepts from Bauhaus, among which the view of "Integration of Technology and Art," that is, "the harmonious unity of technology and art," is very creative and historical. The teaching method of basic courses is a scientific and theoretical teaching method created by Bauhaus. There are also various art and practical courses, which are concentrated on the concept of "Integration of Technology and Art." This concept was first proposed by Gropius and later became the core idea of the Bauhaus design education system. At the same time, it laid a solid foundation for the establishment of the studio system and dual-track teaching model at the Bauhaus, including new teaching methods such as parallel technology and design, laboratory teaching, and art design teaching, which combine knowledge and skills with social practice, cultivate a large number of skilled talents and promote industrial development.

2. The embodiment of the concept of "integration of technology and art" of Bauhaus in the basic education of architectural design in China

2.1. Establishing a fundamental curriculum model for design education as a global paradigm for design learning

The most obvious influence of Bauhaus on Chinese architectural design began with the establishment of the Department of Architecture at St. John's University in Shanghai. The Department of Architecture at St. John's University was officially established in Shanghai in 1942. At its inception, it adopted the modern design education system of Bauhaus, emphasizing the combination of technology and modern aesthetics in architectural design, promoting the development of modern architectural design in China, and becoming the cornerstone of architectural design education in China [1]. The Department of Architecture at St. John's University not only actively cultivates students' architectural appearance and artistry, but also focuses on training and research in architectural structure and function, to achieve the artistry and implementation of the works. The basic courses must involve the composition rules of plane, color, and three-dimensional. The specific course settings are arranged by teachers, and students can choose different teachers to teach them according to their circumstances. These courses effectively provide students with the basic knowledge involved in architectural design, and later gradually evolved into the three major composition theories, playing a very important role in the basic course of architectural design and becoming a compulsory course in design education. At the same time, in the process of architectural design training, students also need to carry out art training such as painting before formally acquiring professional knowledge, and domestic and foreign art history and art appreciation are also indispensable. This course allows students to have a deeper understanding of art while cultivating technical theories, thereby achieving the requirements of high coordination and unity between technology and art in architectural design education.

2.2. Promote the studio teaching model and the comprehensive development of talents

Based on the educational concept of "Integration of Technology and Art," Bauhaus implemented the studio teaching system, which is also a major innovation of the Bauhaus teaching model. The studio is set up according to the needs of teaching and actual work. The graphic design major has a visual communication studio, and the architectural design major has also established a corresponding architectural design studio. Under this teaching method, the basic knowledge learned by students in school can be effectively combined with social practice and actual needs, which helps students understand technology and skills, improve students' practical operation ability, realize the organic connection between school and society, and cultivate more practical talents [2]. Nowadays, many domestic universities are also continuing to use the Bauhaus education model and educational philosophy, and implementing the studio system. For example, the architectural design majors in many universities, including the Central Academy of Fine Arts, have multiple majors such as architectural design studios. After entering the studio, students will not only conduct systematic learning and skill improvement of professional and theoretical courses, but also strengthen students' social practice ability, and regularly carry out school-enterprise joint project cooperation to enable students to learn and use what they have learned. The constraints of the traditional teaching model have been broken by the current studio teaching model. The school will focus on implementing relevant teaching models that are closer to actual projects and will use outstanding designers or people with excellent practical abilities in social enterprises as studio mentors, focusing on cultivating a group of professional design teams with strong professional skills and high practical abilities, which will be more conducive to the development of the architectural design industry and social progress.

3. The expression of Bauhaus's "Technical Integration" concept in Chinese architectural design practice

3.1. Explicit expression

The emergence of the "Greater Shanghai Metropolitan Plan" is a major manifestation of the practical application of the Bauhaus education system in the field of architectural design in China. It is the first overall urban administrative area plan carried out by Shanghai after getting rid of the history of the concession area for hundreds of years, and it is also the first complete urban master plan in modern China. The Greater Shanghai Urban Plan was established on August 24, 1946. It was led by Paulick as the technical director, and the drafters were professors including Huang Zuoshen, Zhong Yaohua, Jin Jingchang, and professionals outside the school. Most of these young elite designers were influenced by Bauhaus design education. They returned to their motherland with strong patriotic thoughts and enthusiasm for architectural design and actively invested in the architectural design and urban planning design that needed reconstruction. At the same time, foreign architectural designers represented by Paulick also brought valuable practical experience to China's architectural design. The students trained in this project played an important role and backbone in the future urban construction of Shanghai [3].

The Greater Shanghai Metropolitan Plan also clearly embodies the concept of the integration of Bauhaus techniques. It not only predicts the future size and population development of Shanghai but also makes bold predictions on the development of Pudong District, ports, and urban status. This has high technical requirements and is one of the most technically difficult projects at the time. It not only has to meet various technical requirements but also has to have a certain artistry and beauty in the design process as a large-scale urban planning project. The Greater Shanghai Metropolitan Plan fully reflects the actual application of Bauhaus in China. Its design fully embodies the integration of art and technology and has very important value and far-reaching impact on Shanghai's future urban development and planning.

