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A Discussion on the Structure and Spatial Composition of Long Museum West Bund

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Abstract: The Long Museum, with its distinctive T-shaped "umbrella-vault" structure, offers a rich array of spatial experiences. This article delves into space from both structural and compositional perspectives. As the construction mediator, the umbrella vault embodies the consistency of construction and implies the causality of the surface. Presented as an element, the space flows freely, showing diverse fields and order. In terms of the liberation of its meaning, the space offers static perception and dynamic experience, creating a rich exhibition atmosphere. As a distinct entity, the umbrella-vault presents the physical nature, and the dialogue between the Long Museum and the city makes it a museum of art for the people.

Keywords: Long Museum; Structure; Spatial composition; Umbrella-vault

Online publication: July 12, 2024

1. Introduction

In *The Four Elements of Architecture*, Gottfried Semper divides the original shack, which served as the prototype of the building, into four basic elements: hearth, roof, enclosure, and mound. The Long Museum is one of the most wonderful designs for the extraction and use of structural elements in China. Its ingenious approach to roof and enclosure design reflects, to a certain extent, both a continuation of and departure from traditional spatial typologies within contemporary architecture. The T-shaped "umbrella-vault" cantilevered structure wraps the exhibition space. On the one hand, the space flows horizontally near the ground. On the other hand, the wall extends and bends upward to form a roof resembling an umbrella or an arch, forming another spatial composition, full of "duality" [1].

As a structure, the umbrella-vault is also a collection of spatial interfaces, formal symbols, and pipeline wells [2]. The main load-bearing structure is poured synchronously with the thermal insulation layer, and the external glass and wall can be spread in the same plane, forming a flattened effect (**Figure 1**). On the ground, there are different levels of umbrella-vault structures forming a staggered structure of buildings, echoing the industrial history of the "coal funnel corridor." The underground is an exhibition hall in pure white square box style (**Figure 2**).

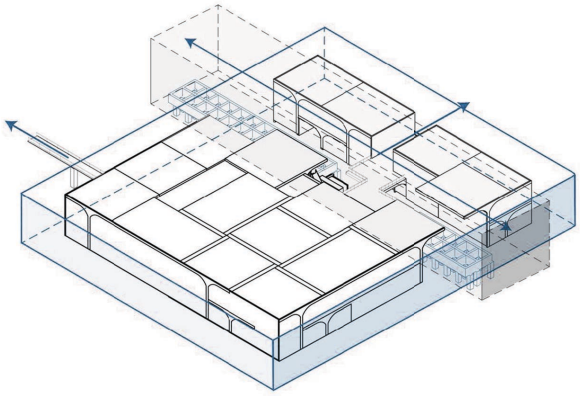


Figure 1. Structure and form of Long Museum (Source: Drawn by author)



Figure 2. Southeast façade (Source: Author's picture)

The interaction between structure as an entity and space is a persistent proposition. To comprehensively and effectively study the space of Long Museum in the context of traditional space type inheritance, this study explores the structure and spatial composition through four lenses: construction mediator, element presentation, meaning liberation, and individual existence.

2. Structure as a construction mediator

2.1. The causality of surface

The cleanliness and purity of the Long Museum are mainly attributed to the consistency of the design language - the use of "surface" [3]. In this space full of "surfaces," the ceiling slides along the curved surface to the wall, creating an ambiguous boundary (**Figure 1**). Different from the separate and independent system of the load-bearing envelope in the frame structure, the umbrella-vault, as a construction mediator, is a complete structural unit (**Figure 3**). It is composed of two 200 mm thick concrete walls and cavities. The concrete walls are inserted into the basement, "clamping" columns and old beams of the original basement, extending to the necessary height and overhanging on both sides and being horizontally balanced by the upper top

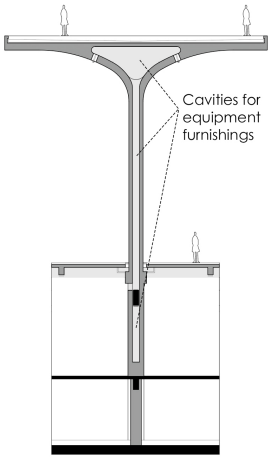


Figure 3. Unit of umbrella-vault (Source: Drawn by author)

plate. A 400 mm thick cavity is formed in the vertical section of the umbrella body, and an inverted triangular cavity for pedestrians is formed in the upper part of the umbrella body. The tube well, ventilation, and sprinkler system are integrated into it, which is the so-called "service space" in Louis Kahn's concept [1], making it possible to have a surface of exposed concrete inside and outside.

The strong character of the structure itself is the unique sense of scale in architecture [4,5], with a focus on being rather than being real. The surface with the same texture, the Mondrian-style flat surface, the blurred boundary between the wall and ceiling, and the umbrella's wrapping and protection of the body collectively create the primitive sense of space - the cave dwelling.

2.2. The classicality of "arch"

From the perspective of spatial composition, the merging of two wall umbrellas forms an "arch" shaped space, and these umbrellas are paradoxically similar to arches when combined. When two umbrellas merge in parallel to form an "arch," intersect vertically to form a "half arch," or merge in the shape of a windmill to form a sort of "cross arch" [4], the "arch" in these shapes is not a true "arch" in the structural sense, but still points to the place where the arch first appeared – Rome. To explore the influence of arches on space, architects even specifically examined Roman arched architecture [1].

In terms of its shape, when the curvature is small, it resembles a folded plate, and when it is large, it resembles an arch. To ensure accurate positioning, the curvature of the umbrella body of the Long Museum has been determined to be an elliptical shape drawn using the four-center method [6]. Because the arc curve at the bottom of the umbrella is an elliptical line connected tangentially by two tangent arcs, the starting point is greatly raised compared to the usual circular arch, and a long flat section is formed at the end. With a large scale, it gets rid of the spatial form meaning as an arch.

In addition, the gap between the "umbrellas" suggests that they are not real structural arches. The use of light reflects "destruction" and "construction." At the moment when light enters through the middle seam, the arch is broken into two simply supported beams, and reinforcement is specially designed for the establishment of the beams. Therefore, it is not an arch in the structural sense, but rather the Vault of Kimbell Art Museum [2] (**Figure 4**). In addition to light, from the rationality of the structure, hard connections are not conducive to earthquake resistance. From the perspective of spatial mobility, the garden concept of "separation" [7] also promotes the independence and detachment of umbrellas.

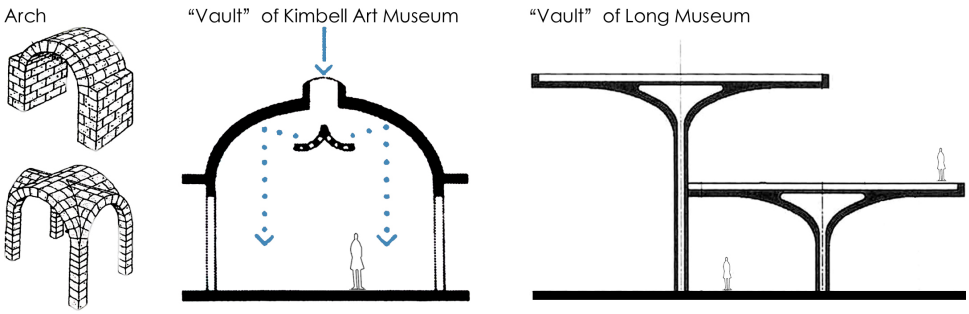


Figure 4. Analogy of arches (Source: Drawn by author)

3. Structure presented as an element

The tension between the integrity of the Long Museum and the structural elements [8] makes the "umbrella" displayed as a spatial element, which is similar to the phenomenon that "columns, domes, arches, and arch of wooden architecture participate in the architecture (the meaning of the term "architecture" here comes from the

Japanese word “architecture”, and Ichiro Sakamoto believes that “architecture = structure + place”) and are also appreciated at the same time“. There is order behind different fields: from the Cartesian orthogonal grid systems to the freely open plane [1], the flow space of the Long Museum seems to be above the plane flow, incorporating Adolf Loos’ thinking about the design of space volume. The diverse spatial transformations between the same units reduce the fluidity of space, while the free plane creates a rhythm of smooth paths and pauses.

3.1. Elements and fields

The multiple fields scattered throughout the Long Museum make it out of homogeneity [9]. When entering the main hall, people are separated from the lower corridor space of the coal hopper at the entrance, and the suddenly raised hall liberates people from their depressed psychology. Guided by the partition walls, they turn right and climb down to another elevated space. The scale of the steps strengthens the sense of falling in the space. The transformation of spatial volume, the displacement, rotation, and height difference between units enhance the narrative.

The importance of the field is not only reflected through the scale but also through the hierarchical organization (the overlap between the coverage space of the top unit and the main space of the bottom unit [10]). The higher the level of the main space is, the more units it covers and the more complex the organization is. Almost every main exhibition space is covered by two or more umbrella arches (**Figure 5**). In the horizontal division, the unit wall shapes the primary and secondary spaces at once, and the windmill plane is formed between the walls. The scale of the exhibits determines the relationship between the primary and secondary spaces, which are located at the side of the building and are half the size of the main space (**Figure 5**).

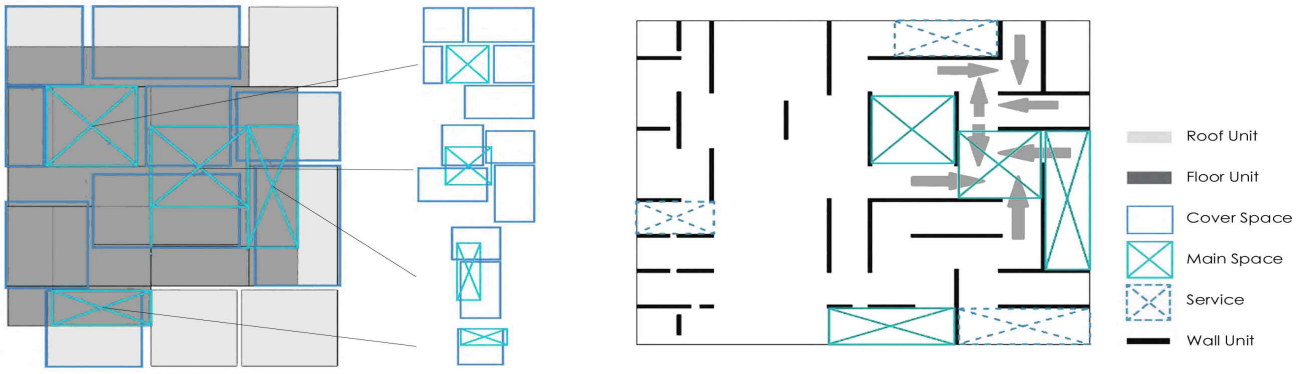


Figure 5. Left: The order of overlapping the top and bottom surfaces; **Right:** The order of horizontal separation (Source: Drawn by author)

3.2. Elements and order

Unit aggregation space is a way of spatial organization, and its combination reflects the order. The huge umbrella arch resembles the tree-shaped pillars of the Sagrada Familia in Catalonia [4], which blocks and cuts the light in the space in five ways, and different combinations introduce light in different directions into the interior (**Figure 6**). The first type is “union,” where light enters from both sides. The second type is “separation,” where the gaps between the bodies bring the top light. The third type is “lining,” where one large and one small form a staggered layer, bringing side light. The fourth type is “intersection,” where a large part and a small part are interlaced, and the light is separated by upper and lower parts. The fifth category is “stacking,” which is decomposed into four independent and homogeneous spaces. These combinations diversify the visual images and perceptual associations of the exhibition.

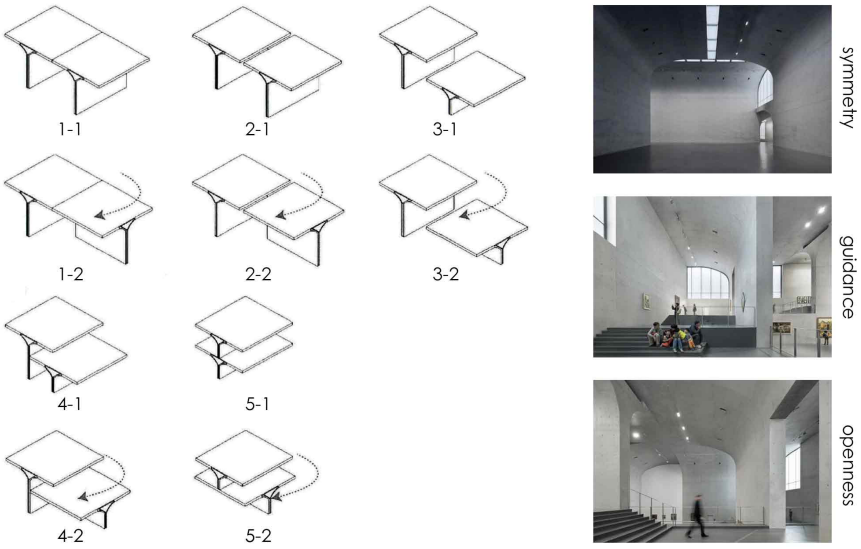


Figure 6. Combination methods and visual effects (Source: Drawn by author)

4. Structure as the meaning of liberation

"One of the intentions of the exhibition is to create indescribable and continuous surprises for everyone. If you go to a building and want to constantly walk inside, you can enjoy surprises while watching, feel at home, and life is a celebration." ——Dorsey (from an interview with Dorsey in "Art Review")

Art museums need elements of "surprise" and "freedom," and also need to meet the "contemplative" characteristics of the exhibition space [9]. The integration and balance of the two have shifted the Long Museum from an artistic container to an atmosphere creation. At this time, the umbrella arch has also achieved the liberation of static perception and dynamic experience and is integrated under a large roof.

4.1. Static perception

Yichun Liu believes that "when the structure begins to associate with our body and actively adapts to the characteristics of the place, it is at that moment that it is breaking away from being solely a physical property of mechanics and entering the realm of culture" [5]. In other words, the static perception of structure can be understood from two perspectives: the association with the body and the imprint of time.

In addition to the translation of the coal hopper bridge structure and the adaptation to the completed underground garage [5], the umbrella-vault can evoke the imagination of the audience about the shelter, and the ventilation and temperature control system is also integrated, resulting in the association between the structure and the body. The temporal nature of the structure enhances the spatial narrative, triggering the audience's association with the story that takes place in the specific site and scene. The scale and materialization analogy of materials reveal the spirit of the place: the umbrella-vault makes the whole space a net height of 12 m and an average span of 16 m, corresponding to the size of the coal hopper bridge with a height of 8 m and a width of 10 m, and the thickness of the vertical part reaches 800 mm, enabling the audience to connect with the industrial culture behind the site when facing the huge structure [3]. In addition, different construction methods using the same materials are also a dialogue between reality and history.

4.2. Dynamic experience

"Viewing" and "action" are the behavioral themes of the exhibition space. In traditional exhibition space, "action"

serves “viewing.” In contemporary times, the experiential nature of “action” has become increasingly active, which is an important way to enrich the audience’s senses and stimulate enthusiasm for exploration [6]. The combination of umbrella-vault gives the dynamic experience with “surprise” and “freedom,” mainly reflected in the freedom of flow and the penetration of vision.

The exhibition space of Long Museum adopts a flowing spatial pattern composed of independent and dispersed vertical walls (**Figure 7**): the wandering flow line combined with the visual sense of natural light penetrating through the arboreal forms the spatial characteristics of the shuttle in the forest [1]. The penetration of vision is mainly reflected between the transportation space and the exhibition hall, as well as between the exhibition halls. The discrete umbrella-vault gradually reveals the exhibition hall on the way to the underground floor. The second-floor exhibition hall interacts with the first-floor elevated exhibition hall through the gap between the umbrella arches.

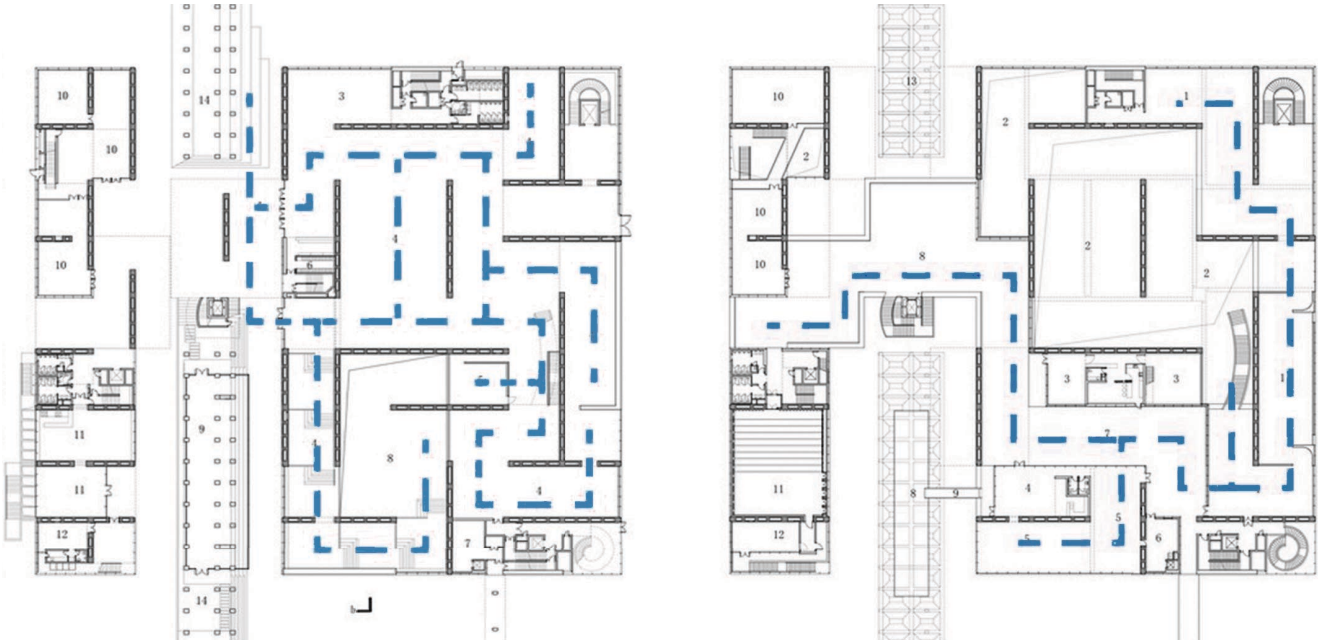


Figure 7. Left: Traffic flow on 1F; **Right:** Traffic flow on 2F (Source: Drawn by author)

5. Structure as an individual existence

5.1. Individuality of umbrella-vault

The “pure space” created by the umbrella-vault fully highlights its individuality (or physical properties [1]): the single material and pure light avoid excessive spatial expression elements, allowing the senses to focus on the material itself and the spatial details. By utilizing the same batch of concrete materials, it achieves pure unity in the overall tone. After pouring, the protective agent is added to reduce the color difference between walls. On the other hand, the use of colored glazed glass with fine holes, combined with the aluminum alloy mesh on the exterior wall to limit the incident hole, purifies the light and makes the overall light environment uniform and soft [6]. Analogously, the circular hole at the top of the Pantheon fixes the visual focus of the human eye in a specific position, with light exhibiting in a focused circular pattern. The Long Museum guides the moving people to observe the light of the sky through the wall. Concurrently, the reflection of the umbrella-vault unit forms a layer of “light ground,” making the audience behave more freely.

5.2 Existence of Long Museum

"For a city, "passing" an art museum is more important than "going" to an art museum." ——Keyang Tang [11]

The combination of the Long Museum and the Binjiang Landscape Belt has made it an important focus of the "West Bund Cultural Corridor Initiative." The "Beipiao Dock" built in 1929 also completed its transformation from a productive waterfront to a cultural public space (**Figure 8**). Liu Yichun talked about her first impression of the base in an interview with The Architect: "Driving from Longhua West Road and Fenggu Road perpendicular to Longteng Avenue, the view of the city, which had just been dense, suddenly widened. In the blink of an eye, we reached the edge of the river, and a huge ship lay in front of us, like a mountain. Some railway tracks and gantry cranes were preserved along the northern route, and the slopes were filled with reeds, which was quite wild". The architect's initial impression of the site was derived from the dramatic transition between industry and daily life [5,12].

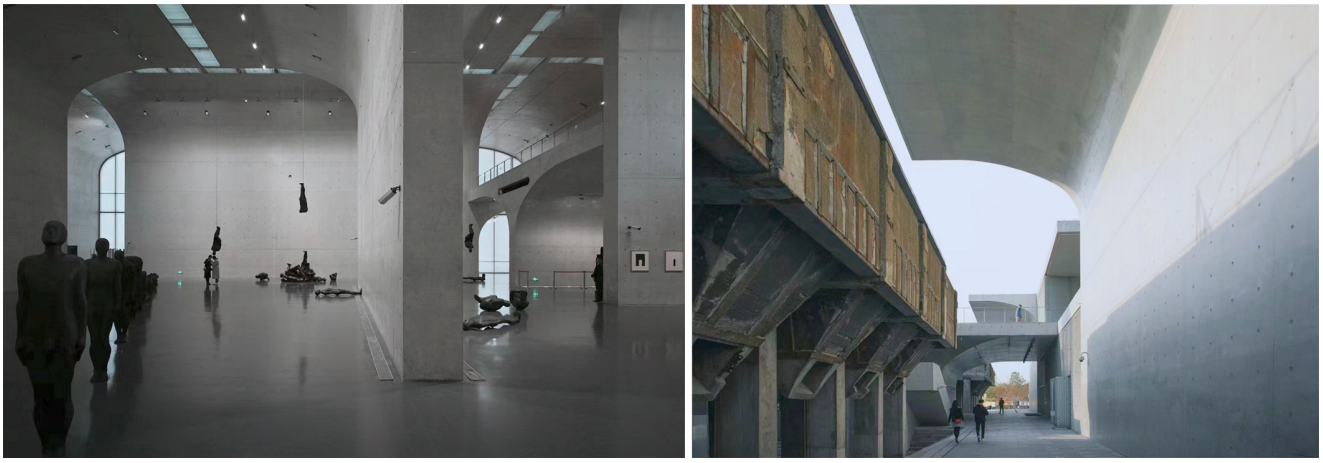


Figure 8. Left: Current situation of public space; **Right:** Old photos of post-industrial sites (Source: Author's picture)

The boundary between the city streets, the landscape, as well as the almost classical unit scale, separated the Long Museum, which is only three or four kilometers away from Xujiahui, from the more "secular" city. However, through a clear, complete, and open interface, as well as a boundary space that can carry out public activities, the distance between the public and the art museum is shortened (**Figure 9**). Entering an art museum is precisely a deviation from daily life and entering a "different kind of space" [12].

The design of the transportation routes, such as crossing the coal hopper from the intersection to the riverside, crossing the restaurant courtyard from the elevated walkway to the art museum, and entering the art museum from the south side of Longteng Avenue, has been influenced by the garden. The architects expect the public to wander, pause, or move in the venue.

"I hope that people around me can come over for lunch, and some people can buy something or take a cup of coffee and come to sit on the platform after visiting the art museum on weekends. Then the art museum truly belongs to the city" ——Yichun Liu [5]



Figure 9. Long Museum in the city (Source: Drawn by author)

6. Conclusion

From the classicism of arches and the protection of umbrellas to the order of space, the freedom of flow line, the penetration of light, and then to the spirit and physical character of places, to the art museums of cities, and the art museums of people, umbrellas in the air allow the consciousness of body to be directed towards infinite distances, maintaining the relationship between post-industrial sites and urban public spaces in a unique posture.

Disclosure statement

The author declares no conflict of interest.

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Study on the Effect of Fibers on the Properties of Asphalt Mastics

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Abstract: To study the influence of fiber on the properties of asphalt mortar, the properties of lignin fiber, polyester fiber, and basalt fiber were summarized and analyzed respectively. The high- and low-temperature properties of fiber asphalt mortar were studied and analyzed by using three indexes, rutting factor and tensile fracture energy. The results showed that all three kinds of fibers could improve the performance of asphalt mortar to varying degrees, with lignin fiber demonstrating the best effect, followed by basalt fiber and polyester fiber. The type the fiber can be selected based on the required thermal stability and cost depending on the project type.

Keywords: Fiber; Asphalt mastics; High temperature; Low temperature; Rheological properties

Online publication: July 11, 2024

1. Introduction

With the rapid growth of the number of vehicles, to ensure the stability and durability of asphalt pavement, it is necessary to constantly improve the performance of asphalt mixtures. Fiber has been widely used as a stabilizing additive to improve the pavement performance of asphalt mixture. Therefore, it is of great significance to study the effect of fiber on asphalt and mixture. Xue *et al.*'s study showed that fiber enhances the performance of asphalt pavement in varying degrees [1]. Liu *et al.* believe that basalt fiber improves the mechanical properties of the pavement structure [2]. Wang *et al.* discovered that basalt fiber has a lesser impact on the phase angle, composite shear modulus, and viscosity of asphalt mortar compared to polyester fiber [3]. Liu *et al.* observed that the order of effectiveness in enhancing the low-temperature performance of asphalt and its mixtures was polyacrylonitrile fiber > lignin fiber > basalt fiber [4]. Zhou *et al.* found that a polyester fiber content of 0.2% enhanced the performance of concrete to the greatest extent [5]. Chen *et al.* advocate for expanding the range of environmentally friendly fibers that enhance concrete performance [6]. Liu *et al.* studied the impact of polypropylene fiber, polyester fiber, and polyacrylonitrile fiber at varying concentrations on the low-temperature performance of asphalt mixtures, noting that polypropylene fiber yielded the most significant improvement [7]. Pan *et al.* found that the addition of basalt fiber had little effect on the low-temperature rheological properties of

asphalt mortar, but it significantly improved its high-temperature rheological properties [8].

The content of fiber also play a role in the enhancement of the concrete's performance aside from the type of fiber used. Tan et al. conducted a comparative test on the properties of carbon fiber, basalt fiber, polyester fiber asphalt mixture and non-fiber asphalt mixture and found that the mixture with 0.28% carbon fiber, 0.2% polyester fiber, and 0.33% basalt fiber had the best performance under high temperatures [9]. Lin found that polyester fiber significantly enhances the performance of asphalt pavement. Interestingly, the effectiveness of the fiber remains consistent whether the content is low with longer fibers or higher with shorter fibers [10]. Wu e*t al.*'s study found that optimal high-temperature performance was achieved when fly ash replaced 40% of the asphalt and the polyester fiber content was 0.4% [11]. Zhang Jun *et al.* investigated the effect of mineral fiber asphalt concrete on the strength of asphalt concrete under the conditions of freezing and thawing cycles by examining the effect of different types of fibers, and the effect of mineral fiber asphalt concrete on the strength of asphalt concrete. Zhang *et al.* determined that mineral fiber asphalt concrete exhibited the highest splitting strength. Specifically, at a 4% fiber content, all three types of fiber asphalt concrete demonstrated maximum splitting strength [12].

Many studies have been conducted on the properties and effects of various types of fibers in asphalt and asphalt mixtures, identifying their roles in reinforcement, crack resistance, adsorption, and bridging. Different fibers contribute uniquely to asphalt and its mixtures based on their distinct structures and properties, thereby influencing performance differently. Based on these considerations, comparisons and analyses were conducted on basalt fiber, lignin fiber, and polyester fiber in relation to their impact on the performance of asphalt mastics and the overall road performance of asphalt mixtures.

2. Materials and methods

2.1. Asphalt

The 90# matrix asphalt was selected and its performance was tested. The results are shown in **Table 1**. The results show that the asphalt meets the requirements and demonstrates good performance.

Table 1. Test results of 90# matrix asphalt

Item	Needle penetration	Softening point	Ductility	Apparent viscosity	Flash point	Asphalt density
Test result	90.6	45.7	109.5	0.30	292	1.023
Specification requirement	80–100	≥ 44	≥ 100	-	≥ 245	-

2.2. Fiber

In order to study the effect of different fiber types on the performance of asphalt mortar, lignin fiber (LF), polyester fiber (PF), and basalt fiber (BF) were selected and their basic physical properties were tested. The results are shown in **Table 2**.

Table 2. Fiber types and physical properties

Fiber type	Appearance	Diameter/ mm	Length/ mm	Density/ ($g \cdot cm^{-3}$)	Melting point/°C	Tensile strength /MPa
LF	Light gray, loosely flocculent	0.045	1.4	1.21	230	< 300
PF	Milky white, fascicular monofilament	0.020	6.0	1.39	220	980
BF	Golden brown, fasciculate	0.013	6.0	2.64	1500	3400

2.3. Mineral powder

To mitigate the negative effects of mineral powder dispersion on test results, mineral powders with particle sizes smaller than 0.075mm were selected. Their performance indicators were rigorously tested to ensure they met specification requirements.

2.4. Preparation of fiber asphalt mortar

The fiber dispersion degree significantly affects the performance of fiber asphalt mortar. To ensure the accuracy of asphalt mortar test results, fibers were dispersed before asphalt mortar preparation. The fixed powder-to-binder ratio was 1.0, with fiber content set at 3% of asphalt. The 90# matrix asphalt was heated to achieve dynamic flow. Mineral powder was added to the asphalt in batches multiple times, ensuring even dispersion. Subsequently, the dispersed fiber was added in batches multiple times under strict temperature control to maintain asphalt fluidity throughout the process.

3. Results

To ease differentiation, 90# matrix asphalt was abbreviated as 90#, basalt fiber asphalt mortar was abbreviated as 90#-BF, lignin fiber asphalt mortar was abbreviated as 90#-LF, and polyester fiber asphalt mortar was abbreviated as 90#-PF.

3.1. Three major indexes

The results of three indexes of each fiber asphalt mortar are shown in **Figures 1 & 2**.

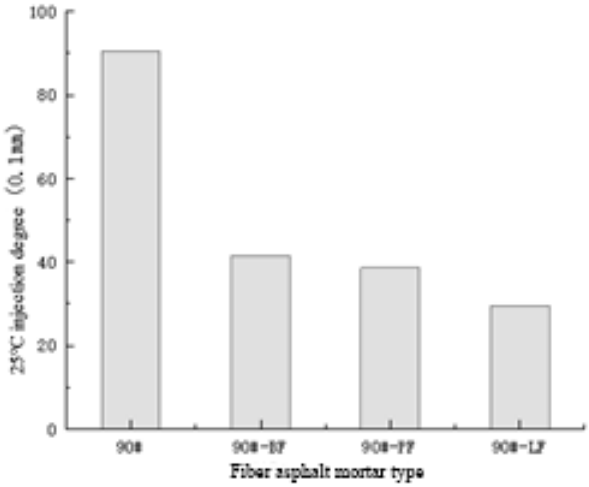


Figure 1. Results of needle penetration of asphalt mortar

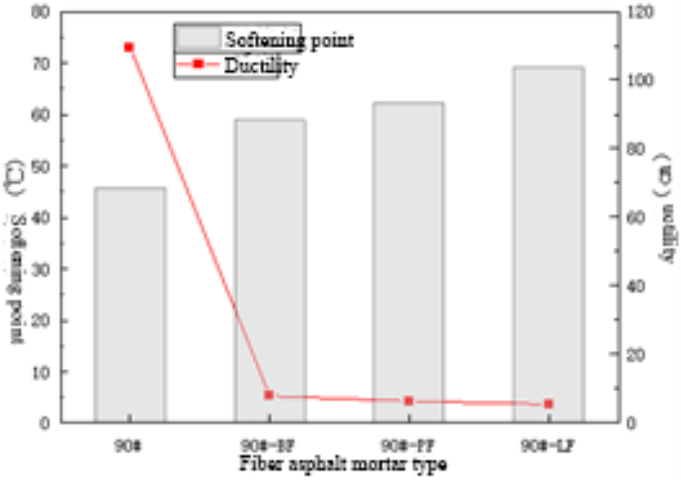


Figure 2. Results of asphalt mortar elongation and softening point

As shown in **Figure 1**, fibers had a significant effect on three major indicators of asphalt mastic. The addition of fibers led to a sharp decrease in the penetration of asphalt mastic, primarily due to uneven fiber dispersion within the mixture, which affected the accuracy of the data results. The penetration values of 90#-BF and 90#-PF were relatively similar, while 90#-LF had the smallest penetration value, attributed to LF's effective adsorption capabilities that caused asphalt to adhere to fiber surfaces, thereby increasing mastic hardness.

Furthermore, fibers reduced the ductility and increased the softening point of asphalt mastic, as illustrated in Figure 2. BF and PF exhibited similar effects on the softening point, whereas 90#-LF showed the highest softening point. This phenomenon resembled the impact on needle penetration; LF's adsorption increased

asphalt viscosity, consequently raising the softening point. The increased viscosity due to fibers inevitably increased asphalt mastic brittleness, resulting in reduced ductility. Among LF, PF, and BF, BF demonstrated a more pronounced reinforcing effect on asphalt mastic. During stress, BF facilitated effective load transfer, mitigated stress concentration, and enhanced the mastic's ability to deform plastically.

3.2. High-temperature rheological properties

The rutting factor can better reflect the high temperature rheological property of asphalt mortar. **Figure 3** illustrates the curve showing how the rutting factor changes with temperature in fiber asphalt mortar.

Temperature significantly influenced the high-temperature rheology of fiber asphalt mastic, causing the rutting factors of the four types of asphalt mastic to decrease as temperature increases. The rutting factors of the four types of asphalt mortar followed this order: 90#-LF > 90#-PF > 90#-BF > 90#. The addition of fibers enhanced the rutting factor of asphalt mortar to varying degrees. This enhancement occurs because fibers reduce the amount of free asphalt in the mortar, promoting asphalt adhesion to fiber surfaces and thereby improving the viscosity of fiber asphalt mortar. Moreover, fibers can establish a stable three-dimensional network structure within the asphalt mortar, enhancing its resistance to high-temperature deformation. At 52°C, the fiber reinforcement effect was most pronounced. Compared to 90#, the rutting factors of 90#-LF, 90#-PF, and 90#-BF increased by 5.89 times, 4.13 times, and 2.97 times, respectively. Among the three fibers, LF demonstrated the most significant improvement in the high-temperature performance of asphalt mortar.

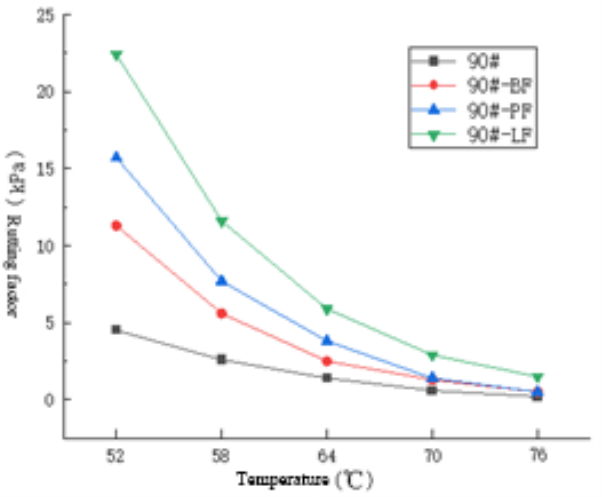


Figure 3. Rutting factor curves of fiber asphalt

3.3. Low-temperature tensile property

Tensile fracture energy serves as a critical indicator for evaluating the tensile resistance of asphalt mortar at low temperatures. **Figure 4** illustrates the curve depicting the change in tensile fracture energy of fiber asphalt mortar from -10°C to -30°C.

The tensile breaking energy of asphalt mastic is influenced by temperature and fiber type. Lower temperatures correspond to lower tensile breaking energies. Compared to 90#, the addition of fiber significantly enhanced the fracture energy of asphalt mastic. This improvement stems from the increased proportion of structural asphalt due to the addition of fiber and mineral powder, thereby increasing asphalt mastic viscosity and subsequently enhancing its low-temperature tensile properties. The tensile breaking energy of asphalt mastic is influenced by temperature and fiber type. Lower temperatures correspond to lower tensile breaking

energies. Compared to 90#, the addition of fiber significantly enhances the fracture energy of asphalt mastic. This improvement stems from the increased proportion of structural asphalt due to the addition of fiber and mineral powder, thereby increasing asphalt mastic viscosity and subsequently enhancing its low-temperature tensile properties.

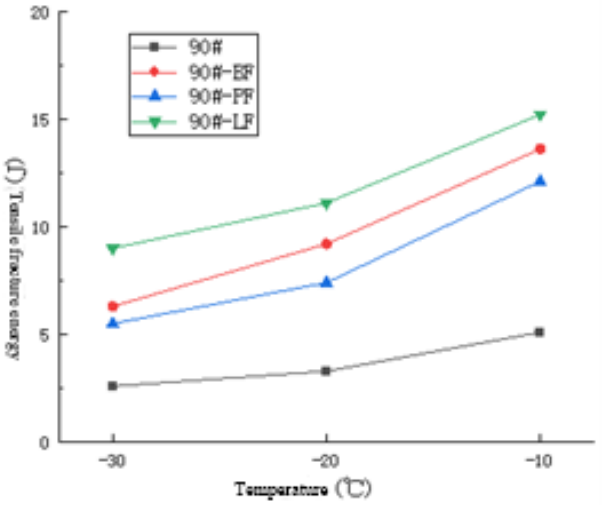


Figure 4. Changes in tensile fracture energy against increasing temperatures

4. Comparative analysis of fiber properties

The water absorption, thermal stability, oil absorption, and economic results of the three fibers are shown in **Table 3**.

Table 3. Water absorption and thermal stability of the fiber

Fiber type	Mean water absorption (%)	Quality loss (%)	Asphalt loss (%)	Price (Yuan·t^{-1})
LF	14.55	24.9	3.26	3500
PF	3.26	6.4	18.67	6000
BF	1.09	2.3	10.98	12000

Based on the data in **Table 3**, it is evident that among the three types of fibers, water absorption follows the order LF > PF > BF, thermal stability follows BF > PF > LF, oil absorption follows LF > BF > PF, and price follows BF > PF > LF.

When subjected to heating in an oven, the three fibers exhibited varying degrees of quality loss. From an appearance perspective, LF changed from its original light gray to brown, PF changed from white to light yellow, and BF showed minimal change in appearance. This difference is attributed to LF being composed of plant-based organic matter, which results in poorer thermal stability, whereas BF, being a mineral fiber, exhibits the best thermal stability.

Furthermore, it can be seen that LF has the lowest asphalt loss, indicating that LF has the best oil absorption. Scanning electron microscopy (SEM) analysis of the three fibers revealed that LF's surface was rougher, while BF and PF had smoother surfaces. The rougher the fiber surface, the better its asphalt adsorption capability. Additionally, LF's surface is irregular and features many intricate branches, whereas PF and BF are mostly factory-made with regular cylindrical shapes and smooth surfaces. Therefore, the surface texture and

roughness of the fibers are crucial factors affecting asphalt bonding.

Economically, BF is the most expensive, costing twice as much as PF and 3.43 times more than LF. Consequently, it is essential to consider the performance requirements and preferences of asphalt mixtures when selecting fiber types in practical engineering applications to achieve high quality at a lower cost.

5. Conclusion

(1) Fibers can effectively enhance the softening point of asphalt mastic, with LF showing the best enhancement effect. At the same time, fibers increase the viscosity of asphalt mastic but inevitably sacrifice its ductility.

(2) Fibers can improve the rutting factor and low-temperature cracking resistance of asphalt mastic, indicating that fibers enhance asphalt mastic's high-temperature and low-temperature performance to a certain degree. Among the fibers, LF is the best for improving these two properties compared to BF and PF.

(3) Based on fiber performance analysis, LF is inexpensive with high oil absorption but poor thermal stability; PF is moderately priced with good thermal stability but poor oil absorption; BF has the best thermal stability and good oil absorption but is the most expensive.

Disclosure statement

The author declares no conflict of interest.

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Environmental Design in the Context of Chinese Regional Culture

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Abstract: Environmental design plays a critical role in shaping human habitats. In the context of increasing homogenization of environmental aesthetics, the pervasive influence of the information age, and challenges in industry growth, the question arises: where does environmental design stand? This article delves into the development of the environmental design industry in view of China's diverse regional cultural contexts. It analyzes the concepts and interconnections between China's regional cultures and environmental design, identifies current issues, and proposes strategies for integrating China's regional cultures into environmental design practices. This exploration provides valuable insights into the evolution of environmental design within the framework of China's distinct regional cultural characteristics in the contemporary era.

Keywords: Environmental design; Problem highlighting; Regional culture; Chinese characteristics; Application strategy

Online publication: July 11, 2024

1. Introduction

In the "14th Five-Year Plan for Cultural Development" issued by the General Office of the CPC Central Committee and the General Office of the State Council in 2022, it was proposed to deeply study the origin and characteristics of Chinese civilization and culture and to build an ideological system based on the cultural genes of China. This plan also aims to promote the construction of national cultural parks. Furthermore, the "Opinions on Implementing the Project for Inheriting and Developing Excellent Traditional Chinese Culture" in 2017 outlined goals to establish a comprehensive system for inheriting and developing excellent traditional Chinese culture by 2025. It emphasized enriching cultural products with Chinese characteristics and styles, significantly enhancing cultural awareness and confidence, and strengthening the foundation of China's cultural soft power. This effort has visibly increased the international influence of Chinese culture. These initiatives underscore the significant importance of environmental construction rooted in China's distinctive regional cultures.

2. Concept and relationship between regional culture with Chinese characteristics and environmental design

Regional culture with Chinese characteristics refers to a unique cultural form shaped by geographical environment, historical evolution, and human activities. It includes not only lifestyles that are compatible with the natural environment but also covers local traditions, customs, and characteristics. China is a huge country with 56 ethnicities, making its regional cultures diverse and colorful. Each ethnicity comes with its own dialect, traditional arts, literature, and festivals. However, in the context of the ever-changing modern society, the future of regional culture remains ambiguous. Urbanization, new media, migration, and other factors have significantly impacted regional culture. Cities now function as platforms for cultural integration, new media have facilitated the widespread dissemination of regional cultures, and Chinese immigrants are actively spreading their cultural heritage globally. This shift presents both opportunities and challenges.

Preserving and transmitting regional culture amidst these changes is crucial, ensuring it remains relevant to contemporary society while safeguarding its distinctive qualities. Environmental design plays a pivotal role in shaping human habitats, encompassing fields such as architectural engineering technology, humanities, art, science, and urban landscape. It involves constructing indoor and outdoor environments that enhance human living spaces. Broadly speaking, environmental design spans across various art and design disciplines, synthesizing these elements into cohesive spatial and form designs centered around architecture and the surrounding environment. In China, environmental design is categorized into indoor and outdoor domains, with numerous subdivisions including urban design, architectural design, interior design, architectural vignettes, murals, and more—all falling under the umbrella of environmental design.

In today's highly integrated art and culture, science and technology, environmental design, and regional culture complement each other [1]. Environmental design carries the mission of inheriting and promoting regional culture and also leads the development direction of regional culture in the future. Only environmental design from the perspective of regional culture can better integrate the Chinese characteristics of culture and humanism into people's lives. Therefore, the development of environmental design with Chinese characteristics of regional culture is imperative.

3. Current situation of environmental design development in the context of regional culture of Chinese characteristics

3.1. Homogenization of environmental style

Under the influence of the international design trend and the pursuit of commercial interests, too much emphasis has been placed on speed rather than regional characteristics in environmental design. Uniform modern high-rise buildings have led to the gradual loss of their original regional characteristics in the process of urbanization and regional heterogeneity. When designers incorporate regional cultural elements, it is essential for them to thoroughly understand local customs and historical development, optimizing their use accordingly. Unfortunately, many environmental design projects either underutilize these symbolic elements, rigidly copy them without adaptation, or diverge too far from their original forms. This failure to refine the symbolic elements and consider their origins and meanings results in a diluted representation that weakens the inheritance of regional culture and leads to a homogenization of regional environmental landscapes [2].

3.2. Impact of the information age

In today's information age, the rapid pace of information updating and integration impacts both the natural environment and the social fabric, influencing people's values and thoughts. However, this accelerated

development has also intensified a cultural crisis in environmental landscape construction. Environmental design is not just about transforming and expressing environmental aesthetics; it also serves as a carrier of regional culture. With the increasing types of communication methods and the ease of information transmission, traditional regional cultures are gradually disappearing and becoming more similar in the information age. Unified and standardized cultures are replacing regional and ethnic cultures. As traditional cultures continue to erode and face destruction, technological innovations also challenge traditional design methods. The primary issue to consider in the integration and development of regional culture and environmental design is how to adapt to current social development trends in environmental art design while preserving original traditional cultures to the greatest extent.

3.3. Industrial development bottleneck

The "Environmental Art and Design" major was officially approved and added to Chinese university programs in 1988. Over the past nearly 30 years, with the advancement of reform and opening up, the speed and scale of urbanization construction in China have accelerated unprecedentedly, leading to a rapid expansion of professionals in the field of environmental design. Given the uniqueness of environmental design, which encompasses architecture, urban and rural spaces, materials, and conceptualization, planners, architects, and designers play crucial roles [3]. However, some environmental projects may not receive adequate attention or effective execution due to either insufficient recognition of the designer's role or disparities in designers' capabilities. As the environmental construction industry continues to evolve along with rapid advancements in materials and technologies, both designers and builders must adapt to regional and contemporary developments.

4. Strategy of applying Chinese regional cultural characteristics in environmental design

Today, environmental design is evolving towards a more systematic and diversified development direction. It no longer solely relies on regional culture; instead, it integrates interdisciplinary approaches and adapts to the development of the times. Environmental design should not be detached from local realities but rather incorporate them. Environmental design must focus on both inheriting and innovating upon local regional cultures. This approach ensures that environmental design not only meets contemporary needs but also preserves and enriches the unique cultural heritage of each region.

4.1. Aligning regional cultural elements with the needs of modern times

In the "14th Five-Year Plan for Cultural Development," there is a call to deeply study the origins and characteristics of Chinese civilization and culture, which provides favorable conditions for the development of China's distinctive regional cultures. Policies such as the Belt and Road Initiative, the development of national central cities, the internationalization of major cities, and comprehensive innovation and reform pilot zones all support urban and rural construction. According to the results of the "Most Beautiful Places in China" selection by the Chinese National Geographic magazine, a total of 100 scenic spots across the country were selected. These places, characterized by diverse geographical locations and climate conditions, have formed unique cultural landscapes. Both the era and the splendid landscapes have laid the foundation for the application of China's distinctive regional cultures in environmental design.

Since its establishment, the environmental design profession has flourished with projects proliferating, serving the public, and significantly contributing to socio-economic development. Therefore, to better leverage the application of China's distinctive regional cultures in environmental design, several approaches are essential.

On one hand, government involvement is crucial in providing strategic guidance for urban construction and actively participating in local urban development. On the other hand, efforts should support rural revitalization, promoting improved living environments in poverty-stricken areas. Additionally, various tourism initiatives can be utilized to stimulate economic development. Furthermore, it is essential to create local distinctive identities, such as Chongqing's "8D City" and Xi'an's designation as a "World Historical City" in Shaanxi Province, both serving as excellent examples and landmarks.

4.2. Integration of environmental elements and regional culture

Environmental elements, also known as environmental substrates, refer to the various independent and distinct elements that constitute the overall human environment, each with different characteristics yet conforming to the overall evolutionary laws. These elements include both natural environmental elements and artificial environmental elements. Natural environmental elements typically include water, organisms, rocks, soil, and so on. Artificial environmental elements encompass productivity, technology, artificial products, political systems, religious beliefs, social behaviors, and more. Environmental design involves not only the design of natural environmental elements but also the integration of artificial environmental elements, particularly cultural and historical aspects. There are numerous exemplary cases, such as the design of the new Suzhou Museum, which extracts elements from Suzhou gardens and incorporates the regional culture of the Jiangnan water towns. This design achieves an organic blend of tradition and modernity, becoming a globally recognized landmark. The new Suzhou Museum adopts the layout of traditional Chinese gardens, connecting the Zhong Wang Mansion and the Humble Administrator's Garden through water landscapes, creating a picturesque setting. The museum's architecture is characterized by gray-white tones, continuing the architectural style of Huizhou architecture with lively charm. Inside the museum, the design technique of changing views with every step is employed, cleverly using renewable materials like bamboo for decoration, which contrasts sharply with the building's strong lines yet harmoniously complements them, showcasing a harmonious scene. The stone landscape sculptures integrate the characteristics of Suzhou's regional culture with the building, embodying the characteristics of "Chinese but new, Suzhou but new," while meeting the functional requirements of a modern museum.

4.3. Utilizing interdisciplinary background to realize integrated development

Art creation in the modern era is shifting toward the direction of cross-media, interdisciplinary, and cross-cultural development. In the context of globalization, different regional cultures and different national cultures intersect each other. Therefore, one crucial issue that designers should consider in artistic creation under interdisciplinary backgrounds is how to maintain the uniqueness of art. Coordinating the relationship between art and technology is a critical issue that cannot be overlooked in the construction of artistic disciplines. It can be said that Chinese art disciplines, through the construction of cross-cultural, cross-media, and interdisciplinary approaches, better align with the characteristics of contemporary disciplines and contemporary art. This represents one of the future directions for development. However, at the same time, we also need to continue deepening our understanding of contemporary art theory construction from multiple perspectives, levels, and angles.

In particular, the integration and development of various disciplines such as regional culture and artistic creation require comprehensive and in-depth thinking. This approach will ensure that artistic creations not only reflect local cultural identities but also resonate with global audiences in a meaningful and impactful way.

Successful design must be rooted in contemporary societal trends, integrating digital technology and modern design concepts while deeply digesting and understanding China's traditional culture. Whether it's grand

projects like space exploration and the Winter Olympics, or smaller-scale endeavors like architectural spaces, Chinese-style homes, and tea sets, continuous engagement in design and art revitalizes China's traditional culture through creative transformation and innovative development. Taking a leap into ancient Shu civilization, the CCTV production *Fantastic Journey to Sanxingdui* utilizes extensive archaeological findings and cloud-based real-time rendering technology. It employs design techniques such as panoramic artifact reconstruction, interactive gaming scenes, and 3D character rendering to create China's first large-scale immersive digital interactive space. Audiences can traverse back to the mysterious ancient Shu kingdom through multiple terminals, embodying archaeologists exploring excavation sites. This shifts from past one-way passive information reception to two-way immersive entertainment experiences, breaking traditional TV boundaries and conventions. From multimedia interactions like the Palace Museum's painting *Thousand-Mile Rivers and Mountains* digital art exhibition to the wildly popular archaeological "blind boxes" from the Henan Museum, contemporary design broadens channels for multimedia exhibitions and museum cultural creations in the digital age [4]. Design and art illuminate our lives with beauty. Environmental design is never an isolated discipline; it requires interdisciplinary integration to build a better future for humanity.

4.4. Integration of sustainable development and historical heritage

The development of historical context relies on the ecological sustainability of the environment. Environmental design first needs to inherit and integrate the characteristics of the environment itself, respecting the natural environment. This involves respecting not only the geographical environment but also natural elements like animals and plants. In environmental design, it is essential to respect the terrain, adapt strategies according to local conditions, and utilize resources wisely ("living off the mountains and the waters"). It is crucial to fully consider local climates and utilize the growth patterns of local flora and fauna in landscaping. Only by fully utilizing local natural conditions and integrating them into the ecosystem can regional characteristics be highlighted effectively. This approach allows for the creation of environmental landscapes that embody the distinctive cultural characteristics of China's regions.

Chinese classical gardens not only symbolize cultural connotations but also emphasize the harmony between nature and humanity. The environmental design courses in colleges and universities should focus on exploring local ecological environments and historical cultures, and on inheriting and utilizing China's distinctive regional cultural heritage. Scholars in the field should adhere to human-centered design principles based on historical continuity and development. They should leverage emerging strengths to create design works that reflect regional cultural characteristics, thus contributing to the inheritance of environmental design and China's regional cultural heritage. Design professionals should fully utilize the ecological functions of the environment, basing their designs on nature and integrating innovative ideas. They should effectively connect mountains, springs, streams, lakes, and cities [5], optimizing human habitats with artistic forms that embody regional characteristics. This approach aims to create comfortable living spaces that enhance people's quality of life and highlight local features.

5. Conclusion

Regional culture is an essential part of Chinese culture and a vital driving force for national development. Actively integrating regional cultural elements into various fields of environmental design is crucial. This integration not only shows concern for local culture and people's lives but also facilitates the effective inheritance of China's excellent traditional culture. By incorporating Chinese regional cultural elements, environmental design works can comprehensively showcase the humanistic customs and cultural connotations

of a region, reflecting the collective will of its people. The process of integrating Chinese regional culture into environmental design involves extracting and re-creating local cultural elements, contributing to beneficial discussions on the development of China's regional culture within the context of the times.

Disclosure statement

The author declares no conflict of interest.

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Study on the Design Scheme of Vehicle Flow Lines in Unilateral Agglomerative Open Service Area

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Abstract: In recent years, with the introduction of the strategy to strengthen the country's transportation infrastructure and the continuous implementation of new economic development models such as integrating transportation with tourism, various open service areas integrating highway service areas with local tourism have emerged nationwide. Examples include the Yangcheng Lake service area in Jiangsu and the Lengshui service area in Chongqing. This paper focuses on the design example of the Dazu Stone Carving service area on the Chongqing section of the Yurong Expressway, comprehensively considering factors such as construction scale, terrain conditions, and local urban planning. It analyzes and studies the traffic flow design of unilateral agglomerative open service areas around two vehicle traffic conversion links: between the main expressway and the service area, and between the service area and local roads. The aim is to provide a case study reference for similar projects.

Keywords: Unilateral agglomeration; Open service area; Traffic flow line

Online publication: July 11, 2024

1. Introduction

In recent years, as the high-speed road network has largely taken shape, China has entered the era of mass tourism. The focus of highway construction has gradually shifted from "more" to "better." Regulatory authorities such as the Ministry of Transport are increasingly emphasizing the development of service areas. The model of "high-speed roads + tourism + intelligent, distinctive + diversified + specialized" has become a new trend.