3.2. Implicit expression

The modernist architectural thought represented by the Bauhaus design concept has had a wide influence on Chinese architecture during its dissemination in China. Its obvious functionalism and rational thought have set off waves in the Chinese architectural community. Its implicit expression in Chinese architectural design practice is reflected in the subtle influence of the Bauhaus design concept on modern Chinese designers, and these influences are reflected in the design works of architects. The buildings in this stage have both the Bauhaus architectural design concept and the implicit Chinese characteristics, which are the cornerstone of the rise of modern Chinese architecture. The most representative of them is the Shanghai Hongqiao Sanatorium, which is a relatively bright work among the first batch of modernist buildings designed and built independently by China. The architect of this building is Xi Fuquan, who graduated from the Department of Architecture of the German Higher Technical University [4]. Deeply influenced by Bauhaus education, he cleverly combined the Bauhaus architectural design concept with traditional Chinese elements when designing this building. The window design of the building cleverly uses the style of traditional Chinese furniture [5]. This work is the product of the combination of Chinese elements and Western modern architectural design. It combines the artistic sense of oriental classical beauty with the exquisite technology of the Bauhaus style. It can be said to be the implicit expression and new integration of Bauhaus educational philosophy in China.

4. The innovative development path of Bauhaus's "Skill Integration" education concept under the Chinese architectural education system

4.1. Cultivating theory and practice, technology and art together

The modern Chinese architectural education system should, based on adhering to the Bauhaus education spirit, emphasize thinking, practicality, and rigor in the education process [6]. It is recommended that students use their brains more, apply more, and practice more [7]. They should learn construction skills based on paying attention to the aesthetics of the building, and summarize the experience and lessons in practice, to truly master the key points of architectural design and effectively apply them to practice in the future, forming a virtuous circle. Through the "explicit" and "implicit" learning of teaching concepts, combined with China's national conditions, the "implicit" and "explicit" expressions in design can be achieved. As for thinking, teachers and students need to pay attention to it in the teaching process. In the teaching process of architectural design, teachers should strengthen the cultivation of students' creativity and independent thinking ability, explore the correlation between design elements in the design process, and think about how to effectively integrate the artistry and technology of architectural works. Simultaneously, they should not rely solely on skills and should try to avoid the mentality of quick success and short-sighted mistakes. They should feel the design process with their hearts and pay attention to the correlation between design elements, to avoid the homogenization of design works and thus explore the soul of architectural design education.

4.2. Combining educational theory with practical projects to create an architectural design education and training system with Chinese characteristics

In the past few decades since China introduced the Bauhaus education concept, the Bauhaus training system has been fully absorbed in architectural design education. However, based on the background of modern China, it is far from enough to refer to the Bauhaus education system alone. On the contrary, the current domestic design colleges and design majors have unified teaching syllabi and teaching methods, and the course content and teaching time are too consistent, which is not easy to reflect the characteristics of each school and region [8]. Based on teaching professional knowledge, the characteristics of regional education should be integrated, and regional characteristics and policy changes should be studied to provide targeted education with regional characteristics. In terms of teacher allocation, many schools now give priority to students trained by the school or teachers who graduated from the school when recruiting teachers, which also hinders the diversified development of the school to a certain extent. Looking at the international situation, many first-class universities are recruiting talents [9]. For example, Harvard University has 90% of its teachers who are not graduates of the school, and its teacher recruitment and absorption methods are international and diversified. Modern China's architectural design education and training should be more abundant, which requires schools to absorb various types and disciplines of teachers and enrich the teaching staff to provide possibilities for the diversified development of the school. Only when the teaching staff is enriched and diverse can the teaching quality and content be improved and changed.

5. Conclusion

Looking back at the history of Chinese architectural development, it is not difficult to find that the development of modern architectural design is not only the development of technology but also the development of ideology and culture. Schools have played a very important role in cultivating generations of architects with unique ideas who can promote the development of the construction industry. The form and development of architectural design education should also be diverse rather than single and self-willed. For China, which was significantly behind in the past, Western culture offers valuable lessons worth learning. However, after the development of modern society, China has become a technological power [10]. The field of architectural design should also have its characteristics rather than blindly copying Western culture. Chinese educators should draw from the nation's unique cultural background to explore modern design thinking concepts inherent in both the "implicit" and "explicit" expressions of "skill integration." This approach can create a design method that balances "implicit" and "explicit" elements, highlighting the integration of Chinese culture, art, and technology in design. By doing so, Chinese design can make a more profound impact on the global design landscape.

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Disclosure statement

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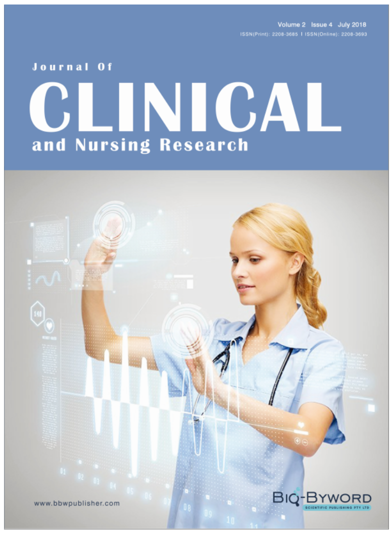

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