While ensuring the self-contained operation, safety, and effective toll management of highways, exploration is underway to integrate service areas with local economic development. This approach supports the open or semi-open development of service areas within their respective regions. For instance, by integrating electronic toll collection stations to connect service areas with local roads, a comprehensive transportation and tourism network known as "fast transit, slow tourism" can be established [1]. The concept of open service

areas has evolved from these initiatives. Current research underscores the importance of scientifically and logically planning traffic flow routes to enhance the operational quality and safety of service areas, significantly influencing their management and operation.

This paper focuses on the Dazu Stone Carving service area as the research subject, primarily discussing the design of traffic flow organization both inside and outside unilateral agglomerative open service areas. The aim is to provide technical references for similar projects, which hold practical significance.

2. Project overview

The Dazu Stone Carving service area is located on the south side of Dazu District in Chongqing City. The construction site is situated within the Longgang-Tangxiang planning area of Dazu District. The total land area occupies approximately 300 acres. The service area is rectangular in shape, oriented from east to west, with flat terrain. It is situated close to the west of the Five-Star Avenue.

The service area is located along the Chongqing section of the Chongqing-Chengdu Expressway (Yurong Expressway). The main expressway adopts a dual six-lane standard, with a design speed of 120 km/h. The roadbed width is 33.5 meters. The Yurong Expressway is equipped with a total of five service areas, with three in Sichuan Province and two in Chongqing. The average distance between service areas is 53.28 kilometers, as shown in **Figure 1**.

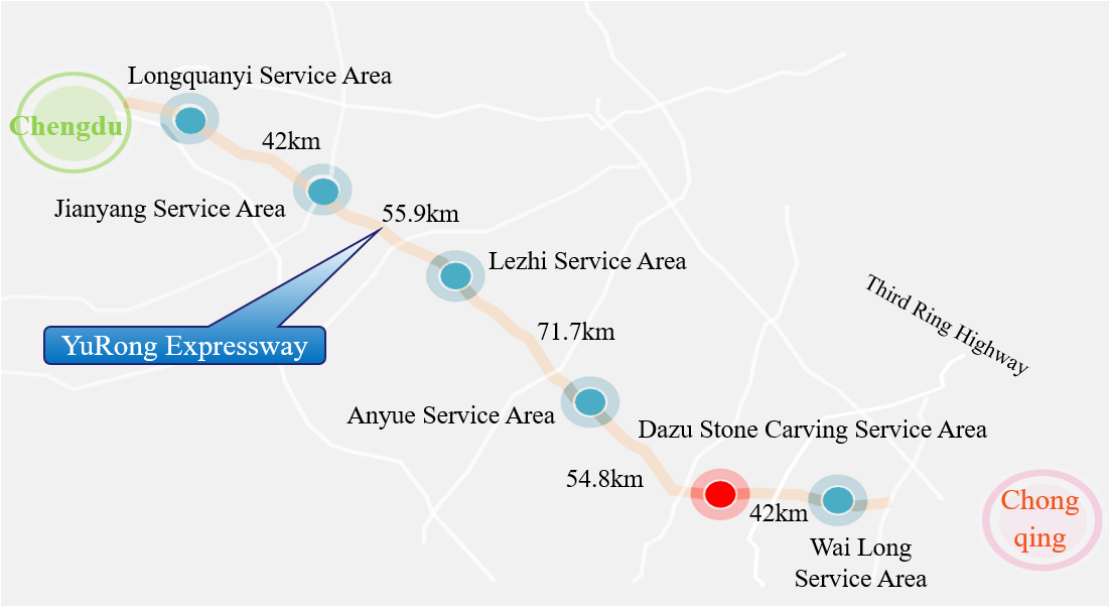


Figure 1. Distribution map of the service area of Yurong Expressway

The Dazu Stone Carving service area occupies a total land area of 280.00 mu (approximately 18.67 hectares), with 20 mu reserved for future use. The total constructed area amounts to 10,124.26 square meters.

The project is positioned as a “Dazu Impression Theme + Open Service Area,” constructed according to the five-star service area technical standards. Visual representations of the service area are depicted in **Figure 2**.



Figure 2. Aerial view of Dazu Stone Carving service area

3. Vehicle flow line design ideas

3.1. Overall design principles

Inside the service area, the traffic organization prioritizes separating pedestrian and vehicular flows to minimize their intersection and mixing [2].

(1) The flow follows a "park first, then refuel" process, with streamlined designs for entering the service area, parking, refueling, and exiting.

(2) Vehicle-type designs minimize interference between different types of traffic flows.

(3) Routes are designated for both vehicles refueling at designated stations and those refueling directly.

(4) Specialized vehicles such as maintenance vehicles, fuel transporters, hazardous material transporters, and livestock carriers have relatively independent traffic routes.

(5) Consistent directional flow at exits is maintained, favoring one-way traffic to avoid intersections.

(6) The layout of traffic flows and service area buildings are integrated to form an organic whole.

(7) Meeting maintenance and management requirements of the service area to optimize construction investment.

(8) Close integration with local urban planning maximizes the functional role of the open service area.

(9) The geometric design of traffic routes meets highway standards to ensure smooth and safe driving. At intersections where traffic flows converge or diverge, visibility is optimized, making it easy to discern the direction of each flow.

3.2. Limiting factors

3.2.1. Existing reserved lands

This project is a new construction service area located on the existing reserved land on the north side of the main expressway. The reserved land has been developed with a Type B single trumpet interchange [3], facilitating traffic transitions between the main expressway and the planned service area.

As shown in **Figure 3**, it is evident that the basic layout of this service area is unilateral agglomerative, with entrance and exit ramps constructed for traffic flowing towards Chengdu and Chongqing.



Figure 3. Map of the service area

3.2.2. Local road network planning

According to the urban planning of Dazu District, the construction site is located in the Longgang-Tangxiang planning area. The existing land on the left side is already developed with the Five-Star Avenue, which serves as the north-south axis of Dazu District. The design of traffic flow lines for the open service area should be closely integrated with the local urban road network planning (**Figure 4**).

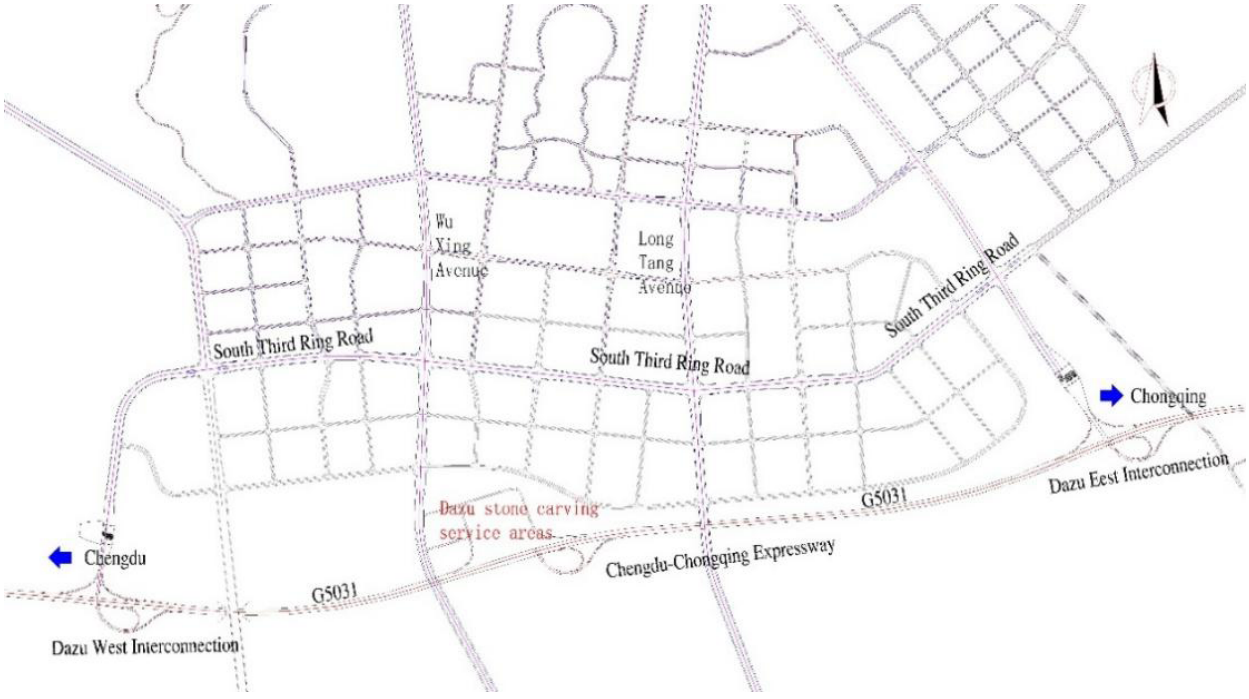


Figure 4. Road network planning of Begonia Area

3.2.3. Terrain conditions

The original terrain of the construction site is characterized by shallow erosional hills. Currently, the site has undergone leveling work, with ground elevations ranging approximately from 374.6–386.5 m, presenting a relative height difference of 11.9 m. The overall terrain slopes gently from west to east, exhibiting a generally flat topography.

4. Open service area traffic flow line design

4.1. Original traffic flow design scheme of the service area

According to the original design drawings of the Chongqing-Chengdu Expressway (Yurong Expressway), the original service area plan adopted a traditional closed unilateral agglomerative layout [4]. The main traffic flow lines for the site are depicted in **Figure 4**.

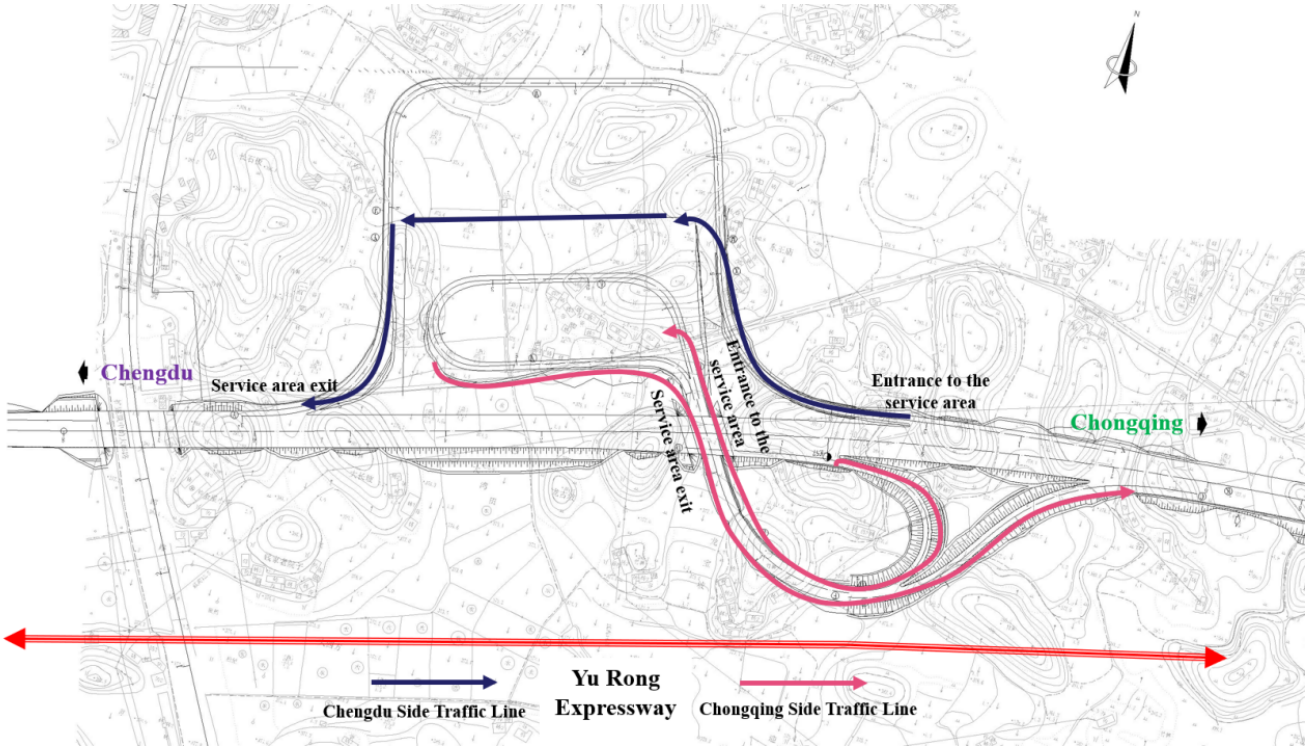


Figure 5. Traffic flow line planning of the original service area

Since the full opening of the G5013 Chongqing-Chengdu Expressway in September 2017, it has served as the shortest and fastest high-speed route between Sichuan and Chongqing. With continuous economic and social development, the traffic volume on the mainline of the Yurong Expressway has been increasing, accompanied by a growing demand for services. Improving the construction of service areas along the Dazu section of the Yurong Expressway and enhancing the overall road network service capacity have become pressing issues that need to be addressed promptly.

Furthermore, Dazu District boasts rich tourism resources such as stone carving culture and grotto culture, including several 5A and 4A tourist attractions. The planned construction site is located in the southern urban area of Dazu District. Aligning with local government development priorities, the intention is to develop the service area as an open service area. This approach aims to create a multifaceted complex imbued with Dazu's unique cultural heritage and strong regional characteristics, envisioned as a lively "city that never sleeps" in

eastern Sichuan.

Based on this, this paper proposes two designs for traffic flow lines from the perspectives of traffic transition between the main expressway, service area, and local roads. These designs are elaborated below, taking into account factors such as the functional requirements of the service area, site traffic organization, surrounding road networks, and terrain conditions.

4.2. Open service area traffic flow line design scheme 1

The central placement of the integrated building in this plan's service area facilitates vehicular traffic transitions between the main expressway, the service area, and local roads via newly constructed onsite roads. Traffic from both directions of the Yurong Expressway transitions into the service area through a Type B single trumpet interchange. Local roads use segregated ETC stations to transition vehicles into the service area. The main traffic flow lines are illustrated in the accompanying diagram.

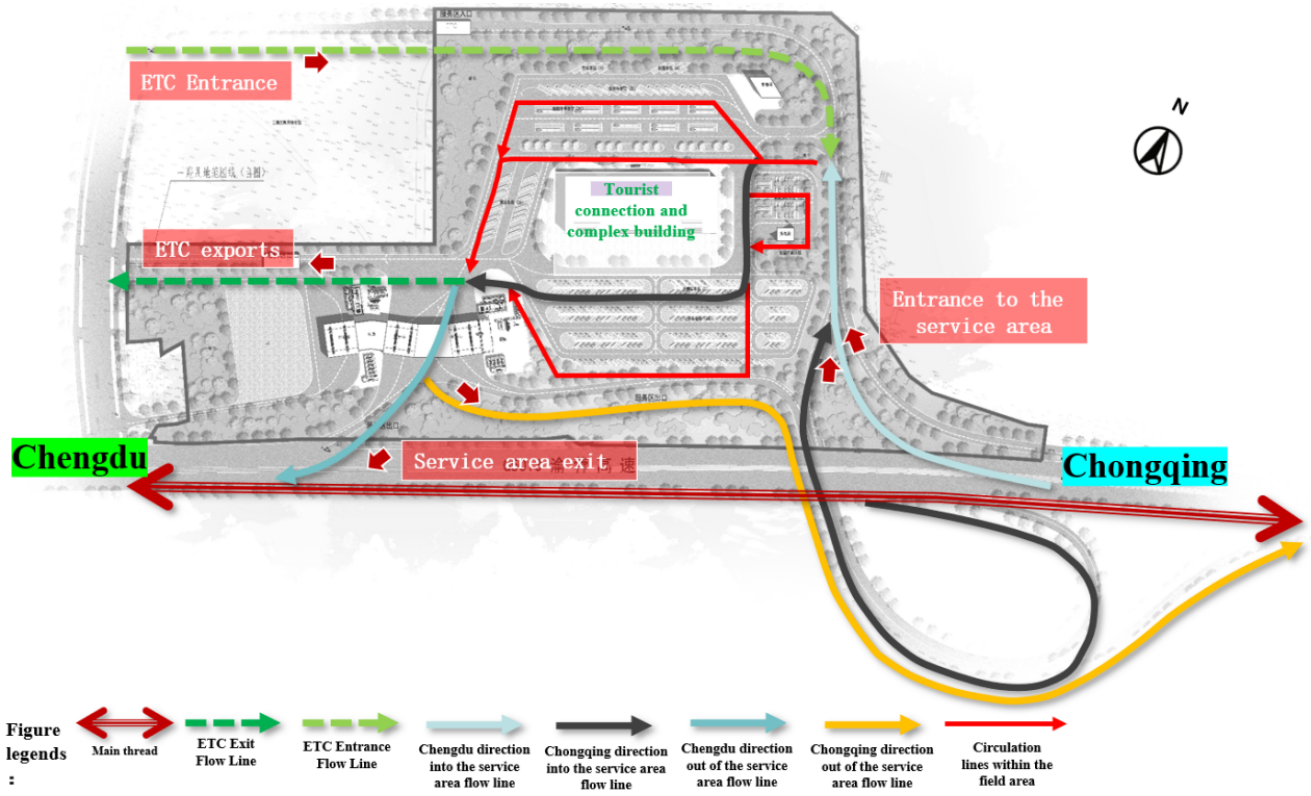


Figure 6. Vehicle flow line of Scheme 1

4.3. Open service area traffic flow line design Scheme 2

This plan situates the integrated building of the service area centrally. Vehicular traffic from the main expressway, service area, and local roads transitions through newly constructed onsite roads within the service area. Traffic from both directions of the Yurong Expressway transitions into the service area through a Type B single trumpet interchange. Local roads use centralized ETC stations to transition vehicles into the service area. Additionally, the integrated building acts as the central axis, forming a circular flow of traffic to enhance fault tolerance. The main traffic flow lines are illustrated in **Figure 7**.

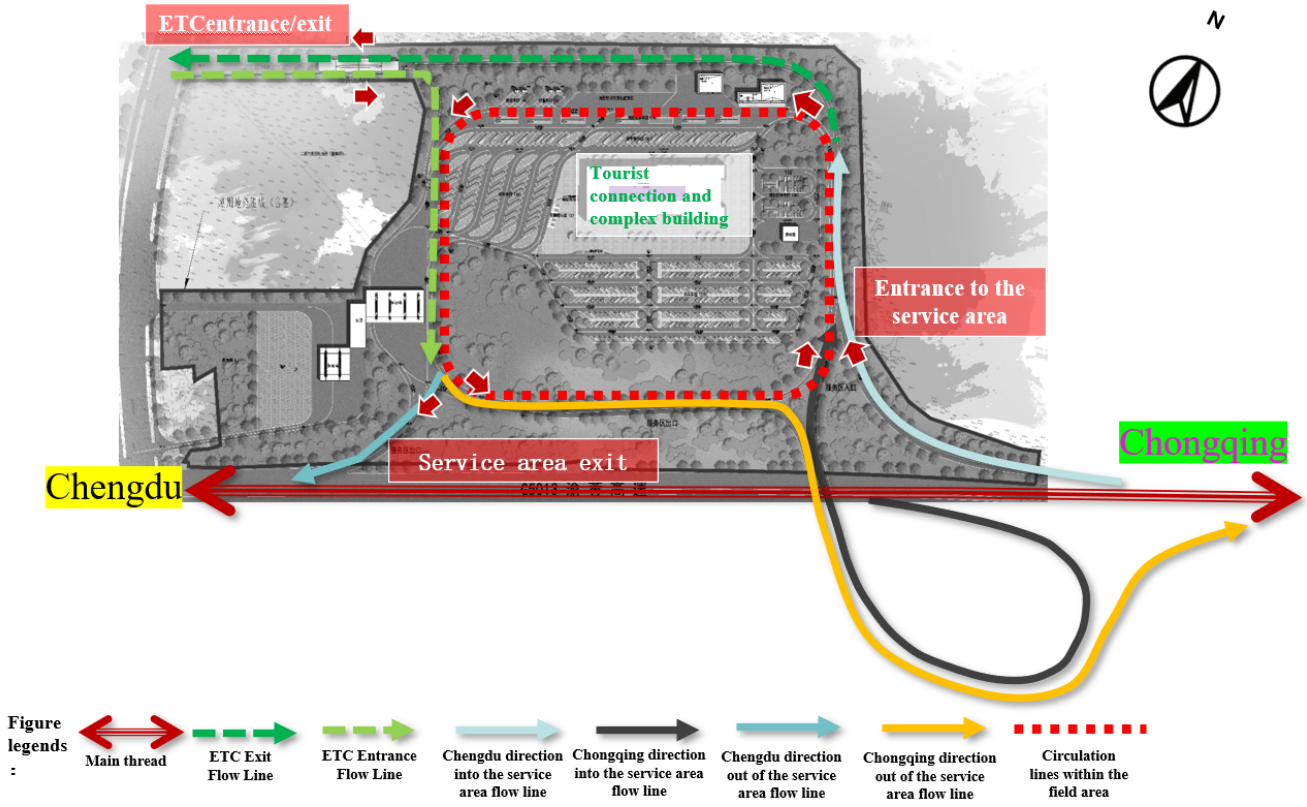


Figure 7. Traffic flow line of Scheme 2

Through the analysis of the traffic flow design of the two open service areas mentioned above, the comparison of technical indicators and engineering scale and the analysis of advantages and disadvantages of both schemes are shown in **Tables 1 & 2**.

Table 1. Comparison of technical indicators and project scale between the two design schemes

Indicator name	Scheme 1	Scheme 2
Design speed (km/h)	20	20
Lane width (m)	3.5/7.0/10.5	3.5/7.0
Minimum radius of road curve (m)	20	20
Maximum longitudinal slope (%)	4.98	4.98
Road length (km)	1.11	1.36
Earthwork (m)	1262	1285
Culvert (channel)	3	3
Road surface (m^2)	7675	8012
Protection works (m^2)	430	543
ETC toll station	1	2
Cost (yuan)	2456800	2564640

Table 2. Analysis of the advantages and disadvantages of the design options

Scheme	Pros	Cons
1	The traffic flow organization in the service area is relatively smooth. The centralized placement of ETC stations facilitates management, and the engineering scale is relatively low.	Within the site, there are X-shaped intersections between east and west side roads, which can lead to congestion during holidays and peak periods.
2	Traffic flow on the east and west sides is less likely to intersect, making it easier to set up and recognize traffic signs.	The traffic flow entering and exiting the toll station needs to detour through the service area, which can easily conflict with the service area traffic flow. The separate placement of the toll station makes it difficult to manage. The toll station roads intersect with local roads in two places, which complicates recognition. This results in a larger engineering scale.

Through comparison, it can be observed that although there is a slight difference in cost and scale, Scheme 1 generally offers smoother traffic flow and stronger fault tolerance. Moreover, the centralized placement of ETC toll stations facilitates management. Therefore, after a comprehensive evaluation, Scheme 1 is recommended as the preferred construction plan.

4. Conclusion

As open service areas continue to thrive, it is crucial to fully consider factors such as terrain and urban planning when designing traffic flow patterns. Rational and scientific placement of traffic flows in unilateral agglomerative service areas is essential for the operational efficiency, safety, and management of open service areas along highways. This approach contributes to establishing a new highway service system, promoting efficient, safe, and stable highway operations [5].

Disclosure statement

The author declares no conflict of interest.

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Designing an Elderly-Friendly City in Cardiff: Cultivating Sense of Security for the Aging Population: Transforming Butetown for the Entertainment, Health, and Diversification of the Elderly

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Abstract: As an important part of urban construction, elderly-friendly construction is crucial to the formation of an elderly-friendly society, which has been widely recognized internationally. Especially after the COVID-19 pandemic, various organizations around the world have called for changes in public space and urban building planning, with an emphasis on the accessibility of green spaces. This underscores the complexity and difficulty of integrating vulnerable groups of the elderly into cities and using infrastructure and public space.

Keywords: Aging population; Elderly-friendly city; Urban planning; Built environment; Design

Online publication: July 12, 2024

1. Introduction

Urbanization and aging are profoundly impacting our lives, work, and spatial experiences, making aging an unavoidable issue in urban development. The proportion of the global population aged over 60 has increased from 9.2% in 1990 to 11.7% in 2013 and is projected to reach 21.1% by 2050 [1]. Countries experiencing rapid demographic transitions must urgently address the challenges of aging. Consequently, the construction of elderly-friendly cities has become a significant and urgent measure to ensure that urban environments can accommodate and support the needs of an aging population.

The redesign of urban public leisure spaces increasingly considers the needs of minority groups by incorporating features like facilities for the disabled and the blind, which exemplify humanized urban construction. However, as society ages, urban space construction often lacks awareness of the aging population. City parks frequently lack adequate signage, causing elderly individuals to get lost easily. Moreover, many leisure squares are built in areas with significant traffic interference, noise, and complexity, making them

difficult for older people to access and enjoy.

The World Health Organization (WHO) issued the *Guidelines for the Construction of Global Friendly Cities on Ageing*, emphasizing that city design should consider the abilities and resources of elders, and flexibly predict and respond to their needs and preferences related to elderly care. The decisions and chosen lifestyles of the elderly should be respected. As a vulnerable group, the elderly require protection, and the built environment should promote their integration into community life [2]. In 2010, the WHO established the Global Network of Elderly-Friendly Cities and Communities (GNAFCC). By 2022, its membership had grown to 1,000 cities across 47 countries [3].

This report aims to enhance public spaces to be more favorable for elderly people in cities. By promoting elderly-friendly initiatives on multiple scales and from all perspectives, cities can improve their performance in health, leisure, services, and accessibility of facilities for the elderly

2. Significance and impact of an elderly-friendly society in Butetown

This study focuses on designing urban public leisure spaces to be elderly-friendly by identifying essential components of an elderly-friendly city. It aims to supply a variety of comfortable outdoor areas for senior citizens, assist them in engaging in social activities, help them realize their values, provide a sense of empowerment, and foster a positive aging-related social environment. The study highlights innovative urban planning initiatives and improvement strategies to make roads, parks, and public spaces socially inclusive, equitable, and safe for the elderly population by analyzing research conducted from the perspective of elderly friendliness.

3. Designing a city that is elderly-friendly

As a valuable resource in society, cities need to foster a friendly attitude toward the elderly and assist them in integrating into the community [4]. This necessitates urban designers adopting elderly-friendly language and thinking models in the design of spaces, structures, and services [5]. It is recommended that cities consider elderly-friendly approaches across three spatial scales: at the city level (urban plan and policy), at the street and community level, and at the housing level (space and product) [6].

Many frameworks have been developed to conduct interventions within urban contexts to improve the overall quality of life for the elderly population. The following are three prevalent models with their essential characteristics: the concept of Active Ageing, brought up by the WHO, which focuses on improving health, participation, and security for the elderly [7]: the Connectivity Model, integrating ecological notions and emphasizing the interaction environment for the elderly, covering housing, transportation options, supportive community, and engagement [8]; and the AdvantAge Initiative (2002) in the United States, which aims to establish an elderly-friendly city with four primary features [9] – meeting basic needs, promoting social involvement, supporting the independence of disabled populations, and enhancing overall well-being. Manchester is part of the pioneer group that joined the GNAFCC. The Manchester City Council developed a strategic plan to address inequalities and challenges in impoverished areas [10].

3.1. Safe transportation system

Ryan and Wretstrand stated that the decline in the well-being of the elderly is caused by social isolation and reduced access to goods and services, which is closely related to low mobility, especially for disabled people [11]. Bannister and Pauling found that urban transportation and travel potential are of great significance to the well-

being of the elderly [12]. Through outdoor activities, the elderly can not only escape a monotonous life but also integrate into modern society and cultivate their own interests. Outdoor activities are beneficial to physical and mental health and can also stimulate the vitality of the elderly.

Many elderly individuals face difficulties when engaging in outdoor activities due to their limited mobility and cognitive challenges. Simple tasks such as navigating unfamiliar areas can cause anxiety, necessitating careful planning beforehand. The absence of pedestrian-friendly amenities like benches, public restrooms, and bus shelters further complicates their outdoor experiences. Road closures and construction projects also present formidable obstacles [13]. Inadequate road infrastructure and transportation services also have a significant psychological impact. Social exclusion limits their ability to participate socially and economically, which in turn exacerbates health issues and lowers their overall quality of life. This situation undermines the cohesion and equity within aging societies [14]. Research indicates that elderly individuals in urban settings often experience marginalization and heightened vulnerability to social inequality, resulting in limited engagement in daily activities and a gradual decline in physical well-being [15]. Insufficient availability and accessibility of transportation and convenient travel options perpetuate these challenges, further exacerbating their conditions.

3.2. Sense of security

Recent studies increasingly demonstrate a positive link between well-designed outdoor spaces and elderly health. However, unfamiliarity with the built environment significantly reduces the frequency of outdoor travel among the elderly. Urban landscapes are rapidly changing due to redevelopment while declining cognitive functions make once-familiar surroundings unrecognizable for older adults. These factors contribute to diminished mental well-being, as simple outings can evoke discomfort and anxiety [16]. Deteriorating navigation skills further exacerbate feelings of insecurity, fear, and reluctance to engage in social activities, thereby deterring elderly individuals from accessing public spaces. Therefore, fostering place attachment becomes essential to support aging in place among the elderly population [17].

Environmental gerontology focuses on how older adults perceive and respond to their architectural surroundings, aiming to understand the dynamic relationship between their capabilities and environmental needs [18]. Studies have shown that poorly designed neighborhoods can exacerbate mobility issues by hindering walking and exercise opportunities [19]. In urban settings, researchers have found that imposing buildings, confusing street layouts, and expansive open spaces can be intimidating for people with dementia [20]. As individuals age, they become more sensitive to loud noises, bright colors, and crowded environments. Spaces that appear unsafe, such as dark alleys, dirty underpasses, and narrow pathways, create barriers that deter older adults from engaging with their surroundings. Additionally, complex transportation hubs, large commercial plazas, and vibrant neon lights and billboards can overwhelm the senses of the elderly, leading to sensory overload.

Urban planning should enhance the awareness of active response to aging and ensure that the needs of the elderly are fulfilled. Constructing green space suitable for the elderly is important. Designers should design public leisure environments according to the physical, psychological, and social characteristics of the elderly. For instance, as most elderly people spend a relatively long time in the park, more restrooms, seats, signs, and maps should be set up around the park. Pedestrian and vehicle areas should be separated, and weatherproof corridors should be designed to provide all-weather travel conditions. Seating and other rest facilities should be available every 20 minutes of walking to help the elderly rest. By offering a comfortable environment, their sense of security can be improved.

4. Research methodology

4.1. Literature review

It is crucial to refine the characteristics and shortcomings of existing studies, identify emerging research trends, and determine the entry points for further investigation in the context of elderly-friendly design. This can be achieved by gathering documents and data that include relevant policies related to urban fitness for the elderly, research on elderly-friendly theories applied at urban and community levels, and specific aspects such as green space construction in parks, road design, and services tailored to elderly populations. Establishing an evaluation system will provide a theoretical foundation to enhance the scientific rigor and comprehensiveness of the research, aiming to contribute to the advancement of elderly-friendly urban design practices.

4.2. Field study

To gather information on Cardiff's fitness for its elderly population, methods like observation and interviews can be used. This will include examining aging facilities in the city, residences, and public spaces used by elderly groups. The goal is to collect case data to support further research.

4.3. Questionnaire survey

Understanding the daily activities and spatial needs of the elderly, as well as conducting satisfaction surveys of comprehensive urban parks, are crucial steps in this study. Additionally, it is essential to comprehensively assess how the elderly utilize roads, public spaces, and buildings within the study area. The research will focus on identifying key aging factors within parks to support the development of an aging evaluation system.

Relevant data can be sourced from three main areas: extensive basic data provided by city officials for service provision and planning, health statistics, and interviews conducted to assess the specific needs of the elderly population.

5. Limitations and barriers of this research on the investigation of elderly-friendly communities

Currently, research on aging issues primarily focuses on evaluating and designing community spaces, residential areas, roads, and parks. However, the existing literature on aging design and evaluation is limited and lacks a cohesive research framework. This study recognizes the inherent subjectivity and limitations in extracting and categorizing evaluation indicators from the available literature on the aging population. To address these shortcomings, future research should broaden the scope of literature review, incorporate more quantitative indicators, and establish a more comprehensive and scientifically rigorous evaluation system.

In studying aging adaptability in urban areas, the research is constrained by time limitations, the specific demographic composition of the elderly population, and their varying capabilities within the study area. Consequently, the selection of studies may be limited, potentially resulting in a somewhat biased understanding of aging adaptability and the activities of elderly groups in urban environments. To overcome these challenges, future research should explore more efficient and comprehensive research methods and data collection approaches to expand the sample size and deepen insights into aging issues in urban contexts.

6. Conclusion

In light of significant demographic aging and the evolving and diverse needs of the elderly, we must actively address the challenges of an aging population by updating our approaches and expanding our design concepts.

Designs should focus on fun, safety, and interactivity to meet new requirements and forms. This research facilitates the integration of social resources for the elderly and breaks down barriers, continuously improving their living conditions and overall quality of life. Creating an elderly-friendly society enhances the city's livability and sustainable growth, boosts its reputation, and promotes social participation among the elderly.

Disclosure statement

The author declares no conflict of interest.

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Application of Key Technologies in Green School Buildings: Taking Sino-German Future City Primary School as an Example

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Abstract: Green building is a manifestation of the response to the national "dual carbon" strategy. With the large-scale promotion of green buildings, the country has successively issued multiple evaluation standards for green buildings. Schools are places for preaching, teaching, and solving doubts, and the campus environment plays an important role in improving students' learning efficiency and promoting their physical and mental health. This article is based on the "Green Building Evaluation Standards" GB/T 50378-2019, analyzing and exploring the integration and application of key technologies in green schools, providing reference for green building designers.

Keywords: Green buildings; Energy conservation and environmental protection; Key technologies; High-quality buildings

Online publication: July 11, 2024

1. Introduction

Green building is a type of building that emphasizes environmental protection and sustainable development. It offers advantages such as reducing carbon emissions, promoting sustainable resource utilization, reducing energy and water waste, and improving indoor air quality compared to traditional buildings [1]. Green buildings are high-quality buildings that save resources, protect the environment, reduce pollution, provide people with healthy, applicable, and efficient usage space throughout their entire lifecycle, and maximize the harmonious coexistence between humans and nature [2]. With the increasingly prominent issues of global climate change and environmental sustainability, green building design and green energy-saving buildings have become important ways to address these challenges. Research shows that the satisfaction level of green buildings is much higher than that of traditional buildings, indicating that the energy-saving effect of green buildings is remarkable [3].

Singapore is an active pioneer in green building and has introduced different green building policies at different stages of its development [4]. Africa actively promotes the development of green buildings, and the coverage of green building research in Africa is in line with the global level [5]. Southeast Asia is located in the tropics and is affected by the tropical monsoon climate. The proportion of refrigeration demand is

high, and renewable energy is easy to obtain. In the application of green building technology, the building envelope structure, equipment, renewable energy, water conservation, greening, etc. are all key factors [6]. Abdelaal *et al.* conducted a survey on multiple stakeholders in the green building industry in New Zealand using a questionnaire, and the results showed that these stakeholders had sufficient knowledge and positive attitudes towards green building design and certification [7]. Ohueri *et al.* used quantitative research methods to investigate 180 architects in Malaysia and analyzed factors using factor analysis. They identified the best method for implementing BIM processes in green building design practices, which can assist architects in delivering buildings with high sustainability [8].

China's green buildings have entered a stage of comprehensive development, and the level of green building technology is constantly improving, showing a trend of benign development. Green school buildings are guided by the theory of sustainable development, creating a healthy, safe, green, and environmentally friendly environment for teachers and students, which is more conducive to the physical and mental health of students. In terms of optimizing the design of school buildings, Deng *et al*. used Revit software to optimize the design of Shuiquan Primary School and Kindergarten in Tai'an City. The school project was rated from four aspects: wind environment, light environment, HVAC, and sound environment, ensuring that the project reached a two-star rating [9]. Ding proposed that for schools, the overall layout, indoor and outdoor teaching and activity spaces of primary and secondary school buildings should be improved and designed according to the needs of different groups and terrain environments, in order to create a high-quality educational space environment that is in line with the times [10]. Fu *et al.* took Kaiyuan Middle School in Hangzhou as an example and proposed a suitable technical system for the green renovation of existing school buildings. By optimizing the building and site, the outdoor sound, light, and thermal environment were improved. By reducing energy and water consumption through HVAC systems, water supply and drainage systems, lighting, and energy consumption monitoring systems, renewable energy was utilized to reduce carbon emissions [11].

2. Standard requirements

The Green Building Evaluation Standards is a specific practice in the field of green development in China, aimed at implementing the concept of green development and promoting high-quality development of green buildings [12]. In 2019, the Ministry of Housing and Urban Rural Development issued the "Green Building Evaluation Standards" (GB/T 50378-2019), which clarified the green building evaluation index system, mainly including five categories of indicators: safety and durability, health and comfort, convenience, resource conservation, and livability.

3. Project overview

The Sino-German Future City Primary School construction project is located in the Hongshiya Street Office of Huangdao District, Qingdao City, south of Tuanjie Road and east of Kunlun Mountain Road. The total land area is 33468 m^2, with a total construction area of 29366.66 m^2. The main functions include the primary school comprehensive building, multifunctional hall, sports activity center, equipment room, generator room substation, guard room, and underground parking lot.

4. Key technologies

4.1. Safety and durability

"Safety and durability" refers to the enhanced durability measures that need to be considered in the design

stage of buildings, which have stronger guidance for building design and are easier to operate in the evaluation of green buildings [13]. The basic requirements for safety and durability include site safety, structural safety, external shading, and the safety and durability design of internal facilities, fundamentally eliminating safety hazards. Green building technology is elaborated from two aspects: safety and durability.

(1) Safety

The location of the project site is safe with no risk of radioactive contamination. Invisible anti-theft nets are installed to improve the security of the windows. Door hoppers and canopies are installed at the entrances and exits of the building to prevent accidental detachment of door and window glass, which may affect pedestrian safety. Green isolation belts are reasonably set up around buildings as buffer zones to increase pedestrian safety. Door and window glass selection complies with the "Technical Regulations for Building Applications" (JGJ 113-2015) [14] and the "Management Regulations for Building Safety Glass" (Development, Reform, and Operation No. 2116) [15]. Outdoor lighting should follow the "green lighting" principle to meet environmental and energy conservation standards. The outdoor lighting control system is divided into multiple circuits based on system distribution and functional requirements, allowing for flexible scheduling according to the season for ease of maintenance and management. All equipment and materials selected for outdoor lighting have a testing certificate (3C certification) from the National Testing Center.

(2) Durability

The project includes adaptive indoor functions, with comprehensive activity spaces on each floor of the teaching building. These spaces can be divided into different functions according to teaching needs to support daily teaching and student activities. A folding stand is set up on the mezzanine of the sports activity center, serving as an activity space in daily life. During school events, it provides sufficient space for the audience, enhancing space utilization. Water supply and drainage, as well as electrical equipment, should use pipes, pipelines, and pipe fittings that are corrosion-resistant, aging-resistant, and durable. The durability of the structure is improved by increasing the thickness of the steel reinforcement protective layer, and the thickness of the concrete protective layer is increased by 5 mm beyond the requirements specified in the "Code for Design of Concrete Structure" [16]. External decorative materials should be durable, and waterproof and sealing materials must have green product certification to meet durability requirements. Interior decoration materials should be made of wear-resistant materials.

4.2. Health and comfort

Health and comfort fully encompasses the principles of healthy buildings, emphasizing the impact of decoration materials, water quality, indoor acoustic environment, hot and humid environment, natural ventilation, thermal comfort, and other factors on human health. The design for health and comfort should elaborate on aspects such as indoor air quality, water quality, sound and light environment, and hot and humid environment.

(1) Indoor air quality

Measures to ensure excellent indoor air quality involve adopting green products, reducing indoor air pollutants, and ensuring that the air quality meets the requirements of current national standards.

(2) Water quality

Disinfection facilities are installed in the domestic drinking water pool (water tank). The water supply facilities are cleaned and disinfected before use, and the water quality is regularly inspected to ensure it meets standard requirements. This project includes a rainwater collection and reuse system, with separate pipelines for rainwater reuse and domestic water applications. The outer wall of the rainwater reuse pipeline should be painted or marked according to relevant standards. The water tank, valve, water meter, water supply hydrant,

and water intake should all have clear “rainwater reuse” signs. The fire hydrant pipeline is red, with a red ring mark on the sprinkler pipeline. The fire hydrant pipeline should be marked “fire hydrant,” and the sprinkler pipeline should be marked “spray.”

(3) Sound and light environments

The indoor sound environment is excellent, with environmental noise levels at 32.83 dB. The soundproof performance of the main functional rooms also meets the requirements. Shading facilities are reasonably set up to prevent glare. Regarding the indoor hot and humid environment, research [17,18] shows that significant deviations from design parameters in indoor temperature and humidity can lead to Sick Building Syndrome (SBS). Excessive indoor temperatures can cause symptoms such as headaches and throat discomfort, while low indoor temperatures can lead to high levels of dissatisfaction among occupants. Reasonably controlling the opening area of external windows can effectively enhance natural ventilation. Adjustable external shading are used to improve indoor comfort during summer.

4.3. Convenience

The ultimate goal of architecture is to serve people. Research shows people spend 90% of their time indoors [19], so various serves should be available in their surroundings for better convenience. Convenience primarily reflects the needs of occupants for public transportation facilities, bicycle parking, accessibility, fitness facilities, intelligent detection systems, and other aspects.

(1) Accessible public transport

There are two bus routes within 800 meters of the site, making transportation convenient. A coherent barrier-free facility is created both inside and outside the venue.

(2) Service facilities in the surrounding area

The school’s swimming pool, wind and rain playground, and outdoor playground are open to the public on holidays, aiming to provide convenient amenities for nearby residents. Engaging in sports and fitness activities can significantly enhance cardiovascular health, muscle strength, flexibility, balance, and overall physical fitness, thereby improving overall health levels. To support these activities, the project includes well-planned indoor and outdoor fitness facilities [20]. The outdoor fitness area spans 10,468 m² and includes amenities such as basketball courts, volleyball courts, and a circular track. Indoors, there is a 1,208 m² fitness space equipped with a windproof playground and a swimming pool. These facilities are designed to cater to diverse fitness needs and promote a healthy lifestyle for the community.

(3) Intelligent operation

the project implements a building energy efficiency supervision platform that complies with the “Technical Specification for Energy Monitoring System of Public Buildings” (DBJ/T14-071-2010). This platform facilitates statistical analysis of electricity, water, cooling, and heating consumption within the building. It provides targeted energy-saving management recommendations based on consumption patterns. Electricity monitoring includes sub-item monitoring of electricity from the low-voltage distribution system’s outgoing side and floor-level electricity monitoring. The system categorizes electricity into lighting, sockets, air conditioning, general power usage, and specialized areas. Additionally, PM_{10}/$PM_{2.5}$/CO2 three-in-one air quality sensors are installed in the building to monitor indoor environmental parameters continuously. The system collects front-end water meter data through a data collector to measure municipal water supply, total water consumption per unit, and usage in specific areas such as restaurants. An online water quality monitoring system is established to monitor tap water and rainwater quality indicators in real-time.

4.4. Resource conservation

Resource conservation mainly includes several aspects, including land use and conservation, energy conservation and utilization, water conservation and utilization, and material conservation and using green building materials. Through resource conservation, the rational utilization of energy resources can be achieved.

(1) Energy conservation and utilization

The thermal performance of the building envelope is designed to meet the requirements of ultra-low energy consumption standards. Compared to conventional buildings, HVAC load is reduced by 63%, with an additional reduction of over 20% in remaining energy consumption. Cold and heat sources employ ultra-low temperature screw air-cooled heat pump units and air-cooled heat pump units, effectively saving energy.

For lighting, while ensuring design illuminance and quality, compact fluorescent lamps, circular fluorescent lamps, T5 straight tube fluorescent lamps, or LED lamps are typically used in general areas. Metal halide lamps or LED lamps are chosen for larger spaces or outdoor areas, prioritizing high efficiency and meeting glare limitations and lighting standards.

The project implements a centralized hot water system using renewable energy sources. A large solar energy collector and low-temperature air source heat pump are installed on the roof to provide hot water. Solar energy primarily heats domestic shower water, supplemented by air-source heat pumps. The system aims for a 45% guarantee rate from solar energy, with scheduled daily hot water supply maintaining a temperature of 60°C for water supply and 50°C for return water.

(2) Water-saving and water resource utilization

The water efficiency level of all water appliances reaches level 1, and water-saving irrigation is used for outdoor greening irrigation. Rainwater collection and reuse facilities are set up for greening irrigation, garage and road flushing, and car washing.

(3) Material conservation and green building materials

All parts of the building are designed and constructed using an integrated approach of civil engineering and architecture. The proportion of ordinary steel bars with a stress level of 400 MPa or above is 96.7%, and the proportion of green building materials application reaches 50%.

4.5. Livability

Livability prioritizes human well-being by creating a healthy and enjoyable environment at the site. This approach focuses on factors such as sunlight, thermal comfort, outdoor greenery, sound quality, wind conditions, and mitigating heat island effects. By optimizing these elements comprehensively, a livable environment is cultivated for residents.

(1) Site ecology and landscape

The project achieves a green space rate of 20%, enhancing the ecological foundation with a combination of trees and shrubs. It maintains a total annual runoff control rate of 85%. Public green spaces are accessible to enhance the overall green environment for community enjoyment.

(2) Outdoor environment

The outdoor sound environment meets Class 2 standards, ensuring minimal noise disturbance. The visible light reflection ratio of the curtain wall is carefully controlled to prevent light pollution. Optimal building layout contributes to a favorable outdoor wind environment.

4.6. Improvement and innovation

Improvement and innovation in construction involve adopting advanced, practical, and cost-effective technologies, products, and management methods at various stages of construction. These efforts aim to

enhance performance and integrate innovative technologies, marking significant advancements in construction practices and technology. Key aspects include further reducing HVAC energy consumption, integrating regional architectural heritage, designing green spaces thoughtfully, promoting industrialized construction, implementing BIM technology, adopting green building practices, and ensuring engineering quality through defect insurance. These advancements enable buildings to better embody principles of green and low-carbon development, fostering sustainable and environmentally responsible construction practices.

By adopting efficient cold and heat sources and equipment systems, the energy consumption of HVAC can be reduced by more than 40% compared to current standards. The entire process applies building information model (BIM) technology to achieve information sharing and collaborative work. During the design phase, the entire process of building carbon emissions is carried out to effectively control the amount of building carbon emissions. After sorting out the evolutionary process of the development of primary education architecture at home and abroad, this project shares the three educational cores of art, reading, and sports with the public, making the educational community more socially significant and providing more platforms for communication and sharing for the growth of young people. Provide independent and shared community-based campuses for minors of different ages.

5. Conclusion

This project actively innovates and practices the construction concept of green, low-carbon, and ecological protection, and the ecological standards meet the requirements of the new era. Choosing and implementing appropriate green building measures based on local and project conditions not only saves costs but also achieves the expected results. The materials selected for green building design in this project can serve as a reference and model for future architectural design in other projects, for reasonable comparison and promotion.

Disclosure statement

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Energy-Saving Construction Technologies for Buildings

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Abstract: The development of the construction industry is shifting towards low-carbon construction, so it is necessary to improve and optimize related construction concepts, methods, and processes. By improving resource and energy control efficiency in building projects, minimizing construction waste, and reducing environmental impact, a foundation for the sustainable development of the industry can be established. This paper mainly analyzes the significance of low-carbon energy-saving construction technology and the control factors of construction, summarizes the status quo of the development of building energy-saving construction, and puts forward strategies for applying building energy-saving construction technology. These strategies serve to achieve low-carbon and energy-saving goals to promote the healthy development of energy-saving construction.

Keywords: Low-carbon energy-saving concept; Construction; Energy-saving construction; Thermal insulation technology; Intelligent technology

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1. Introduction

Low-carbon building technology involves saving resources and reducing environmental pollution in construction by adopting energy-saving technologies and reducing the emission of pollutants. The construction industry accounts for a huge proportion of energy consumption in China. Therefore, it is imperative to improve energy conservation efforts by employing low-carbon energy-saving technologies [1].

The sustainable development of the construction industry can be ensured by optimizing construction technology at various stages of building projects and incorporating scientific insulation techniques alongside a green construction management system.

2. Significance of low-carbon energy-saving construction technology

Energy-saving construction technology for housing begins at the design stage, where adherence to energy-saving standards is crucial throughout all phases, including program design, material selection, construction,

and subsequent use. The utilization of advanced technology and careful selection of materials and equipment reduce material waste and environmental pollution. Using renewable energy sources and protecting the ecological environment contribute to energy efficiency and savings. Implementing low-carbon energy-saving construction technology not only conserves resources and energy during construction and use but also reduces carbon emissions and protects the environment [2]. Therefore, building energy-saving construction technology is vital for the success of China's sustainable development strategy. Given the country's limited energy, land, and water resources, strengthening their protection is essential for their citizen's survival and well-being.

Large amounts of carbon dioxide are released during building construction in China, which accounts for 50% of the total carbon dioxide emissions in the country. During the period from the 11th Five-Year Plan to the 13th Five-Year Plan, the carbon emissions from buildings have continued to increase. The details are shown in **Table 1**.

Table 1. Carbon emissions during the period from the 11th Five-Year Plan to the 13th Five-Year Plan

Carbon emissions/billion CO_2	Building operation (billion tCO_2)	Building materials production (billion tCO_2)	Construction process (billion tCO_2)
During the 11th Five-Year Plan period	11–15	12–18	22.3–32.5
During the 12th Five-Year Plan period	16–19	24–26	32.5–45.2
During the 13th Five-Year Plan period	2–23	27–29	45.2–52.2

Under the "dual-carbon" strategy of the "14th Five-Year Plan," it is crucial to enhance environmental protection and achieve energy savings. The construction industry, one of the largest consumers of materials, contributes significantly to energy consumption, with construction materials accounting for over 13% of society's total energy use, representing a substantial energy loss [3]. Therefore, it is essential for building construction to ensure the rational use of energy and effectively address various issues within the industry.

3. Factors influencing low-carbon and energy-saving construction

3.1. Carbon emission control

Building construction releases huge amounts of carbon, which are contributed by building materials and the machinery used in construction and human construction. The accumulation of carbon waste will then lead to severe pollution. Furthermore, the demand for electrical energy in construction projects will further exacerbate the issue of carbon emissions and pollution. To achieve low-carbon and energy-saving construction, it is essential to establish a scientific management system, implement robust supervision and management of the construction process, and strengthen carbon emission controls. This ensures that carbon emissions remain within the prescribed limits [4].

3.2. Conversion of carbon exchange rate

The conversion of the carbon exchange rate in construction projects is crucial. The carbon exchange rate refers to the reduction rate of carbon dioxide per unit space. During construction, managers and personnel can reduce carbon dioxide emissions, enhance the conversion rate of carbon dioxide in the ecological environment, and maintain the balance of carbon dioxide levels. This helps mitigate the impact of carbon dioxide on the surrounding climate, improve the greenhouse effect, and ensure the environmental quality around the construction site.

4. The current situation of building energy-saving construction

4.1. Flawed building energy-saving regulations

Under the background of sustainable development, China has introduced a series of policies and regulations for building energy-saving construction. However, there are still many shortcomings and deficiencies in these regulations [5]. Firstly, the regulations and systems are often not applicable to actual construction projects, and there is duplicity and conflict in the provisions, which leads to difficulties in the implementation. Secondly, some policies and regulations lack clarity, particularly regarding specific indicators for building energy conservation and energy consumption limits. Furthermore, the legal provisions for energy-saving design and construction are often weak, lacking enforceability and binding power. These provisions may also be superficial and one-sided, preventing effective implementation [6]. These factors are the primary reasons why building energy consumption cannot be effectively reduced.

4.2. Building energy-saving policies are unreasonable

The energy-saving construction of housing buildings is still in its early stages. As a result, the technical level, management capabilities, and innovative thinking in construction are lacking. Additionally, building energy-saving technology has not received enough attention in China, and its application often increases construction costs. For instance, when energy-saving measures exceed 30%, construction costs can rise by about 5%. Strictly following national energy-saving standards can significantly raise these costs, which owners and constructors might find hard to accept, thereby hindering the adoption of low-carbon energy-saving technologies. To address this issue, economic subsidies should be offered to encourage the use of these technologies in future projects.

5. Low-carbon energy-saving concept of building energy-saving construction technology application strategy

5.1. Improving laws and policies on energy-saving construction

China has provided considerable support for building energy efficiency through the introduction of various policies and regulations. However, these efforts lack strong guidance and enforceable, targeted regulations for effective constraint and management. This absence of mandatory and standardized system constraints in applying energy-saving construction technology makes it challenging to effectively address environmental pollution and energy wastage in building construction [7]. Therefore, the State should enhance the optimization of technical standards, laws, and regulations related to energy conservation in housing buildings. This includes strengthening the implementation of the legal framework and ensuring effective supervision and management of the construction process for building energy efficiency. The impact of building energy efficiency extends directly to the living environment and the future development of the country. Therefore, it is crucial to formulate systems from the perspective of national strategic objectives to raise societal awareness and attention towards energy-saving policies [8]. For instance, specific carbon exchange rates and energy consumption standards can be set for buildings of various volumes. These standards should be dynamically monitored for strict implementation, with severe disciplinary measures enforced if the specified values are exceeded. The penalties should be designed to ensure that they outweigh any illegal profits gained by the enterprise, thereby serving as a strong deterrent. In addition to financial penalties, there should also be penalties affecting the construction qualifications of the involved parties.

5.2. Employing building insulation technology

The application of thermal insulation technology plays a crucial role in promoting energy-saving practices.

This technology focuses on reducing heat conduction through building materials, thereby preventing indoor temperature loss to the outside environment. One of the most commonly used insulation materials for building walls is polystyrene board, known for its insulating properties. In the summer, it effectively blocks external heat from entering the room, ensuring indoor coolness. In cold winters, it prevents indoor heat from escaping outdoors, maintaining a comfortable indoor temperature. In addition to enhancing indoor comfort and reducing energy consumption for heating or cooling, polystyrene board insulation also helps prevent wall cracks and protects the structural integrity of the building.

In addition to installing thermal insulation layers, incorporating shading facilities is essential for effectively managing building temperatures and ensuring a balanced indoor environment. This approach not only enhances comfort for building occupants but also improves overall quality of life. Shading facilities play a crucial role in reducing energy loss during building operations and promoting the adoption of low-carbon energy-saving principles in construction. Thorough environmental surveys should be conducted before implementing sunshade construction technology. These surveys should include assessments of the building's surroundings such as geological structures and climate conditions. Continuous optimization of building construction plans is also crucial to ensure their rationality and effectiveness in achieving energy-saving and consumption-reduction goals.

5.3. Applying intelligent technology in construction

In the context of low-carbon and energy-saving principles, the construction industry must address the challenges posed by energy consumption and environmental pollution. A key focus is ensuring the healthy development of low-carbon, energy-efficient buildings, facilitated by intelligent control technology. Building energy-saving construction technology utilizes automated equipment and computer technology to monitor and manage various systems and equipment during construction. This includes implementing automatic power-off or load-reduction management modes. These measures effectively control energy consumption, promoting sustainability and reducing environmental impact [9]. Intelligent technology also allows the automatic adjustment of indoor temperature, humidity, and other parameters, which reduces energy consumption while ensuring the comfort of users.

In the context of intelligent energy-saving control systems for buildings, the central component is the intelligent control system, which manages aspects like ventilation and lighting within the building. This system allows for precise control tailored to different needs and conditions. For instance, many households in our country face issues with inefficient electricity consumption due to poor habits in daily electricity use. By deploying intelligent control systems integrated with the Internet of Things (IoT) and wireless communication technologies, facilities such as lights can be automatically switched off when rooms are unoccupied, effectively reducing electricity consumption. Moreover, automatic detection and sensors can monitor and evaluate energy consumption within rooms, proposing corresponding energy control strategies. Remote monitoring of energy control operations ensures efficient energy utilization. Utilizing advanced technologies is key to achieving energy-saving and environmentally friendly construction outcomes. For heating, methods such as underground water source absorption and solar energy conversion can significantly reduce reliance on high levels of electricity. Ultimately, it is crucial to dynamically adjust building energy and environmental settings to meet energy conservation and emission reduction standards effectively.

5.4. Creating a healthy indoor living environment

The application of building energy-saving construction technology can ensure a healthy indoor living

environment. The application of building energy-saving construction technology plays a critical role in ensuring a healthy indoor living environment. Quality control during construction is paramount, focusing on well-designed ventilation systems to promote optimal indoor air circulation and efficient removal of pollutants. Selecting environmentally friendly materials is crucial to minimize indoor pollutants such as formaldehyde. Addressing noise issues involves using double or triple-layered glass for doors and windows, along with implementing sound insulation and noise reduction devices in areas prone to noise. Maximizing natural lighting by strategically locating and sizing windows reduces reliance on artificial lighting, enhancing visual comfort and conserving energy. Installing effective heating and insulation facilities maintains stable indoor temperatures and humidity levels, reducing the need for heating and cooling systems. Thoughtful interior layout and space planning ensure that different areas meet ventilation and lighting requirements, catering to diverse needs such as leisure, learning, and entertainment, thereby fostering a comfortable and energy-efficient indoor environment.

5.5. Adopting green construction management

Green construction management is pivotal in the effective application of building energy-saving construction technology. During the project's design phase, it is essential to depart from traditional design concepts and prioritize energy-saving and environmental protection. This involves comprehensive consideration of energy-saving details early in the design process to optimize efficiency and avoid material waste during later stages. Site selection and planning should meticulously account for daily, climatic, and terrain characteristics to prevent issues like building shading. Maximizing natural light and ventilation while avoiding designs that hinder airflow direction is also critical. It is imperative to educate construction personnel in green construction practices, ensuring they understand and implement environmentally friendly concepts and technologies throughout construction. Environmental protection should be core to construction practices, maximizing resource efficiency and improving the overall quality of green buildings. Implementing environmental protection technologies, such as dust reduction measures through regular site watering and effective dust shielding, is crucial. Furthermore, enhancing the utilization efficiency of construction materials involves prioritizing low-carbon, low-energy, and recyclable materials to minimize waste and promote sustainability in building projects [10]. In addition to energy conservation, protecting water and land resources is crucial in construction practices. Building projects consume significant amounts of water, especially in concrete mixing and ongoing maintenance, necessitating stringent water resource management. Regular maintenance of water supply equipment is essential to prevent water loss from leaks caused by aging equipment. Effective land management involves strategic planning of construction spaces and environments to optimize material storage and functional area division, maximizing land resource utilization. External building design should prioritize reducing hard pavement and increasing green spaces to foster microclimate ecology and utilize natural resources like woodlands and water sources efficiently. Furthermore, enhancing the adoption of new energy sources and materials is essential. Utilizing natural energies such as solar and wind power in construction minimizes reliance on non-renewable energy sources, promoting sustainability and reducing environmental impact.

6. Conclusion

The application of building energy-saving construction technology within the framework of low-carbon energy efficiency contributes significantly to reducing carbon dioxide emissions and pollution associated with building construction. This approach also conserves non-renewable resources, protects the ecological environment, and fosters the sustainable development of both the construction industry and the environment. By integrating energy-saving and intelligent technologies, building energy-saving construction enhances living environments,

minimizes energy and resource consumption during construction, and promotes overall industry health and sustainability.

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Research on Adaptability Analysis of Environmental Space Demand and Design Optimization of Daycare Centers: Taking Chongqing's Community F as an Example

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Abstract: Currently, there is a lack of research on the detailed environmental spatial design of community daycare centers at the micro level. This study focuses on Community F in Chongqing, using the elderly's "willingness to demand" as a central aspect. It examines indoor and outdoor environmental space needs at a micro level, considering both functional requirements and spiritual needs based on existing research. The analysis incorporates three adaptive elements: current construction, surrounding environment, and operational management. It explores the feasibility of restructuring spatial layouts, utilizing local resources, and integrating Bayu cultural characteristics. Finally, through design optimization practices, the study proposes three strategies for aging optimization: functional integration and interaction, user-friendly facilities, and emotional connections to place.

Keywords: Daycare center; Environmental space; Willingness to demand; Design optimization

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1. Introduction

Aging has emerged as a significant and pressing challenge for China in the twenty-first century, presenting a new national situation and task. According to comprehensive data, China faces substantial demographic shifts: the population aged 60 and above exceeds 260 million, placing it among the world's largest elderly population. The proportion of elderly individuals requiring support approaches that of the fourth-largest country globally. The nation's aging rate stands at 18.70%, reflecting a 5.44% increase since 2010, indicative of rapid and deepening aging trends. Notably, over 50% of the elderly are empty-nesters, with figures surpassing 70% in major cities and rural areas, underscoring profound societal implications and challenges posed by aging demographics [1].

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shifts: the population aged 60 and above exceeds 260 million, placing it among the world's largest elderly population. The proportion of elderly individuals requiring support approaches that of the fourth-largest country globally. The nation's aging rate stands at 18.70%, reflecting a 5.44% increase since 2010, indicative of rapid and deepening aging trends. Notably, over 50% of the elderly are empty-nesters, with figures surpassing 70% in major cities and rural areas, underscoring profound societal implications and challenges posed by aging demographics.

The concept of community daycare centers has gained prominence in response to China's aging society, particularly in the years before and after 2000. Research on these centers has become a focal point, addressing various aspects such as performance evaluation [2], optimizing building space models [3,4], and drawing lessons from advanced experiences in developed regions [5,6]. Scholars have focused on defining service demands, facility types, and standards [7,8], as well as categorizing services to meet diverse needs [9,10]. However, there remains a notable gap in research concerning the micro-level design of indoor and outdoor environments and facilities directly used by elderly individuals. These aspects significantly impact their sense of well-being and accessibility, highlighting the need for more detailed exploration and design considerations at this level.

2. Research on the demand for daycare services among the elderly

2.1. Site selection analysis

Due to the current inadequacies in China's pension system and the significant gaps between community daycare center construction and relevant state ministry requirements, there are widespread issues such as insufficient total floor space and activity scale [11]. In this study, we focused on a district in the western region (with a per capita GDP 15% higher than the national average), highlighting that out of 80 communities (villages) within the development boundary, only one care center meets the basic standards. Given these challenges, the study emphasizes a micro-level approach, selecting research subjects that already meet basic national ministry requirements regarding site selection, scale, and other macro and meso-level criteria. This approach aims to explore how the environmental spaces of daycare centers can more accurately cater to the elderly's needs and optimize their design and transformation effectively.

Community F, situated in the core urban area of Chongqing, benefits from a mountain park to the east, convenient transportation links, and comprehensive urban amenities. It encompasses 11 neighborhoods with a population exceeding 22,000, including over 1,000 elderly residents aged 65 years and above, typical of mountainous communities in the region. The community daycare center is strategically located in the southeast corner, adjacent to the mountain park, offering a picturesque environment. Comprising two buildings, it spans approximately 750 square meters. The main building adopts a simple Bayu residential style, characterized by green tiles and white walls, with two floors above and below. The auxiliary building houses toilets and ancillary rooms. Following onsite visits and research, which included evaluations of social workshops, service rooms, day lounges, health guidance areas, art rooms for painting and calligraphy, vocal practice spaces, committee rooms, an activity hall, and a kitchen, it is evident that the care center's basic functions are relatively comprehensive and well-equipped.

2.2. Research on specific needs

The basic attributes of the elderly in Community F encompass nine key aspects: gender, age, education level (junior high school and above for over 76%), occupation before retirement (over 78% previously employed in roles like employees or in institutions), household composition (typically 2 elderly family members), retirement preference (close to 90% prefer aging at home or in the community), living arrangements (over 90% live with

their spouse or children), and utilization of daycare centers (56% utilize these services). Among those using daycare, over three-quarters reported feeling psychologically happier or physically healthier. This data reveals a community of elderly with a high cultural level, secure retirement finances, a strong preference for aging in familiar settings, and a significant demand for daycare services.

The analysis of demand and willingness among users of the daycare center in Community F is based on current utilization patterns and user feedback. Out of 120 elderly individuals studied, 67 were regular users of the center. Their primary reasons for using the facility included physical exercise, enriching their retirement life, and socializing with peers, with health care and public activities being the most frequented services, averaging over 45 visits. Home management services, psychological care, birthday celebrations, and access to organic food were utilized over 20 times. Meal assistance and daycare services were accessed more than 10 times. Regarding suggestions and demands, there was a recurring call for outdoor recreational and sports facilities, as well as spaces for outdoor social interactions, cultural enrichment, and improving indoor lighting. Additional requests included opening counseling services, installing indoor elevators and barrier-free stairways, creating storm corridors for safety, and establishing comprehensive geriatric file management systems, all highlighted more than 10 times by respondents.

The preferences of other family members should also be considered, particularly the adult children of the elderly. During the research involving guardianship groups and support networks for the elderly, there was a notable preference for daycare services, specifically during specific time periods to accommodate work schedules. Nearly 80% expressed willingness to pay between 300–600 yuan for these services. Additionally, feedback from these groups highlighted a strong desire for the establishment of a children's area within the daycare center. Overall, these findings align closely with the preferences identified among the elderly themselves, emphasizing the importance of catering to both generations' needs when planning and enhancing daycare facilities.

2.3. Summary of research

Based on the research and summary conducted above, it can be deduced that meeting the needs of the elderly involves both functional and spiritual aspects. Functionally, day care centers must cater to a wide range of activities for self-care elderly groups, including health care services, psychological counseling, advice on aging issues, and even childcare assistance. Additionally, facilities need to accommodate semi-self-care and disabled elderly groups, providing services like assisted living, daily care, and rehabilitative care. Spiritually, the centers should fulfill the elderly's desire for social integration, allowing them to both observe and be observed within their community. Cultural enrichment is also crucial, providing opportunities for intellectual stimulation and the preservation of personal memories. Furthermore, fostering self-realization and personal growth among the elderly is essential.

3. Adaptive analysis of environmental space needs

3.1. Key elements of adaptability analysis

3.1.1. Current conditions

The current conditions of Community Daycare Center F include two separate buildings with a frame structure connected by corridors. Each building features small, independent single rooms that serve specific functions but are not interconnected. The height difference between activity areas is minimal, and the plots are square-shaped. However, the center lacks a cohesive indoor and outdoor cultural atmosphere and does not evoke a strong sense of place memory or spiritual elements.

3.1.2. Surrounding environment

The surrounding environment of Community F Daycare Center encompasses various factors such as land conditions, transportation accessibility, commercial presence, and topographical features that influence the design of its indoor and outdoor spaces. Through research, it's observed that the center is situated east and north of a mountain park, where significant height differences exist. However, the interaction between the building and activity areas with the park is limited. To the west, the center interfaces with a community service center, allowing for some functional interaction. On the south side, there are terrace fortresses and residential areas, which do not significantly obstruct overall lighting and ventilation for the center. These environmental considerations play a crucial role in shaping the design and functionality of Community F Daycare Center.

3.1.3. Operation and management

The operation and management of Community F Daycare Center encompass several aspects including the range of services offered, service projects, activity organization, operating hours, operational mode, and associated costs. Currently, the center employs four staff members dedicated to medical rehabilitation services and another four for management and other services. Services are predominantly provided in a public mode, with no centralized or unified charging system in place. Only certain services incur charges, such as assistance for the elderly, psychological counseling, and massage. Additionally, there are non-revenue-generating services like nursing and bathing, as well as paid services such as home delivery and hourly wage earners.

3.2. Main conclusions of the adaptability analysis

3.2.1. Flexible spatial layout

Firstly, the frame structure of the care center building offers flexibility to redesign the interior layout, moving away from small independent rooms connected by corridors. This allows for better integration between spaces and facilitates the creation of vertical circulation elements between the two buildings. Secondly, the flat and square outdoor activity space provides an ideal layout for zoning and facilitating movement, catering to the diverse needs and groupings of elderly activities. Lastly, by treating indoor and outdoor environmental spaces and functions as an integrated whole, enhancements to the building's exterior can create a more inviting and comfortable environment. This approach includes renovating the building's appearance and reconfiguring indoor and outdoor functionalities to foster seamless integration between the interior and exterior spaces.

3.2.2. Potential of exploring the surrounding environment

Due to the steep terrain of the mountain park and the care center, which are both integral parts of the community and significant public spaces, addressing this barrier involves micro-remodeling the terrain. This could include adding health ramps and introducing vertical transportation methods to integrate the three-dimensional landscape and leisure functions of the mountain park into the care center. This approach aims to expand the range of activities available to the elderly and enrich the functional offerings of the care center. Additionally, functions like the cultural library within the community service center can also be integrated into the activities offered by the care center.

3.2.3. Bayu characteristic scene imprints

Incorporating the concept of "improving cultural quality" into the deep investigation and interviews revealed that users of the Community F Daycare Center generally have higher education levels and a background in rural or urban life. Many have clear memories of traditional Bayu life, which aligns with the center's simple Bayu residential style. Therefore, during the process of reshaping and further integrating with the surrounding area,

efforts are being made to incorporate Bayu vernacular symbols. This approach aims to evoke emotional resonance among users by tapping into their cultural memories and enhancing the overall cultural identity of the care center.

4. Indoor and outdoor environment space optimization design research

4.1. Functional integration and interaction

4.1.1. Indoor and outdoor functional interaction

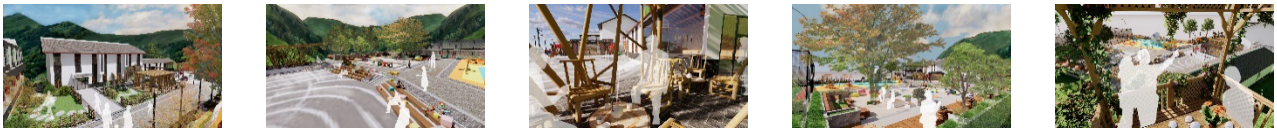
In this design approach, two integrated functional rings are constructed to break the traditional separation between indoor space and outdoor landscape: The first functional ring includes an outdoor entrance area → first-floor reception and counseling area for the elderly → first-floor calligraphy and activity areas → first-floor dining and tea rooms → outdoor recreation, sports, performance, and music areas → outdoor entrance area. The second functional ring features the first-floor reception and counseling area for the elderly → second-floor medical care and nursing service area → care and living area → mountain park or outdoor leisure spaces → outdoor sunshine leisure area (or outdoor entrance area). This layout aims to enhance interaction between internal and external environments, facilitating a holistic and enriched experience for users of the community daycare center (**Figures 1–3**).

4.1.2. Interaction between functional areas

In this optimization design process, the interior design employs the strategy of "zero to whole" and reduces boundary treatments to create a spacious and permeable layout conducive to group activities for the elderly. Meanwhile, the landscape design breaks away from traditional square zoning methods on the square plot. Instead of compartmentalizing, it centers around an outdoor performance area and integrates peripheral functions like music, sports, and leisure, fostering a dynamic environment that encourages interaction and participation, enhancing the overall sense of community.

4.1.3. Interaction within the functional area

Whether indoors or outdoors, the activity areas designed for self-care elderly groups are expanded to include spaces for children's participation and enjoyment. For instance, the indoor calligraphy area and activity room on the first floor are equipped with children's picture books and other interactive features. Outdoors, the sunshine recreation area, sports area, and performance area incorporate amenities such as sandboxes, colorful playgrounds, graffiti walls, and children's slides. These additions enable elderly groups to comfortably care for their grandchildren while enhancing their own quality of life.



(a) Building entrance (b) Performance Plaza Grandstand (c) Afternoon tea at the Wind and Rain Lounge (d) Yellow Oak Tree Storytelling Club (e) Mountain Park Pavilion

Figure 1. Functional index and traffic flow organization of Chongqing Community F Daycare Center



(a) Function room (b) Cafeteria (c) Calligraphy room (d) Daycare center (e) Living room

Figure 2. Nodal design of the landscape environment of Chongqing Community F Daycare Center

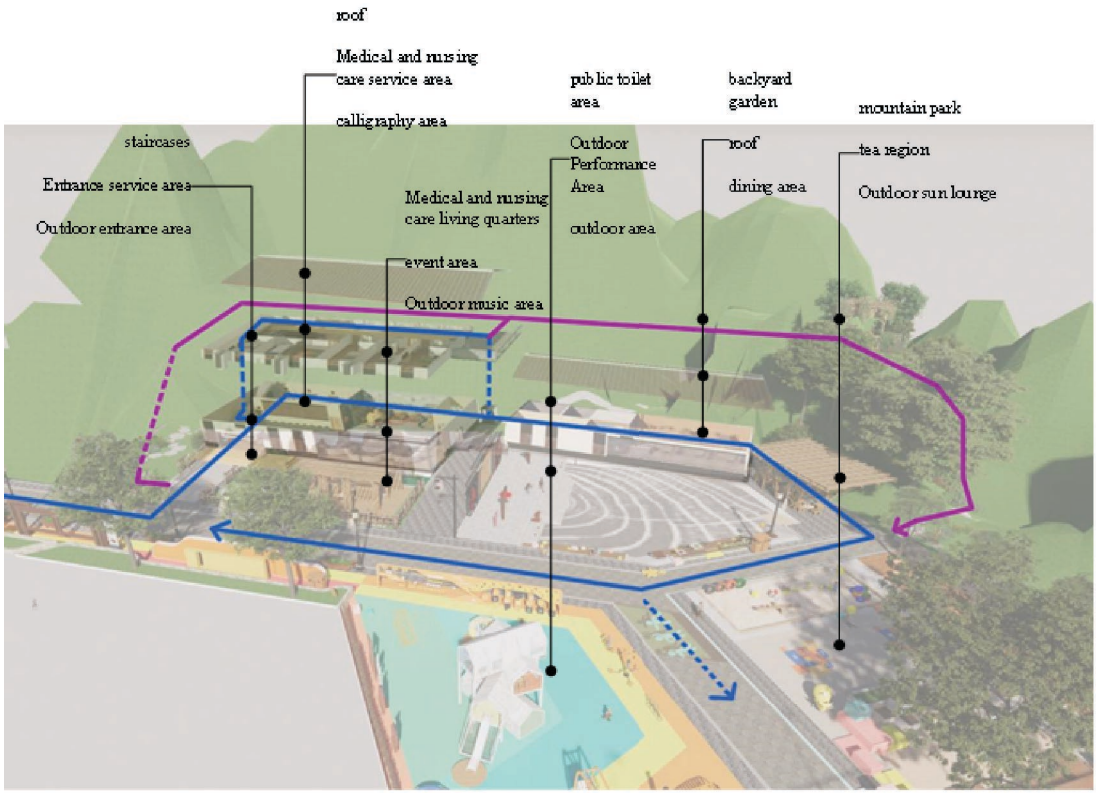


Figure 3. Nodal design of the indoor environment of Chongqing Community F Daycare Center

4.2. Facility-friendly assistance

4.2.1. Transportation facilities

The new wind and rain corridors between the two buildings introduce vertical elevators to create semi-outdoor platform connections, facilitating elderly groups requiring assistance to navigate stairs, deliver meals to the restaurant, and access the mountain park. Traditional slope stair handrails are replaced with “L” stacked handrails for easier movement and handling of goods by the elderly. Multiple barrier-free access routes are established to enhance transportation links between indoor and outdoor areas. Age-friendly transportation facilities further strengthen connectivity between people and various spaces, promoting efficient use of space and enhancing overall accessibility.

4.2.2. Shared facilities to assist movement

Based on the construction of two functional interaction rings, along with the shared functional areas, numerous shared facilities are incorporated to enhance the diversified use of space. The outdoor activity stage serves as both a space for elderly activities and a key venue for other community events. The shared kitchen island functions not only as a daily culinary hub but also as a participatory space for the elderly. The activity room podium accommodates children’s picture books while also hosting health lectures and skill workshops for the elderly. Additionally, the platforms within the mountain park, designed as vegetable gardens, serve as both aesthetic landscape features and tangible reflections of labor processes.

4.2.3. Other facilities

Based on the construction of two functional interaction rings, along with the shared functional areas, numerous shared facilities are incorporated to enhance the diversified use of space. The outdoor activity stage serves

as both a space for elderly activities and a key venue for other community events. The shared kitchen island functions not only as a daily culinary hub but also as a participatory space for the elderly. The activity room podium accommodates children's picture books while also hosting health lectures and skill workshops for the elderly. Additionally, the platforms within the mountain park, designed as vegetable gardens, serve as both aesthetic landscape features and tangible reflections of labor processes.

4.3. Place emotional touch

4.3.1. Implanting Bayu small micro-life elements

By integrating Bayu's traditional bamboo weaving tables and chairs, wooden furniture, ceramic vessels, traditional farming tools, seasonal paving, hanging local agricultural products, and warm yellow herringbone slope roofs into indoor and outdoor furnishings, landscape paving, and decorative structures, traditional elements are harmoniously fused with modern design. This integration aims to enhance the spatial texture and warmth while showcasing the charm and historical heritage of Bayu's traditional way of life.

4.3.2. Reproducing the lifestyle scene of Bayu

Through modern design methods and an open, integrated spatial layout, the project not only meets the requirements of modern living environments but also recreates scenes of small-scale Bayu life. Examples include storytelling under the yellow oak tree and afternoon tea in the wind and rain corridors, which facilitate post-dinner discussions and family interactions. The micro vegetable garden in the mountainous area and countryside canteen evoke memories of rural labor and life. Furthermore, the performance plaza hosts traditional folk performances such as Sichuan Opera Face Changing and Bayu Dance, blending traditional and modern spatial elements seamlessly.

4.3.3. Utilizing Bayu materials and plants

In the process of interior decoration and landscape construction, environmentally friendly, renewable, lightweight, and flexible local bamboo and wood materials are incorporated, and the building and landscape paving is mostly made of earth and stone, green bricks, and grey tiles, which have unique colors and textures, making the space appear rustic and elegant. In terms of the use of native plants, the outdoor recreation area is planted with yellow rafter trees alone, and the intersection with the mountain park adopts column planting of bamboo, ivy, etc. as vertical greening in order to offset the sense of steepness of the mountainous terrain, and the other areas are combined with the needs of the landscape, with tea trees, osmanthus, azalea, etc., to ensure that the space is aesthetically pleasing and practical.

5. Conclusion

This study focuses on exploring the willingness to use the care center as a starting point, particularly examining the adaptability of indoor and outdoor environmental spaces at a micro level. Through an analysis of adaptability, the research emphasizes optimizing design practices in three key areas: functional integration, user-friendly facilities, and spaces that evoke emotional responses. The goal is to enhance the environmental quality of community day care centers, ensuring they better cater to the needs of elderly groups. This research aims to provide valuable insights for enhancing environmental space quality in community day care centers and effectively meeting the needs of elderly users.

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Strategies for Applying LED Lights in Night Space Lighting for Bridges

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Abstract: LED lights have been widely used in urban night space lighting in recent years as they are small, energy-saving, and efficient. This article explores the use of LEDs in bridge night space lighting and their application strategies. The aim is to offer valuable insights and references for urban planners and bridge lighting designers in China. By advancing the application of LED technology in bridge night lighting, the goal is to enhance the city's nighttime ambiance, making the bridge an iconic landmark and a defining feature of the city.

Keywords: Bridge night space lighting; LED application; Color band and gradient; Artistic value

Online publication: July 11, 2024

1. Introduction

Bridges are a crucial aspect of modern urban construction. Urban overpasses, river-crossing bridges, and footbridges often serve as regional landmarks and play a significant role in urban landscape planning. The distinctive night lighting design of these bridges showcases a city's unique style to both residents and tourists. LED lighting is commonly used in modern bridge designs for night illumination. Designers frequently incorporate LEDs as a key element in bridge decoration, leveraging their characteristic lighting effects to create visually pleasing and impactful designs for nighttime bridge lighting.

2. Characteristics of bridge night lighting project

(1) Significance of bridge night lighting

Bridge night lighting plays a crucial role in urban construction and development. Firstly, the night view of a bridge can enhance the city's nighttime landscape, maintaining its vitality after dark and providing rich visual effects that significantly boost the city's appeal. Secondly, a well-crafted lighting design can highlight the structural aesthetics of a bridge, enhancing the urban space's artistic ambiance. This not only elevates the city's image and sophistication but also positively impacts the quality of life for its residents. Thirdly, bridge night lighting design

can help convey cultural information. Through innovative lighting technology and design, bridges can be imbued with symbolic meanings that reflect the city's history, culture, technological advancements, or future aspirations. The deeper meanings and narratives expressed through lighting can transform a bridge from a mere functional structure into a symbolic representation of the city's identity and spirit.

(2) Characteristics of bridge night lighting project

Each bridge's structure, length, shape, and location are distinct, necessitating differentiated lighting strategies tailored to these characteristics, creating a unique visual effect for each bridge. Secondly, the interactivity of light and the environment is crucial. Bridge nightscape lighting must harmonize with the bridge's architectural aesthetics while considering the surrounding environment's impact. During the design phase, factors such as light pollution control, reflections on water, and the interplay between light and nearby buildings are typically addressed. Thirdly, advanced lighting technology has expanded artistic possibilities in bridge night lighting. Modern technologies, particularly LED light sources, offer advantages such as long life, energy efficiency, environmental friendliness, and full-color range. Intelligent lighting systems can adaptively adjust the bridge lighting based on environmental conditions and events, enhancing both the lighting effect and user experience. Fourthly, public safety is a significant consideration in bridge night lighting projects. Designers must ensure that the lighting setup does not impair visibility while providing sufficient illumination to create a safe and visually pleasing environment. Lastly, bridge night lighting plays a role in cultural dissemination. Beyond their transportation function, many bridges also serve as historical and cultural landmarks. A thoughtfully designed lighting scheme can highlight these cultural characteristics, making the bridge a focal point in the urban nightscape and effectively showcasing the city's image and character.

3. Bridge night lighting requirements

(1) Night scenery and functional lighting coordination

Bridge night lighting, as a crucial element of urban art lighting systems, must prioritize functionality in people's lives. This type of lighting needs to create an elegant and captivating nighttime effect while ensuring the safety of pedestrians and vehicles through synergistic functional lighting. Designers must carefully calibrate lighting intensity, illuminance, and evenness in the nightscape lighting design. Additionally, they must consider factors such as light color temperature, color vividness, and visual comfort to ensure that the lighting harmonizes seamlessly with the surrounding night scene.

(2) Integration and coordination of night scene lighting and environment

Bridge night lighting design must fully consider the surrounding environment. First, the lighting program should account for environmental influences on the light source, including recommended lighting styles for the area, the bridge's location, and both soft environmental factors (like vegetation and nearby water bodies) and hard environmental factors (such as weather and seasonal changes). Additionally, during the design stage, it is crucial to ensure visual unity with the surrounding buildings and environment. This coherence and consistency helps create a more natural and harmonious visual effect.

(3) Set the installation position of the lamp reasonably

The positioning of lamps is crucial for achieving the desired light and shadow effects and overall visual impact. During the design phase of a bridge night scene lighting project, the installation positions of the lamps should be carefully determined based on the bridge's structure and shape and the angles and ranges of illumination. The placement of the lamps directly influences the effectiveness and safety of the night lighting. Therefore, the design phase must also consider future maintenance and management of the lighting, ensuring that replacing lamps and performing maintenance tasks are convenient and efficient.

(4) Artistic design needs

A bridge night lighting project serves as a canvas for urban nightscape art, making it essential to emphasize artistic design needs. The design should adhere to the principle of "less is more," ensuring each light source achieves optimal display through skillful lighting techniques. Designers should prioritize the color and emotional impact of light, fully leveraging the expressive power of light and shadow. This approach allows the creation of thematic styles that evoke a festive atmosphere, a sense of history, technological innovation, or artistic flair, aligning with the bridge's design. Ultimately, the goal is to satisfy people's emotional responses and aesthetic pursuits [1].

4. Application of LED in bridge night scene lighting

(1) Highlighting the outline of the bridge with LED

In bridge night lighting design, LED lamps, known for their compact size, durability, energy efficiency, and controllable color temperature, color, and brightness, can effectively highlight a bridge's outline when properly arranged.

In the process of applying LED lighting for bridge night illumination, designers first conduct a detailed analysis of the bridge's structure and characteristics to establish clear lighting objectives. During the implementation phase, they deepen their understanding of the bridge's architectural design by studying drawings and conducting on-site assessments to grasp the surrounding environment and landscape. The primary goal is to emphasize the bridge's outline using LED technology, creating a vibrant and layered night scene. In designing the LED lighting program, designers use their understanding of the bridge to plan the placement of LED lamps, considering factors like installation positions, quantities, types, power ratings, color temperatures, and brightness levels. They also carefully design the angles and directions of illumination to ensure comprehensive coverage and a cohesive lighting effect across the bridge's floor and piers [2]. This plan undergoes optimization and implementation phases, including model testing, computer simulations, and meticulous lamp selection and procurement based on design outcomes. Following installation, the overall lighting system undergoes thorough debugging according to a predefined schedule. Finally, a comprehensive LED lighting control program is developed to ensure the lighting not only delivers high-quality visual effects but also prioritizes energy efficiency, environmental sustainability, and the protection of structures and surroundings. Adjustments in the brightness and color of LED lamps are made based on local weather conditions, traffic patterns, and time considerations, thereby optimizing the lighting's performance effectively [3].

(2) Highlighting gradient effect with LED

In bridge night lighting design, a common and effective technique involves using LEDs to highlight rich color bands and create gradient effects. This approach is widely adopted in contemporary bridge lighting design because it imbues bridges with distinctive artistic characteristics and enhances their recognizability [4].

To achieve the desired effect in bridge night lighting design, designers must possess a thorough understanding of the bridge's structural characteristics and its surroundings. This includes parameters such as shape, structure, direction, height, length, and their visual relationships with the environment. Using this data, designers can plan the overall arrangement of light bands and gradient effects, specifying details such as LED color configurations, the length and positioning of light bands, and the range and transition rate of gradients. During the design phase, particular attention should be paid to the visual impact and artistic expression of the color bands and gradients. Implementing these elements requires designers to apply artistic aesthetics and innovative thinking while deeply understanding LED characteristics. The ribbon and gradient effects should harmonize with the bridge's form and structure, creating a visually pleasing relationship with the surrounding

environment and enhancing the bridge's nocturnal appeal in the urban landscape. Furthermore, designers must optimize LED lamp selection, considering factors such as color temperature, color rendition, brightness, and angle to precisely achieve the intended color bands and gradient effects. This comprehensive approach ensures that the bridge lighting design not only meets aesthetic goals but also integrates seamlessly with its architectural and environmental context [5]. In addition to considering the aesthetic aspects, the layout of lamps in bridge lighting design should align with the bridge's shape while carefully managing sightlines and irradiation angles to minimize visual disturbance and light pollution for pedestrians and vehicles. Moreover, for LED lamps installed on bridges, an intelligent control system is essential. This system enables dynamic gradient effects by independently controlling each light. While ensuring basic functional lighting, the control system automatically adjusts parameters such as light color, brightness, gradient speed, and strobe frequency based on preset schemes. This approach ensures the bridge achieves a rich and gradual color band effect in its night lighting.

For instance, the Jacques Cartier Bridge in Montreal serves as a prime example of effective lighting design. As a prominent landmark in the city, the bridge utilizes LEDs to create captivating color bands and gradual transitions, as illustrated in **Figures 1 & 2**.



Figure 1. LED design of Jacques Cartier Bridge 1



Figure 2. LED design of Jacques Cartier Bridge 2

As shown in **Figures 1 & 2**, the Jacques Cartier Bridge employs LED light sources in the form of lines spanning the entire bridge. Whether viewed from a distance or up close on the bridge itself, one experiences the striking and gradual beauty of the color bands across the Jacques Cartier Bridge. The slow, rhythmic transition of the nighttime illumination resembles the natural pace of breathing, creating a highly harmonious and perfectly integrated contrast with the surrounding environment, sky, and water [6].

(3) Highlighting the artistic value and significance with LED

Bridges serve as vital connectors in physical space, transcending geographical boundaries and linking urban areas. Through flexible and creative LED lighting design, bridges can acquire significant artistic and even existential value [7]. In the design of bridge nightscape lighting, emphasis is placed on artistic expression, considering every element including structure, shape, and color. LED lamp selection, tailored to these characteristics, aims to reveal the bridge's design details and create a distinctive visual experience that enhances its artistic depth. Furthermore, at the design stage, integrating the bridge's symbolic role in human life adds profound meaning. Serving as a metaphorical journey from one stage to another, bridges symbolize life's transformative essence. LED lighting can symbolically represent this journey, imbuing night lighting designs with deep symbolism and emotional resonance [8]. For instance, the Double Helix Bridge in Singapore exemplifies this approach, where LED lamps simulate the dynamic flow of a DNA double helix structure in the night scene, as illustrated in **Figures 3 & 4**.



Figure 3. Singapore's Double Helix Bridge 1



Figure 4. Singapore's Double Helix Bridge 2

(4) Creating landmark buildings with LED

In recent years, nighttime lighting design for landmark buildings has become increasingly crucial in urban lighting design, with LED light sources emerging as the preferred choice due to their numerous advantages [9]. In designing nighttime lighting for landmark buildings like bridges, designers focus on enhancing the structural characteristics through precise light control and directional lighting, ensuring the texture of surface materials is fully highlighted. Emphasizing the contrast between light and shadow accentuates the bridge's lines and streamlined forms, creating a powerful visual impact at night. Dynamic changes in LED colors and brightness adjustments are utilized to create flowing light and shadow effects, enriching the spatial perception and evoking the profound beauty of the bridge. For example, the Binhe Yellow River Bridge exemplifies this approach by employing LED design concepts that span from macro to micro, emphasizing the overall bridge outline for enhanced nighttime recognition. Additionally, targeted local lighting highlights architectural details, as illustrated in **Figure 5**.



Figure 5. Binhe Yellow River Bridge

In the design of the Binhe Yellow River Bridge, the designer maximizes the versatility of LED lights, utilizing their dimmable capabilities to create vibrant color changes that produce a visually dynamic effect. Moreover, through the implementation of an intelligent control system, remote operation, and preset scene switching are achieved, enhancing the usability and flexibility of the lighting setup. This strategic approach to LED night lighting design has transformed the Binhe Yellow River Bridge into a stunning nocturnal landscape, resembling

a ship navigating the Yellow River. It now stands as a dynamic and historically resonant landmark, uniquely identifying the city and significantly boosting the image and influence of the Ningxia Hui Autonomous Region [10].

5. Conclusion

The thoughtful use of LED lamps in bridge night lighting can enhance both the visual impact and cultural significance of bridges. This approach not only fulfills the practical lighting requirements of bridge structures but also plays a crucial role in promoting urban branding efforts. By employing LED technology effectively, designers can achieve unique visual effects and convey cultural meanings through bridge night lighting. This not only enhances the aesthetic appeal of bridges but also contributes to their broader societal and historical significance. Drawing on the strategies outlined in this paper, which emphasize the application of LED lamps to highlight rich ribbon and gradient effects, accentuate artistic and existential values, and leverage LED technology's potential in bridge night lighting, can significantly enhance urban imagery and foster sustainable development within the bridge engineering industry and urban planning and design sectors.

Disclosure statement

The authors declare no conflict of interest.

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Key Points and Difficulties in the Management of a New Guangzhou 12th People's Hospital Branch

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Abstract: During the 13th Five-Year Plan period, to improve medical and health services, the Guangzhou Municipal government invested billions in medical construction. During that time, Guangzhou was renewing its approval procedures for construction projects, and the COVID-19 outbreak changed the requirements of hospital construction. In addition to focusing more on spatial planning and layout, the integration of specialized departments, large-scale medical equipment, and numerous intelligent systems increased the complexity of hospital construction projects. The success of these projects often hinges on the quality of the management team. If a hospital construction project manager lacks experience and an understanding of the project's key aspects, they may struggle with organization, management, and problem-solving, leading to rework, resource waste, and delays. This paper uses the construction of a new Guangzhou 12th People's Hospital branch as an example to describe the key points and difficulties in each stage of project construction and proposes solutions for the management of similar projects in the future.

Keywords: Hospital construction project; Project management; Management essentials

Online publication: July 11, 2024

1. Introduction

In recent years, amid efforts to expand high-quality medical resources and achieve a balanced regional layout, hospitals nationwide have embarked on construction projects of varying scales. This period has seen an increase in new branches, the demolition and reconstruction of original sites, as well as maintenance and renovation of existing facilities. During the hospital construction and management process, a trend towards grouping, scientific research, intelligence, and comprehensive development has become apparent. This trend has increased the complexity of hospital construction, leading to more frequent issues such as project delays, rework, and budget overruns. The relocation project of Guangzhou 12th People's Hospital exemplifies the challenges in building quality medical resources in Guangzhou. By examining this project, common problems encountered in hospital construction project management can be identified from the perspective of a construction manager. This research proposes management solutions to address these issues and aims to summarize the management experience across all phases of a new hospital construction project, including the preliminary stage, design, construction, and completion acceptance stages.

2. Project pre-planning stage

The 12th People's Hospital of Guangzhou is a tertiary general hospital that offers comprehensive medical treatment, education, scientific research, and occupational disease prevention. The new project (**Figure 1**) was originally located in the second Central Business District of Guangzhou. However, due to conflicting development objectives with the district and Huangpu Harbor Economic Zone, the location was shifted to the Nangang plot, west of the Guangzhou International Toys and Gifts Centre and north of the Guangzhou-Shenzhen-Yanjiang Expressway. This new site lacks other tertiary hospitals and has an increasing population, necessitating adjustments in the design positioning and service coverage. Compared to the original site approval, the construction scale has increased by 24,192 m², and the green building certification has been upgraded from one star to two stars according to the latest "Green Building" review requirements. The adjusted project plans for a total of 800 beds and a construction area of approximately 141,210 m². This includes 88,290 m² for the general hospital, 7,700 m² for the occupational disease prevention business room, 2,500 m² for the overhead floor, and 42,720 m² for the underground garage. The project is divided into two phases. The first phase covers a land area of 55,144 m², and the second phase covers about 48,374 m². The first phase includes a total construction area of about 123,650 m², with 77,990 m² above ground and 45,660 m² underground (including the underground garage and some general hospital functional rooms). The construction scope includes an outpatient building, medical technology building, inpatient building, comprehensive building, hyperbaric oxygen chamber, logistics building, guard room, oxygen storage tank area, basement, road square, greening, and other outdoor supporting projects. The total investment for the first phase is estimated to be 108.549 billion yuan, which is about 36.304 billion yuan more than the original project.



Figure 1. The new 12th People's Hospital of Guangzhou branch

2.1. Emphasizing early-stage communication and research among relevant departments and construction personnel

A tertiary general hospital typically consists of at least 30–40 departments [1], each led by a different director and staffed with various doctors, technicians, nurses, and other personnel. The design needs of each department require input from multiple positions within the general department, and these requirements can change over time, resulting in a significant communication workload. Consequently, the preliminary planning and design phase for hospital construction often takes longer than for other types of construction projects. From inception to completion, a hospital construction project generally spans 4–8 years. This timeline includes 1–3 years for

pre-consultation, planning, and design approval stages (such as land acquisition, demolition, and relocation), 3–4 years for the construction and implementation phase, and 6 months to 1 year for equipment commissioning. The longer the duration, the higher the likelihood that construction costs will exceed the initial investment.

The new project of Guangzhou 12th People's Hospital (referred to as the new 12th Hospital) was approved at the beginning of 2015. The modification, planning, and design phases occurred from 2017 to 2020, with formal construction starting in September 2020 and completion by the end of 2023. The project spanned eight years. Due to a lack of early-stage communication between the hospital and government departments in the site selection area, an adjustment in site selection was necessary after one-third of the preliminary design work had been completed. This led to wasted financial resources and a five-year delay in construction. The preliminary survey had to be redone, and opinions from various departments had to be reconsidered, leading to further complications. Additionally, the project faced rising costs for building materials and labor, necessitating extensive budget adjustments and increased investment. During the COVID-19 pandemic, construction frequently halted to comply with epidemic prevention policies, and the workforce could not be significantly increased. In the later stages of the pandemic, municipal financial investment funds became tight, and the project relied on bond issuance for three consecutive years to maintain construction funding.

2.2. Significance of zone planning

The planning of hospital construction should incorporate insights and input from a wide range of stakeholders, including nurses, doctors, administrative staff, patients, and individuals with relevant experience in hospital construction. This inclusive approach ensures that the flow lines for indoor and outdoor traffic, as well as regional flow planning, accurately reflect the needs and perspectives of those who will use the hospital daily. The success or failure of hospital construction often hinges on comprehensive planning that considers not only the functional distribution of buildings and entrance/exit design but also transportation planning.

The most significant disruption to the flow of people in a hospital occurs due to the interaction between the queues in the registration, payment, and medicine collection areas and the flow of patients in the outpatient building. The peak periods for hospital foot traffic are from 8:00–10:00 a.m. and 2:00–3:30 p.m. [2]. To mitigate these disruptions, a vertical elevator is situated on the external wall of the outpatient building in the planning and design. This would allow individuals who do not need to register or pay fees to bypass the internal queues and directly access the floors from the outside of the building. Additionally, situating the registration and charging areas in zones connected to the external entrance of the outpatient building can minimize interference with the registration fee queue. Separating the medicine collection queue into a more independent space can further reduce mutual interference In the design of the new 12th Hospital, the layout of the single-hall foyer in the outpatient building separates the registration fee area from the medicine collection area. However, the elevator is positioned far from the outpatient entrance, which is not conducive to efficiently directing individuals who do not need to register directly to their appointments. The first-floor plan of the hospital building is shown in **Figure 2**.

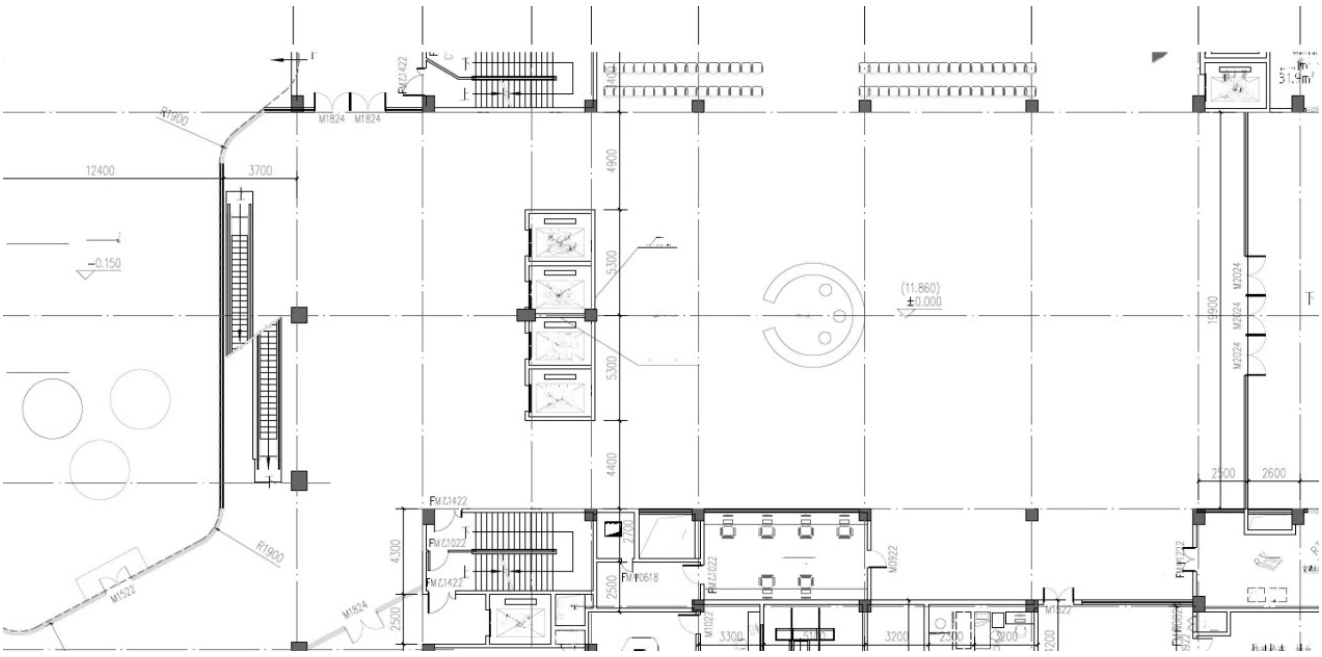


Figure 2. First-floor plan of the hospital building

In addition, the impact of the planning of special departments and functional rooms cannot be ignored. As medical technology advances, the number of specialized departments in hospitals is increasing, and these departments often have unique spatial planning requirements. For example, the nuclear medicine department should not be located adjacent to obstetrics, pediatrics, dining halls, or other departments and densely populated areas. Instead, it should be housed in a separate building within the medical institution to ensure safety and compliance with specific regulatory standards [3]. The nuclear medicine department of the new 12th Hospital is strategically designed on the underground floor of the medical technology building. It includes a clear boundary separation between the treatment area and the diagnostic area. One-way doors with controlled access and lock permissions are implemented at the entrances and exits of these zones and the control area. This setup ensures independent pathways for staff, patients, radiopharmaceuticals, and radioactive waste, reducing interference (**Figure 3**). The ward's ventilation system will be equipped with differential pressure controls, and the air outlets in the department's workplace will be positioned as far away from surrounding high-rise buildings as possible. A sanitary passage room will be designed at the exit of the dispensing and drug delivery rooms for pollution detection. The diagnostic and treatment workplaces in the "supervision area" will include auxiliary rooms such as cleaning supplies storage, staff rest rooms, a nurse station, locker rooms, toilets, and decontamination shower rooms [4].

Four nuclear medicine treatment wards are designed to accommodate up to 4 patients per week, adhering to environmental protection standards. The facility includes two slag pools, one of which is operational, alongside a buried 3-stage parallel decay pool. The combined effective volume of these pools is approximately 60 m^3 each, totaling 180 m^3. These pools are dedicated to collecting and treating radioactive sewage generated from the facility. Radioactive wastewater primarily consists of diagnostic and treatment patient residues following drug injections and daily cleaning operations. This wastewater is channeled into the decay pool through a designated collection pipe for radioactive waste. Liquid pollutants undergo decay within the pool until they meet discharge requirements. Subsequently, they are directed to the hospital's sewage treatment center and eventually discharged into the municipal pipe network. This process ensures compliance with regulatory standards for the safe disposal of radioactive materials and wastewater.

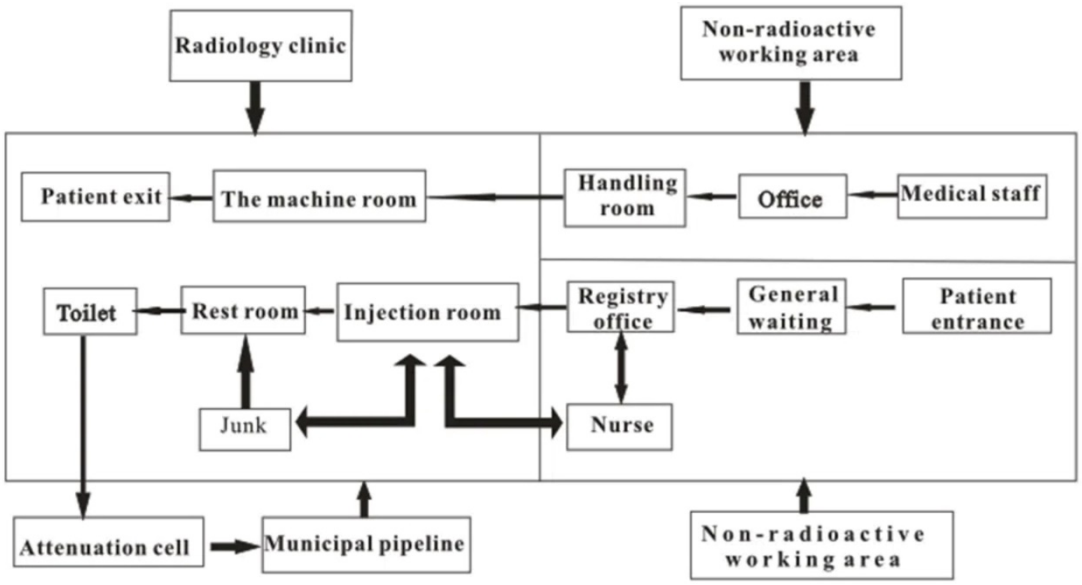


Figure 3. Functional distribution diagram of the nuclear medicine department

3. Design management phase

3.1. Impact of detailed design drawings and construction personnel on hospital construction

Hospital construction projects represent a convergence of expertise from highly skilled technicians. Given their lengthy construction periods, it is crucial to maintain a stable core team. Frequent turnover in management personnel leads to loss of experience, detrimentally impacting both quality and cost control. In the realm of hospital architectural design, domestic firms specializing in this field are relatively small. Designers often lack robust expertise in medical specialty technologies, research on hospital construction functional requirements, medical processes, new materials, and equipment. Additionally, tight deadlines imposed by general contractors on design firms result in shallow drawings, which subsequently lead to design errors and omissions. To mitigate these challenges, project managers with relevant experience should provide adequate time for designers to identify and rectify design issues promptly. This approach significantly reduces management errors. Hospital construction management, overseen by the hospital president and contractors, involves long-term coordination with the project management team. Successful project completion hinges on the project manager's adept gathering of opinions, balancing contractor interests, and resolving team conflicts. For complex construction decisions and technological challenges, timely expert meetings and research investigations are essential for effective problem-solving.

3.2. Utilizing building information modeling (BIM) technology in design adjustment during the pre-construction stage

Effective control of design adjustments is crucial for ensuring project schedule adherence and cost control in hospital construction projects. Therefore, proactive pre-control of design changes should commence as early as the preliminary design stage. Several common types of changes encountered in hospital construction include (1) adjustment of utilization requirements, (2) changes in functional area layouts, (3) alterations in pipe direction and positioning, (4) modifications to accommodate on-site equipment installations, (5) revisions or

replacements of design drawings, and (6) changes in construction processes, among others. The implementation of BIM technology plays a pivotal role in detecting and consulting these changes in advance [5]. For example, BIM technology is utilized in the new 12th Hospital project to calculate earthwork balance and external transport distances, as well as to perform comprehensive pipeline balance and collision detection on the facade and interior, as depicted in **Figure 4**. Three-dimensional modeling and internal virtual tours enabled hospital departments to gain a sensory understanding of the design's effects during the preliminary design stage, facilitating early identification of potential issues and allowing for modification suggestions to reduce the need for design changes later on. This proactive use of BIM enhances communication among stakeholders, improves design accuracy, and ultimately supports efficient project execution in hospital construction.

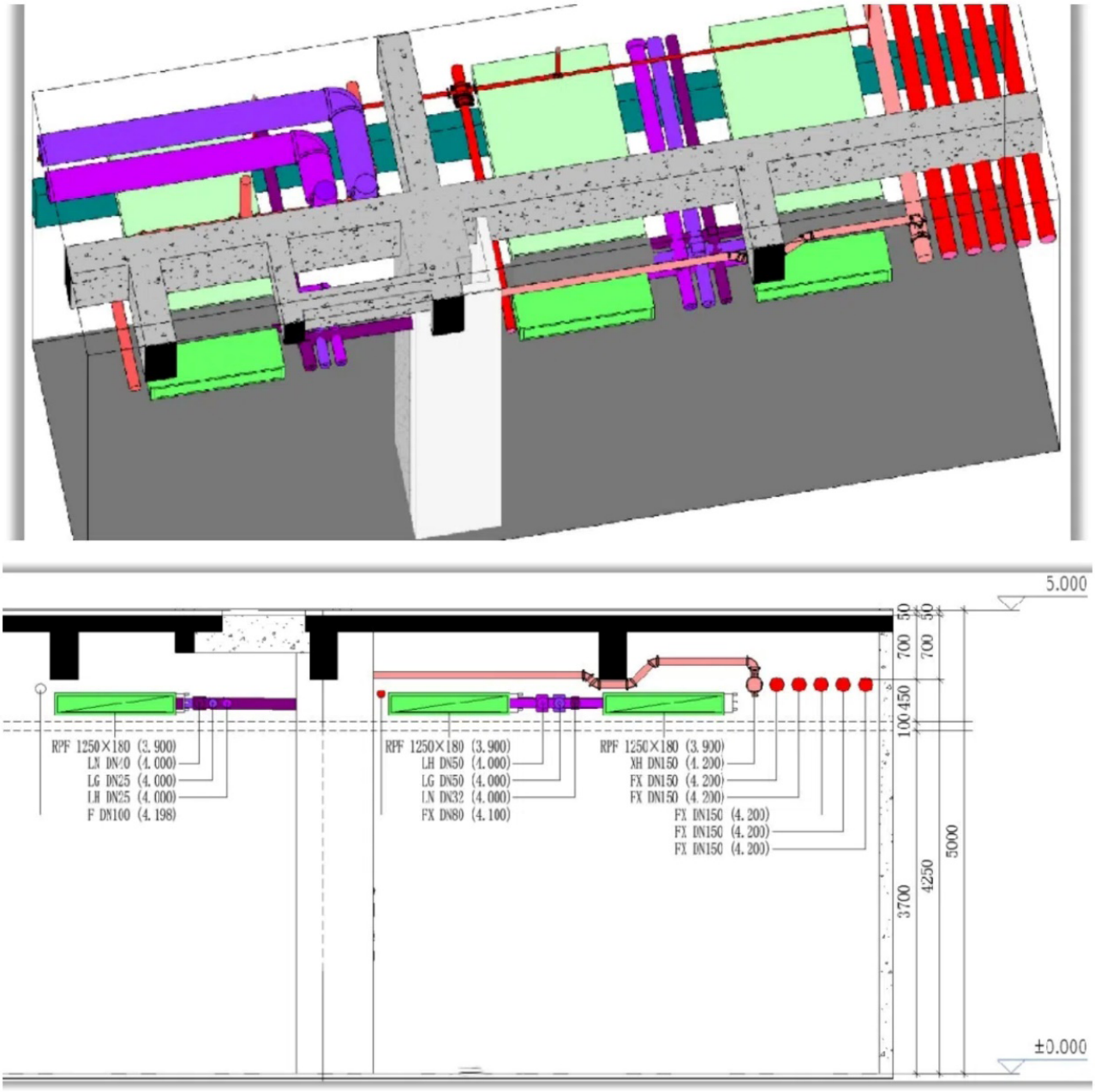


Figure 4. Application of BIM technology in designing the pipe layout in the lobby of the first floor of the inpatient building

Before equipment selection, the general contractor should proactively coordinate with the hospital to finalize the equipment procurement list. This list should include detailed specifications such as equipment nature, bare and packaging sizes, models, parameter requirements, load-bearing capacities, required areas, reserved holes, ordering timelines, arrival schedules, entry points, transportation, and installation requirements. Subsequently, the general contractor should convene a specialized meeting to thoroughly review these details. During this meeting, participants can utilize BIM technology to simulate equipment lifting scenarios, ensuring appropriate reservation of lifting ports and optimal installation environments.

In addition, in hospital construction management, it is crucial to emphasize the interface compatibility between imported and domestic equipment, as well as the matching of components, spare parts, and maintenance capacities among the main imported equipment. For instance, after completing the new 12th Hospital, some medical equipment from the old hospital will be relocated for continued use. This transition may lead to interface mismatches and differences in power consumption between the new and old equipment. Designers should compile a comprehensive list and detailed parameters of the equipment slated for relocation well in advance. This step allows for necessary design adjustments to accommodate the integration of existing equipment into the new hospital setting seamlessly.

3.3. Allowing for flexibility in the design of electromechanical and information equipment systems

In recent years, the investment in electromechanical equipment, information technology, medical equipment, and intelligent systems in hospital construction projects has been increasing. From the smallest X-ray film dispenser to the largest medical logistics system, the number of intelligent equipment used in the daily operation of modern hospitals is on the rise every year [6]. Equipment planning should prioritize enhancing treatment effectiveness, following the principle of "moderate design, allowing for future capacity upgrades, and avoiding wasteful pursuit of overly sophisticated resources." In the spatial design of new hospital construction, public corridors, passages, and doorways should be sized to accommodate equipment placement and movement effectively. To prevent collisions, service desks should be designed as inverted trapezoidal tables, and ample electrical sockets should be installed on both walls and floors. Hospitals typically procure medical equipment without always fully understanding the project's power load requirements, leading to mismatches between ordered equipment and actual power capacities. This discrepancy complicates project demolition and renovation. Therefore, designers should regularly assess and verify the total power consumption of equipment, ensuring that the power system wiring anticipates capacity needs for the next decade. Additionally, special attention should be given to specific medical equipment requirements; for instance, surgery rooms, ICU, and large-scale medical equipment should ideally have separate power sources directly from the distribution room to avoid disrupting system-wide power supplies. Furthermore, MRI machines should be installed in magnetically shielded locations, positioned far from sources of vibration. If located in the basement, it is essential to avoid placing them along driving routes used by parking vehicles.

4. Construction management

4.1. Coordinating progress plans among participating parties and subcontracted specialties

Upon entering the construction stage, it is essential for the general contractor to ensure seamless coordination among all parties involved in hospital construction, including hospital infrastructure and equipment procurement departments. This coordination involves decomposing the overall project duration plan and mandating each

contractor to develop a detailed work schedule. Given the diverse subcontracting specialties typical in hospital construction projects, specific measures are crucial. Firstly, mechanical and electrical contractors, along with equipment distributors, must finalize their plans before the main civil engineering construction begins. This ensures timely embedding of mechanical and electrical equipment pipelines during civil engineering works. Additionally, professional contractors hired by the hospital should proactively define and manage construction interfaces in advance.

During the sprint and final stages of construction, when all site specialties are fully operational, multiple contractors often work concurrently in the same areas, potentially causing interference and complications if not managed properly. Effective project management is crucial to mitigate risks such as rework and major accidents. The project management company should enforce the supervision responsibilities of the supervisory firm, ensuring they deploy sufficient supervision engineers and increase personnel as needed. The supervisory firm should assist in monitoring site progress comprehensively, overseeing material inspections, reviewing installation and testing processes, and ensuring timely handover between phases. They should promptly address deficiencies, enforce deadlines for corrections, and alert responsible contractors to lagging progress, urging them to implement effective recovery measures. Emphasizing quality control throughout project execution and installation phases is essential for maintaining construction standards and ensuring project success.

4.2. Addressing conflicts during commissioning, acceptance, and operation of hospital equipment

Compared to other types of construction projects, hospitals have additional requirements such as radiation protection evaluation, health and epidemic prevention assessments, and environmental impact assessment reports. Upon project completion, hospitals must apply to local water companies, the Southern Power Grid, gas companies, and network operators to connect water, electricity, coal, and network services before equipment commissioning and acceptance. Furthermore, hospitals must obtain a sanitation license from the health and epidemic prevention department for secondary water supply before commencing operations. Applying for joint acceptance and approval for the project involves various specialized assessments including planning, fire protection, environmental protection (including sewage station and radiation protection assessments), and compliance with “Sponge City” requirements, which can be challenging [7]. The final acceptance stage of the new 12th Hospital project presents several intricate challenges: The new 12th Hospital encountered the following situations in the final acceptance stage: (1) Certain imported medical equipment requires uninterrupted power supply. However, recent revisions in transformer and distribution room standards mandated by the Electric power company clash with the fire department’s insistence on fire doors during the equipment acceptance process. This conflict complicates the alignment of safety standards with operational needs, requiring careful resolution to ensure compliance and functionality without compromising safety protocols [8]. (3) Changes in construction technology have altered the curtain wall area, and discrepancies between planned and actual acceptance areas arise from equipment installation on the top floor. [9]. (4) Due to the project’s extended construction duration, compliance with updated building codes is required for both old and new construction phases during the acceptance processes.

During the project’s completion stage, challenges arise, such as the commissioning of equipment in the negative pressure ward taking several months to half a year. Hospitals often rush to use the ward prematurely, prompting the general contractor to deliver it before completing equipment commissioning and acceptance procedures, thereby impacting accurate equipment testing results [10]. Premature hospital operations alter the environment, complicating subsequent acceptance work for various specialties. Contractors then incur additional costs for site restoration due to premature installations, posing future audit and accountability risks

for the project management company. To prevent these issues, project management should pre-negotiate with the hospital regarding the implications and responsibilities of early project use, ensuring clear agreements are in place to manage such situations effectively.

5. Conclusion

Hospital construction is considered the most complex form of civil building construction due to its multifaceted functions, rapid development, and broad service scope. The experience from the Guangzhou 12th People's Hospital relocation project underscores the challenges posed by new hospital constructions and ongoing urban construction reforms. Experienced construction managers in hospital projects prioritize the stability and proficiency of their construction teams. Key strategies include: (1) Effective communication and coordination among stakeholders. (2) Thorough analysis of project planning and internal functional zoning. (3) Utilization of modern technology to enhance project execution. (4) Vigilant control over design changes. (5) Forward-thinking planning across all project stages, harmonizing actions and plans of all involved parties. As urban development promotes the fusion of talent and technology, innovative technologies will increasingly support construction management in future hospital projects, accumulating diverse project management experiences and enhancing the maturity of future managers in the field.

Disclosure statement

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Application of Energy-Saving Materials in Architectural Design

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Abstract: The conventional process of building construction is associated with issues such as the waste of construction materials and environmental pollution. Sustainable development highlights the importance of energy conservation and eco-friendly practices. It is essential to use energy-efficient and green materials in building designs to ensure the healthy growth of construction companies. This article discusses the advantages and principles of incorporating energy-saving materials in architectural design. It examines the strategies and critical control points for using energy-saving materials in architectural design, offering guidance for the sustainable development of the construction industry.

Keywords: Energy-saving materials; Architectural design; Advantages; Control strategy

Online publication: July 11, 2024

1. Introduction

As the energy crisis intensifies, countries worldwide have begun to emphasize improving environmental awareness and formulating green development indicators in various industries to achieve energy-saving goals. The construction industry is an industry that involves high energy consumption and severe pollution. However, it also demonstrates the most potential for energy-saving development. The energy-saving development of the construction industry will help improve the energy utilization rate in building construction, prevent energy waste, and reduce losses and environmental pollution. Therefore, energy conservation should be prioritized in current architectural design, which involves correctly understanding the advantages of energy-saving materials in architectural design and adopting scientific application principles to promote the healthy and sustainable development of the construction industry.

2. Advantages of energy-saving materials in architectural design

2.1. Reducing energy consumption

The application of energy-saving materials in buildings can effectively reduce energy consumption. In building design, various energy-saving materials and technologies can be applied to reduce the consumption of electrical and heat energy while ensuring warmth and sufficient lighting inside the building. For example, glass curtain

walls, solar photovoltaics, and other materials can be used to leverage natural resources for heating and lighting. Therefore, applying energy-saving materials in construction can ensure that building construction conforms to green environmental protection.

2.2. Improve material usage efficiency

The application of energy-saving materials in building design can not only effectively control energy consumption but also help improve the efficiency of building materials. For example, using ground source heat pumps can provide a more stable heat source for the building while reducing the materials used for combustion and insulation [1]. In addition, the indoor temperature and humidity can be adjusted based on the climate where the building is located.

2.3. Reducing construction pollution

Most of the energy-saving materials in architectural design are environmentally friendly, which reduces environmental pollution. For example, current energy-saving materials are required to meet low emission standards to avoid chemical pollution inside the building. In addition, installing drainage and air purification systems can reduce pollution and improve the environmental friendliness of the building.

2.4. Promoting the development of the construction industry

Applying energy-saving materials in architectural design can also promote the healthy and sustainable development of the construction industry. By designing energy-saving technology, harmful emissions can be reduced, thereby improving people's quality of life. Therefore, the construction industry should strive towards developing more environmentally friendly technologies, materials, and concepts to facilitate energy-saving building design.

3. Application principles of energy-saving materials in architectural design

3.1. Healthiness

The design of energy-saving buildings should also fulfill the user's needs. Traditionally, buildings are designed based on the designers' aesthetic preferences. However, energy-saving buildings should be designed based on the long-term use of the building, indoor performance, user comfort, and other aspects, while considering their impact on the environment [2].

3.2. Flexibility

Energy-saving building design is currently a popular concept in architectural design that emphasizes integration with the surrounding environment. Besides, designers must possess strong market sensitivity, keep abreast of new materials and processes, and strive to meet customer needs. In addition, design planning is carried out from a more macro perspective by combining social and economic aspects and clients' interests.

3.3. Economy

Energy-saving design of buildings serves to achieve energy-saving and environmental protection in building construction. Energy saving involves reducing the consumption of non-renewable resources and using clean energy to the greatest extent. Environmental protection emphasizes the careful selection of building materials in architectural design. The materials used should be green, pollution-free, and easy to decompose, which facilitates resource recycling and reduces environmental pollution. Besides, materials management must be

done with conservation being prioritized.

4. Strategies for applying energy-saving materials in architectural design

4.1. Energy-saving design for the overall structure of the building

The building's overall structure should be the primary concern in enhancing energy-saving design. This involves integrating the planning and design with the geographical and climatic conditions of the location. The building should be oriented and house types selected based on the local temperature and wind direction, ensuring the building can leverage the external microclimate to achieve energy-saving effects [3]. For example, when selecting a building's site, a comprehensive evaluation and consideration of the terrain, water quality, and other environmental factors must be carried out. It should not only meet the life cycle requirements of the building but also avoid damage to the overall ecological environment. Additionally, the overall planning of building energy conservation should be strengthened, and building materials should be selected according to the local climate.

4.2. Energy-saving design of building roofs and floors

The design of roofs is also a crucial aspect of building design. The roof of a building connects the building with the outside atmosphere, which plays a role in the exchange of indoor and outdoor energy. It is also the primary source of indoor energy loss. Therefore, energy-saving materials can be used in the design of the roof to conserve indoor energy. For example, insulation materials can be installed to avoid internal thermal diffusion. Different roofing models, such as planted roof systems, can be implemented depending on the environmental conditions in various regions. The design of the floor is also crucial for facilitating air exchange between the building and the outside environment, as well as for separating internal spaces. The design of the ceiling shape should be optimized. For example, circulating water pipes can be prefabricated in the floor slab; cold water can be injected through these pipes in summer to achieve a cooling effect, while hot water can be used in winter to keep the room warm, maintaining a comfortable indoor climate year-round. Given the extensive contact surface between the outer wall of the building and the indoor space, it is important to install moisture-proof and thermal insulation materials as part of the energy-saving design. These materials should be selected based on the specific requirements of different regions, enabling the building to fully utilize the external microclimate for optimal energy efficiency.

4.3. Energy-saving design of building doors and windows

The position and material of doors and windows impact building energy consumption. Statistics show that the main source of internal energy consumption in buildings in China is doors and windows, which can be up to 40% of the total energy consumption. Therefore, the design of doors and windows should be taken into account to reduce energy consumption. To achieve this, the first measure is to rationally design the number and position of doors and windows in different directions to maximize their lighting and warmth functions while minimizing heat loss. Summer ventilation issues must also be considered to ensure the circulation of internal air. Additionally, external shading can be incorporated into window designs to mitigate the increased cooling load caused by extensive glass curtain walls in summer [4]. In addition, the ventilation effect of doors and windows should also be emphasized to reduce reliance on electrical appliances such as air conditioners and fans, thereby reducing electrical energy consumption. Furthermore, selecting materials for doors and windows with high energy efficiency is crucial. Curtain walls, doors, and windows should be chosen based on their energy performance. Renewable sources like wind energy, solar energy, and other resources should be integrated

into the building. The gaps between doors, windows, and walls should be sealed with insulation materials. Understanding the properties of these materials in advance is necessary to avoid issues such as cracking, which can compromise the insulation performance. For buildings with exterior facades entirely made of glass curtain walls, the gaps between floor slabs, partition walls, and curtain walls must be filled with insulation materials to ensure optimal energy efficiency.

4.4. Building space layout design

Reasonable space layout design is also the key to energy saving in architectural design. Special partition boards can be used to divide the internal space of the building to avoid large-scale excavation in later construction. Besides, attention should be paid to indoor ventilation, insulation, lighting, and other aspects, and reasonable micro-structure adjustments should be made to enhance energy efficiency. Energy conservation should be the main concern in material selection.

5. Control points for energy-saving material design

5.1. Utilizing clean energy

Applying energy-saving materials in architectural design involves using clean, renewable energy sources such as solar and wind energy. By integrating these energy sources into building design, the consumption of heat and electrical energy can be significantly reduced. For instance, wind energy can be utilized through the strategic placement of doors and windows to ensure good indoor ventilation and promote air circulation without needing special materials. On the other hand, solar energy applications do require specific materials. For example, solar water heaters can be installed on the roof to collect heat via solar panels, converting it into thermal energy. This setup allows the building to use hot water without relying on gas or electricity, thereby reducing energy loss.

5.2. Recycling old materials

In some projects, buildings would need to be demolished before the construction takes place. The materials from the demolished buildings can be collected, processed, and redesigned to be used in new buildings. Recycling old materials not only helps save construction costs but also reduces waste emissions during demolition, contributing to energy conservation and environmental protection. Recycling old building materials is an important strategy for creating green and energy-saving buildings. Using renewable materials from old buildings, such as metal guardrails and fiber insulation materials, can effectively mitigate the environmental impact caused by the excessive consumption of new materials and resources. This approach promotes sustainability and helps maintain ecological balance [5].

5.3. Reducing the impact on the environment

While reducing energy consumption in the design of energy-saving buildings, it is also essential to strengthen the protection of the natural environment, avoid environmental pollution, and minimize the impact of various forms of waste and pollutants generated by buildings. To achieve this, materials with a relatively low environmental impact should be selected whenever possible in architectural design [6]. Construction activities typically involve high energy and resource consumption and can cause significant environmental pollution. Therefore, designers must consider ecological and cost factors when selecting materials to meet performance requirements while reducing energy consumption and pollution. For example, using high-performance and long-lasting materials, ecological cement, or prefabricated components can help reduce waste and material loss during construction. Additionally, environmental impact should be thoroughly considered in both architectural

and process design to minimize energy consumption.

5.4. Utilizing renewable resources

New energy-saving materials should be used in architectural design. For instance, current building construction often incorporates thermal insulation materials to enhance energy efficiency. There are many insulation materials available, including polystyrene boards and rock wool. Selecting appropriate insulation materials based on the architectural design requirements and specific insulation locations can significantly reduce heat loss. This approach helps to minimize the need for extensive use of air conditioners or other heating equipment, thereby conserving energy in the long term [7]. Applying thermal insulation materials in building design offers several benefits such as improving thermal insulation, reducing the exchange of hot and cold air, and ensuring comfort indoors. It also helps prevent issues like frost formation on floors and walls. Some advanced insulation materials are environmentally friendly and can even absorb harmful substances. However, the use of insulation materials needs careful consideration due to potential drawbacks. Some materials may occupy room space, reduce ceiling height, or release harmful substances that can affect residents' health. Therefore, it is crucial to comprehensively evaluate thermal insulation materials in building design [8]. Photovoltaic materials integrated into the external architecture of buildings can harness solar energy, converting it into electrical energy to provide heating and other services, thereby reducing energy costs. This application leverages renewable resources, offering flexibility with photovoltaic panels that can be customized in various specifications and shapes to suit building structures and specific needs. Despite these advantages, photovoltaic panels are expensive and susceptible to weather conditions, which can limit their effectiveness [9]. In addition, the structural characteristics of the building also need to be considered when installing photovoltaic panels. Finally, the application of rainwater collection materials in architectural design. Another aspect of sustainable architectural design involves rainwater collection systems. These systems utilize natural precipitation for tasks like swimming pool flushing and plant irrigation, reducing reliance on potable water sources and minimizing water pollution. While beneficial, rainwater collection materials can occupy significant space and increase construction costs. Additionally, materials used in high-efficiency doors and windows play a vital role in energy conservation. These materials, often made from metals, aluminum, or plastics, enhance insulation and comfort while reducing heating consumption. However, their initial cost and potential for future replacement should be carefully weighed when selecting materials suited to the construction site [10].

6. Conclusion

Applying energy-saving materials in architectural design plays a crucial role in reducing both construction and operational energy consumption, thereby achieving energy conservation and emission reduction goals. This approach aligns with the principles of sustainable development and contributes to minimizing environmental pollution. When incorporating energy-saving materials, it is essential to adhere to corresponding principles and strengthen control over design considerations. This includes prioritizing the use of raw materials sourced from clean energy whenever possible. Additionally, there should be a focus on recycling old materials, minimizing construction waste, and conserving limited resources throughout the design and construction phases. Architectural design should adopt a holistic approach that innovates in materials and technologies. This involves reducing energy inefficiencies commonly found in traditional buildings while fostering the development of new energy-efficient models.

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Analysis of the Application of Artificial Intelligence in Transportation

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Abstract: With the advancement of the information age, the transportation industry has experienced rapid growth, leading to an expansion in the scale and number of highway constructions. However, this development has also given rise to numerous traffic issues, including frequent vehicle congestion and traffic accidents. To address these problems, it is essential to leverage modern technology for real-time information collection and analysis, providing robust technical support for intelligent transportation systems. This paper focuses on artificial intelligence (AI) technology, explaining its concept and its role in intelligent transportation. It reviews the various application areas and analyzes the use of AI in intelligent transportation. Finally, it proposes strategies for applying AI to promote the healthy development of intelligent transportation systems.

Keywords: Artificial intelligence; Intelligent transportation; Traffic monitoring; Unmanned driving

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1. Introduction

Currently, China's infrastructure construction is continuously improving, and the transportation network is becoming increasingly interconnected. However, traffic problems are also becoming more severe. To effectively address these issues, it is essential to increase investment in urban traffic management, utilizing advanced technologies to support transportation development. Instead of implementing restrictions as the solution to these problems, there is a need to implement intelligent transportation systems. By applying these systems to various areas of traffic management, operational efficiency can be improved, providing safe and convenient travel conditions for the public [1]. The construction of intelligent transportation aims to enhance transportation efficiency and ensure safe and convenient travel by integrating advanced technology across different areas of traffic management.

2. Artificial intelligence and intelligent transportation concepts

2.1. Connotation of artificial intelligence

Artificial intelligence is based on the theories of human intelligence and neural networks, aiming to replicate

human cognitive processes through advanced technological systems. In China, artificial intelligence is widely applied and integrated with various disciplines and technologies, creating a multifaceted technological landscape. Presently, artificial intelligence can highly simulate human thought and activities, addressing challenges that traditional methods and machines cannot solve. Current AI applications primarily focus on language processing and information acquisition. Additionally, AI is progressing into the deep learning phase, poised to significantly impact various fields as development continues [2].

2.2. Definition of intelligent transportation

In view of the current scale of urban transportation in China, intelligent transportation has become an important development trend in the transportation industry as it addresses many problems in transportation [3].

3. Application areas of artificial intelligence in intelligent transportation

3.1. Driverless vehicles

Under the background of the information age, artificial intelligence technology has been developed rapidly and gradually applied to various fields. One notable application is the development of self-driving cars, which are advanced vehicles powered by artificial intelligence technology. While similar in appearance to conventional cars, self-driving cars differ significantly in their operation, as they can drive autonomously without human intervention. These vehicles utilize intelligent technology to follow predetermined instructions, ensuring rationality in their routes and improving driving efficiency through sophisticated information acquisition and processing.

3.2. Intelligent traffic command system

The traffic command system is crucial for ensuring smooth transportation operations and requires stringent technological standards. Intelligent transportation systems can enhance traffic management by collecting and analyzing data from traffic routes. Artificial intelligence can monitor multiple intersections simultaneously, summarize traffic information, and provide real-time feedback to drivers through methods like voice broadcasts and display screens [5]. This enables drivers to adjust their routes promptly, helping to alleviate traffic congestion. Additionally, can be integrated into traffic intersection robots to manage traffic signals based on real-time conditions. These robots can also record traffic violations and upload the information to the internet, improving the efficiency of law enforcement and reducing the burden on traffic police. Furthermore, intelligent pass lights and voice prompts can be installed at intersections to remind pedestrians to follow traffic rules, contributing to overall traffic safety and efficiency.

3.3. Traffic monitoring system

The application of intelligent technology in intelligent transportation not only records traffic violations but also enables real-time collection of traffic data by monitoring intersections. This approach significantly reduces the need for manual traffic management, thus lowering associated costs and simplifying traffic oversight. Traffic managers no longer need to be constantly present at intersections, easing the burden of traffic control. Additionally, intelligent technology can transmit information to the traffic command center, allowing for timely intervention in emergencies, such as tracking hit-and-run vehicles [6]. Moreover, by capturing data on vehicle frequency and movements at intersections, intelligent technology facilitates the optimization of traffic signal timings. This data-driven approach ensures better allocation of traffic control resources, enhancing overall traffic efficiency.

3.4. Electronic toll collection (ETC) system

The development of artificial intelligence (AI) technology has led to the creation of various technical frameworks, including cloud computing, visual recognition, and data acquisition and storage. These technologies can be effectively integrated into the toll collection systems of intelligent transportation. For instance, the implementation of the ETC system allows vehicles to pass through toll stations without stopping, as the system automatically identifies the vehicles and processes the charges via the ETC device installed on them [7]. Additionally, the system can record details such as the vehicle's model and color. In cases of toll evasion, the system triggers an alarm, prompting staff to intervene and request payment from the vehicle owner. Although the current ETC system has some shortcomings and instances of toll evasion, it significantly enhances operational efficiency at toll booths and is generally well-received in its applications.

4. Problems in the application of artificial intelligence in transportation

The application of artificial intelligence in transportation is still in its early stages and faces several challenges and deficiencies. These include imperfect data quality control, insufficient interaction between systems, and unscientific technical environment settings. These issues hinder the development and effectiveness of intelligent transportation systems.

4.1. Imperfect data quality

In the context of China's current intelligent transportation construction and development, the application of big data technology is continuously improving and is being increasingly integrated into various traffic management tasks, forming an initial smart management model. This includes managing traffic violations and traffic commands. These technologies rely on sensing and detection equipment. However, despite these advancements, there are still many challenges in the application and management of big data. The quality of the collected data and information often falls short of the requirements for intelligent transportation planning, leading to unscientific traffic management practices.

4.2. Poor system interactivity

System interaction is the main form of technical expression in the application of artificial intelligence technology. The implementation of intelligent transportation systems in traffic management can achieve comprehensive coverage of traffic information, ensure a wealth of management data, enhance interaction and communication between traffic management departments, and facilitate the sharing of traffic information. However, current transportation management faces challenges. Once intelligent transportation facilities are constructed, their subsequent use and maintenance are often inadequate. This results in superficial implementation, making it difficult to apply these systems to daily transportation management. The lack of interactivity also hampers the efficiency of transportation planning, preventing intelligent transportation from fully realizing its operational advantages [8].

4.3. Unideal technical environment

As information technology continues to advance, including intelligent technology, big data, cloud computing, and other technical means, the requirements for the technological environment are also evolving rapidly. In the realm of intelligent transportation, these advancements introduce new demands, particularly in enhancing data mining capabilities within traffic management. This is crucial for accurately predicting road conditions and optimizing the operation of intelligent transportation systems [9]. However, from the current operational

perspective of transportation in China, artificial intelligence technology has not yet found a robust application space. There are challenges in fully leveraging its technical advantages.

5. Application strategy of artificial intelligence in transportation

5.1. Optimizing the design of the intelligent system

The application of artificial intelligence in intelligent transportation systems requires a systematic approach to optimize the top-level design of information technology. Establishing a scientific management system is essential to create an effective environment where intelligent technology can fully function. Innovative management methods are crucial in the construction of intelligent transportation to ensure efficient traffic management. As the core entity responsible for traffic management, the government must assume corresponding responsibilities. This includes comprehensive transportation planning, optimizing the organization and coordination of traffic management efforts, and fostering the healthy development of intelligent transportation systems. In planning, designing, and managing intelligent transportation, attention should be given to constructing various transportation infrastructures and supervising transportation operations. Furthermore, strengthening the formulation and enforcement of relevant laws and regulations is vital. This legal framework provides a solid foundation for applying intelligent technology in managing intelligent transportation effectively. Government departments should take the lead in information technology construction and data integration, establishing dedicated teams for network security management to support e-government initiatives. This approach will facilitate the implementation and utilization of intelligent technology across transportation management systems.

5.2. Establishing anti-unlicensed vehicles and anti-fee evasion linkage

The application of intelligent technology in the development of intelligent transportation systems offers several benefits, including enhancing information collection, facilitating data sharing among relevant departments, and providing a foundation for effective traffic management. By constructing an information management platform, intelligent transportation can achieve centralized management, which is essential given the modern transportation industry's vast scale and rich data sources. However, managing the rapid growth and large storage requirements of data and ensuring its security and efficiency are critical challenges. For instance, in toll management, intelligent transportation systems can establish networked connections between transportation departments, public security departments, and urban management authorities. This integration enables comprehensive management actions when vehicles evade tolls or when criminals attempt to flee. The intelligent platform allows traffic management departments to record incidents like toll evasion or criminal activities and share this information seamlessly across platforms. This collaboration mobilizes multiple forces to locate and intercept offenders, thereby leveraging a synergistic effect. Moreover, the information recorded on the platform can automatically generate records, which may impact the credit records of responsible individuals, enhancing deterrence against misconduct [10]. Furthermore, in transportation road design, the intelligent traffic management platform facilitates information sharing and online communication among departments such as land management, urban planning, and public security. This collaboration enhances the design of traffic models by incorporating diverse opinions and suggestions. By breaking down traditional information silos, intelligent technology enables the automatic synthesis of collected data to propose optimized traffic design solutions.

5.3. Enhancing intelligent safety awareness

The application of intelligent technical means in intelligent traffic management presents significant challenges

due to an insufficient understanding of intelligent technology and operational abilities among personnel, coupled with a lack of an intelligent management mindset. Relying solely on traditional platforms and hardware/software facilities limits the stable development of intelligent transportation systems. To overcome these obstacles, collaboration across societal fields and effective human resource management are essential to create an open environment conducive to advancement.

To effectively implement intelligent transportation systems, it is paramount to enhance awareness of safety management across all stakeholders, leveraging big data and intelligent technologies to ensure the security of information resources. This involves strengthening data security training within the transportation sector, fostering a culture of prevention and professionalism in intelligent operations, and cultivating a supportive environment for intelligent transportation initiatives. Public education efforts must prioritize safety and protection management, advocating for standardized applications of information technology. Establishing a robust data security management information base within modern intelligent transportation systems is crucial in safeguarding the confidentiality of information amidst the big data era's rapid evolution. Implementing an open management model and security guarantee system involves stringent system security management through measures like firewalls, antivirus software, and software upgrade protocols to prevent external breaches. Incorporating confidentiality technologies into intelligent transportation management platforms enhances their capability to manage diverse data characteristics and classify management risks appropriately, ensuring effective protection strategies are implemented across varying security levels.

6. Conclusion

In summary, the application of artificial intelligence technology in intelligent transportation enhances traffic management efficiency, optimizes traffic command capabilities, establishes intelligent detection systems, and constructs big data-sharing platforms to optimize traffic management. This technology helps alleviate road congestion and ensures the safety of both traffic and pedestrians. However, current applications of artificial intelligence in intelligent transportation still have significant shortcomings, limiting the full development of intelligent transportation systems. To address these challenges, there is a need to further optimize artificial intelligence technology, enhance intelligent transportation management and operations, continuously update technological infrastructure, cultivate a skilled workforce, and foster better integration opportunities between artificial intelligence and intelligent transportation. These efforts are crucial for promoting the healthy development of China's transportation industry in the future.

Disclosure statement

The author declares no conflict of interest.

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Research on the Comprehensive Development Trend of National Fitness Activity Centers

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Abstract: With the further advancement of the "National Fitness" strategy and the continuous development of the information age, the National Fitness Activity Centers have become more comprehensive. The comprehensiveness is reflected in the design of diversified sports functions and spaces. The article serves to explore the comprehensive development trend of National Fitness Activity Centers. Through summarizing and sorting out domestic and foreign cases, the trend of the comprehensive development of National Fitness Activity Centers is predicted at three levels: industry, city, and individual functions.

Keywords: National fitness; National fitness activity center; Comprehensive development trend

Online publication: July 11, 2024

1. Introduction

Since the concept of "National Fitness" was introduced in the late 1980s, it has been largely advocated by the Chinese government as a key approach for encouraging widespread participation and comprehensive promotion of physical activity. According to relevant policy documents and future development trends in the sports industry, "National Fitness" has evolved from continuous in-depth development into a national strategy, significantly boosting public enthusiasm for participation. Guided by the National Fitness Plan during the "14th Five-Year Plan" period, national sports facilities have seen continuous improvement and development, leading to the establishment of National Fitness Activity Centers across various regions [1].

During the "14th Five-Year Plan" period, the goals of the sports industry include reaching a total scale of 5 trillion yuan, with its added value accounting for 2% of GDP. The total scale of residents' sports consumption is expected to exceed 2.8 trillion yuan with a workforce of more than 8 million employees. The proportion of people who regularly participate in physical exercise is projected to reach 38.5%. By 2025, it is estimated that the scale of the sports industry will reach 5 trillion yuan, with an average annual compound growth rate of 12.8%. This indicates that the sports industry has substantial macro policy support and significant development potential [2]. Overall, the sports industry is a rapidly growing sector and is gradually becoming a pillar of the national economy. It offers extensive opportunities for future development and continues to infuse new vitality and energy into economic, social, and urban development.

2. Problems faced in the comprehensive development of National Fitness Activity Centers

The construction of National Fitness Activity Centers plays a significant role in urban development because the core of a city lies in the health and happiness of its residents. Therefore, understanding and meeting the fitness needs of residents is key to facility construction. ANational Fitness Activity Center is not only a sports venue, but also a comprehensive fitness and sports facility that serves the community and the city. However, the construction of these centers comes will several challenges.

One of them is the functional singularity of sports building design. Many sports venues are designed with specific sports in mind, often ignoring the needs of daily use outside the Olympic Games. This results in lower utilization of these venues on non-match days or non-specific event days, resulting in lower investment returns [3].

In addition, the lack of individual characteristics and functions of sports buildings is also a problem. In a competitive urban environment, the uniqueness and versatility of sports buildings are crucial to attracting more users. In addition, the operation and management of sports venues also face challenges. Some stadiums find themselves struggling to achieve economic sustainability due to high maintenance costs and low utilization rates. Hence, collaboration between government and the private sector is essential to develop more attractive operating models.

The design of greenways, community sports parks, and sports plazas also needs to be revisited. These public spaces play a vital role in cities, providing places for people to exercise, relax, and socialize. However, some greenway designs may not fully consider the requirements of multi-functional aggregation, resulting in the inability to meet the needs of different groups of people in some cases. In addition, the accessibility of some community sports parks and sports plazas needs to be improved [4].

Today's National Fitness Activity Centers are no longer limited to traditional sports venues but emphasize complex functions and diversification. These new types of sports buildings need to incorporate multiple functions such as sports, theatrical performances, exhibitions, entertainment, hotels, restaurants, shopping, and leisure to cater to the needs and interests of diverse groups of people. The development of these centers has evolved from a single sports function stage to a composite function stage, necessitating innovative construction concepts for functional composite sports buildings.

3. Overall development trend of National Fitness Activity Centers

Today's National Fitness Activity Centers are no longer limited to traditional sports venues but emphasize complex functions and diversification. These new types of sports buildings need to incorporate multiple functions such as sports, theatrical performances, exhibitions, entertainment, hotels, restaurants, shopping, and leisure to cater to the needs and interests of diverse groups of people. The development of these centers has evolved from a single sports function stage to a composite function stage, necessitating innovative construction concepts for functional composite sports buildings.

3.1. Overall trend of sports industry clusters

The compounding of the sports industry system refers to the combination of the sports industry and urban planning. By developing and merging the sports industry within cities, this approach aims to achieve deep integration and coordinated development between urban areas and the sports sector, known as the "Sports +" model. This involves linking with related industries to foster the in-depth integration of sports with tourism, cultural creativity, technology, and other sectors, forming a complex industrial structure (**Table 1**).

Table 1. Compilation of industry types of national sports projects

Number	Project (year)	Industrial composite model
1	Hangzhou National Fitness Center (2022)	Culture-sports-business
2	Chengdu Xinjin Sports Center (2023)	Sports-culture
3	Zhuhai National Fitness Complex (Under construction)	Culture-sports-business-health
4	Tampines World, Singapore (2017)	Culture-sports-business-health
5	SESC Complex, Brazil (2019)	Culture-sports-business
6	Churchill Meadows Community Center (2021)	Sports-catering-training

3.1.1. Sports industry and business

The model of integrating the sports industry with business has matured and is now exhibiting diversified development trends. People's demand for sports consumption is gradually shifting from purely leisure and fitness to a multi-functional approach encompassing leisure, entertainment, shopping, and business. This change is also driving the construction of comprehensive sports service facilities with sports as the theme in cities. This further enhances the integration of the sports industry with other industries.

The currently popular development model of "mutual promotion of sports and business" – "nurturing the body through business and promoting business through sport" – emphasizes the reciprocal relationship between commercial and sports activities. This concept highlights that commercial activities can provide financial support and development opportunities for sports, while sports activities can generate more market opportunities and brand value for businesses (**Figure 1**).

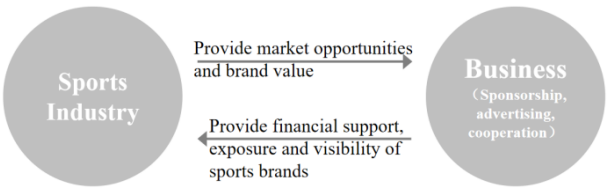


Figure 1. "Sports industry and business" development model

3.1.2. Sports industry and cultural industry

The integration of the sports industry and the cultural industry is an important trend in the development of "Sports+." This integration not only provides the possibility for the long-term development of the industry but also lays the foundation for the comprehensive promotion of urban culture and sports. The integrated development of the sports and cultural industries is one of the important trends in today's social and economic development. The key lies in their mutual penetration and cooperation to create richer and more diverse cultural and sports products and services [5].

Sports elements should be integrated with cultural elements by holding large-scale cultural and sports events and other activities to create more attractive and unique cultural and sports products. Additionally, the influence and market share of the sports industry can be expanded by developing extended products, such as sports peripherals and sports-themed amusement parks. Promoting sports culture and enhancing the structure of the sports culture industry are also crucial directions for advancing the integrated development of the sports and cultural industries (**Figure 2**).

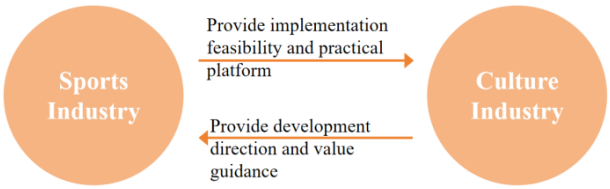


Figure 2. "Symbiosis of culture and sports" development model

3.1.3. Sports industry and health industry

The report of the 20th National Congress of the Communist Party of China emphasized "Promoting the construction of a healthy China" and prioritized the protection of people's health as a key strategic goal. In line with this, governments at all levels have issued various policies and regulations, such as the "Healthy China 2030 Planning Outline," which elucidates the relationship between sports and health and outlines their respective roles in health promotion. The integrated development of the sports and health industries has thus become a crucial component in advancing the construction of a healthy China [6].

In this context, the National Fitness Activity Center has become an important platform, not only a venue for sports and fitness services but also a hub to promote a healthy lifestyle. With the expansion in scale and number of National Fitness Activity Centers, a new sports rehabilitation industry has emerged. This model of sports rehabilitation centers deeply integrates "Body" and "Nurturing," fostering a comprehensive service industry that integrates "ecology, leisure, sports, and healthcare." Ultimately, this development transforms the National Fitness Activity Center into a multifunctional venue offering comprehensive support services, marking a significant trend in the integrated development of China's sports and health industries (**Figure 3**).

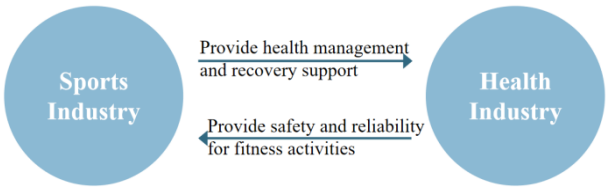


Figure 3. "Integration of sports and health" development model

3.2. Trend of sports industry clusters

emphasis should be placed on promoting the integration of urban functions and achieving coordinated regional development. Urban functional space encompasses the diverse functions and activities performed within different areas of the city. These functions are typically aligned with the city's development objectives, demographic requirements, and economic, cultural, social, and other considerations (**Table 2**).

Table 2. National fitness project urban public space resource complex

Number	Project (year)	Composite urban function type
1	Hangzhou National Fitness Center (2022)	Community
2	Chengdu Xinjin Sports Center (2023)	City park
3	Zhuhai National Fitness Complex (Under construction)	City parks, communities
4	Maryland Heights Community Center (2017)	City park
5	SESC Complex, Brazil (2019)	Town square
6	Churchill Meadows Community Center (2021)	City parks, communities

3.2.1. Integrating "urban sports functions" into urban parks

As an important green space in the city, urban parks serve many purposes, including providing fitness, leisure, social, and other services. They are also an important part of the ecological environment (**Figure 4**). In urban development, urban parks are not only concentrated displays of green spaces but also the core elements of urban demonstration areas [7].

Urban green open spaces, particularly parks and green areas, have evolved beyond conventional land use practices and urban environmental management concerns. In the context of National Fitness Activity Centers being strategically positioned near city parks, these centers typically feature fitness facilities as the core infrastructure, complemented by diverse outdoor sports venues and green spaces. This composite approach enhances the synergy between National Fitness Activity Centers and parks, fostering a feedback loop where emerging trend sports and current activities are integrated to enhance the park's appeal and utilization among the public.

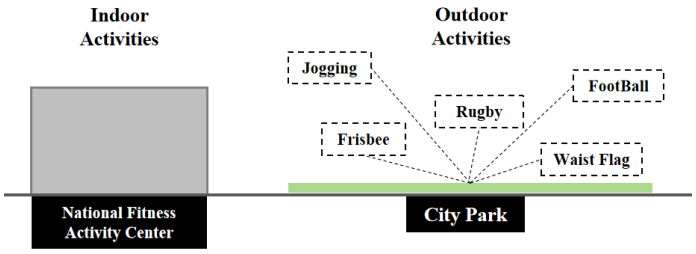


Figure 4. "Urban sports function" and urban parks

3.2.2. Integrating "urban sports function" into urban community spaces

An urban community space usually includes aspects of residence, community activities, and commerce, all designed to fulfill people's fundamental needs for survival and daily life. The development of urban community spaces often coincides with urban renewal initiatives and the integration of regional resources, aimed at enhancing the quality of life services and living experiences for residents (**Figure 5**).

Positioning National Fitness Activity Centers near urban communities is a growing trend aimed at enhancing accessibility to physical exercise and fitness activities for nearby residents. By locating these centers within urban communities, not only are the community's sports amenities enriched, but additional commercial, leisure, entertainment, and other functions are also brought in. This dual benefit enhances the development and appeal of urban communities, offering new opportunities and perspectives for the construction of urban community spaces.

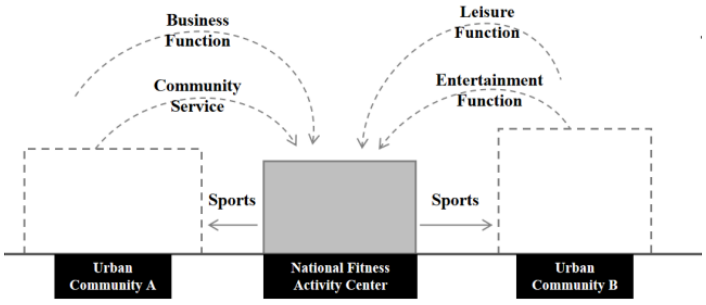


Figure 5. The compound relationship between "urban sports function" and urban community space

3.2.3. Integrating "urban sports function" into urban square spaces

The city square serves a pivotal role in urban planning and design, functioning not only as a key node and iconic landscape but also as a hub for daily activities. As a leisure area within the urban fabric, the city square

draws significant numbers of sports and fitness enthusiasts owing to its high foot traffic. Its central location also appeals to visitors and tourists, facilitating their participation in fitness activities and contributing to the promotion and growth of National Fitness initiatives.

In addition, the city square provides huge development opportunities for the National Fitness Activity Center and also brings new business opportunities to sports-related industries. For instance, suppliers of fitness equipment, specialized sports product stores, and other businesses can establish outlets here to offer a wide range of services and products to fitness enthusiasts. This symbiotic relationship fosters the vibrant expansion of the sports industry, generating additional employment opportunities and driving economic growth (**Figure 6**).



Figure 6. The composite relationship between "urban sports function" and urban square space

3.3. Integration of sports industry clusters

In previous design studies, the integration of National Fitness sports buildings primarily emphasized diversifying sports functions through the configuration of various small and medium-sized spaces to cater to different needs. However, the current trend in integrated design suggests that it is not merely about intensifying these sports functions independently. Instead, it advocates viewing various sports functions as components of a unified "National Fitness" function and exploring their composite development in conjunction with other functions. This approach delves deeper into understanding how sports facilities can synergize with other activities, offering insights and guidance for future projects in this domain.

3.3.1. "National Fitness" + "business services" functional model

Over the past two decades, the integration of "National Fitness" + "business services" in China's large shopping malls has progressed through three distinct stages. Initially, the focus was on introducing basic sports amenities, exemplified by the debut of the Guomao Ice Rink in 1999, marking the first phase where shopping centers began incorporating sports activities. This laid the groundwork for subsequent developments in combining business formats. In the second phase, driven by increasing consumer demand and the expansion of commercial centers, a wider array of renowned domestic and international sports brands and fitness facilities emerged. Simultaneously, children's sports venues were introduced to cater to the growing interest in youth sports. The third stage has seen a more diversified approach, with shopping malls exploring specialized sports IPs such as indoor ice and snow sports and Frisbee sports. These projects not only satisfy citizens' sporting interests but also enhance shopping malls by offering new attractions and experiences.

However, the "National Fitness" + "business services" functional composite model focuses predominantly on sports functions, typically occupying areas exceeding 10,000 m^2. Often referred to as a commercial activity center or sports business complex (**Figure 7**), this model's essence lies in attracting consumers through sports

activities while offering diverse business services like dining, retail, and entertainment to boost operational revenue. It balances both public welfare objectives and profit motives, ensuring sustainable funding for sports venues while delivering high-quality facilities and services to the community. This symbiotic relationship is pivotal in advancing the National Fitness initiative.

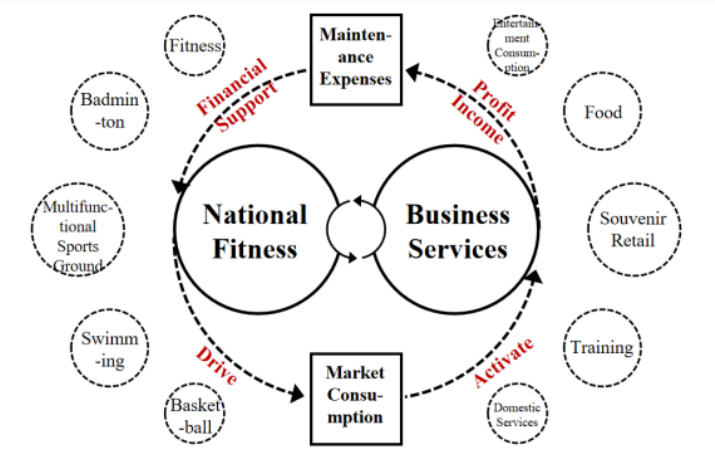


Figure 7. "National Fitness" + "business services" functional model analysis

3.3.2. "National Fitness" + "production and life" functional mode

The integrated development model of "National Fitness" + "production and life" services represents a crucial trend in current residential area construction. In these developments, the sports functions of National Fitness Activity Centers are seamlessly integrated into community living spaces, incorporating multi-functional sports fields, social leisure areas, and other facilities. Through participating in mass sports activities, residents engage in communication and cooperation, fostering community cohesion and vitality. The "National Fitness" function not only offers residents convenient venues for physical exercise but also generates ample social opportunities, enriching community life.

In the integrated model of "National Fitness" + "production and life" (**Figure 8**), various social production and life services are incorporated alongside sports activities [8]. This includes setting up exhibition venues for hosting a variety of exhibitions, performances, and cultural events, providing residents with diverse cultural and entertainment options. Additionally, training centers and office spaces are established to offer convenient facilities for learning and work. This development model focuses on meeting residents' material needs while also enhancing their social awareness and promoting physical exercise awareness.

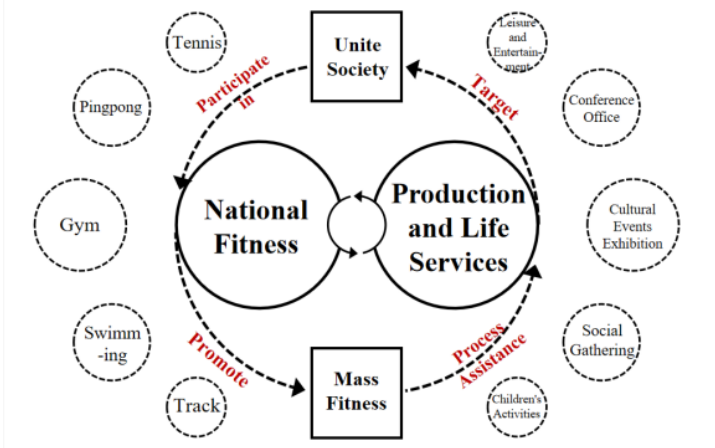


Figure 8. "National Fitness" + "production and life" functional model analysis chart

4. Conclusion

In the context of high-density urban construction, the National Fitness Activity Center serves as a pivotal point for exploring its functional composite design. Through an analysis of existing issues and related cases, including industrial integration categories, urban public space types, and their own functional types, several trends in the comprehensive development of National Fitness Activity Centers emerge:

(1) The trend of "Sports +" industry integration development focuses on integrating the sports industry with other sectors such as business, culture, and health.

(2) The trend of "New Sports Space" involves integrating National Fitness Activity Center buildings with urban resources such as parks, squares, and communities to create innovative urban sports environments that diversify the venues beyond traditional sports facilities.

(3) The trend towards complex development integrates "multiple functions" into National Fitness Activity Centers, transforming them into multifaceted sports complexes that combine fitness, entertainment, cultural events, commercial exhibitions, and more.

Looking ahead, the complex development of National Fitness Activity Centers is a growing trend. This preliminary study underscores their potential to enhance urban development by providing multifunctional, convenient, and attractive spaces that improve residents' quality of life and enhance the city's image and competitiveness. The "people-oriented" composite design model aims to cater to diverse resident needs effectively.

Disclosure statement

The authors declare no conflict of interest.

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Strategies for Teaching the Reinforced Concrete Structures Course in Engineering Majors

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Abstract: The cultivation of engineering capabilities aims to equip engineering professionals with high-level expertise to meet the demands of society and industry development, thereby enhancing their competitiveness and career potential. This article focuses on engineering capability development, exploring teaching strategies for the Reinforced Concrete Structure course. It aims to provide insights for educators in engineering programs at universities and vocational colleges in China. By doing so, teaching plans that meet the needs of engineering capability development, laying a solid educational foundation for the healthy growth of engineering professionals in the new era, and enhancing their application of knowledge and skills can be developed.

Keywords: Engineering ability; Reinforced Concrete Structure course; Classroom practice; Expert exchange

Online publication: July 11, 2024

1. Introduction

The development of engineering capabilities is crucial for the growth of engineering professionals. On one hand, excellent engineering capabilities aid individuals in understanding and mastering fundamental theories and applying them to solve practical engineering problems effectively. On the other hand, engineering capabilities emphasize the cultivation of practical skills. This allows engineering professionals to operate and practice in real-world environments, enabling them to comprehend and master engineering principles, design, construction, and management procedures. This enhances their abilities in engineering design, analysis, and management while fostering critical thinking and innovation skills during their learning process. Therefore, conducting research on teaching strategies related to engineering capability development in relevant courses is a highly valuable endeavor. It aims to enhance the competitiveness and career potential of engineering professionals.

2. Connotation of engineering ability cultivation

Engineering professionals, as the central force driving the development and innovation in the engineering field,

require the cultivation of engineering capabilities, which is a crucial aspect of engineering education. These capabilities include specialized knowledge, innovation and problem-solving skills, practical and operational abilities, as well as a sense of responsibility and professional ethics.

Firstly, the cultivation of specialized knowledge forms the foundation of engineering capability development. This typically includes mastering fundamental disciplines, basic engineering knowledge, and specialized field expertise. At this level, professionals are required not only to grasp theoretical knowledge but also to undergo training in experimental skills. Secondly, fostering innovation and problem-solving capabilities is essential for engineering professionals. They need to possess strong innovative thinking and problem-solving skills to propose innovative solutions and approaches for challenging engineering projects. This ensures effective handling of various difficulties encountered in engineering design and construction. Thirdly, developing practical and operational skills constitutes the core practical aspect of engineering capability. This usually involves acquiring skills in experimentation, operation, and engineering design. Fourthly, fostering interdisciplinary knowledge is crucial in the current era where engineering projects often span multiple disciplines and fields. Therefore, engineering professionals need to possess interdisciplinary knowledge to address various challenges in practical engineering projects [1].

3. Principles of the Reinforced Concrete Structure course

3.1. Practical

The practicality of the reinforced concrete structure course means the applicability of the knowledge and skills of the course in engineering projects. The syllabus should align with real-world engineering problems and emphasize the cultivation of practical and problem-solving skills.

3.2. Forward-looking

The syllabus of the Reinforced Concrete Structure course should also be forward-looking. This means that the course content should be updated regularly and align with the latest development trends. The course should also prepare the students for solving future engineering problems. The content should not only encompass traditional knowledge of reinforced concrete structures but also integrate emerging construction methods, technologies, and materials. This includes information on environmentally friendly and sustainable materials, construction techniques, and other relevant advancements, which should all be incorporated into the teaching curriculum.

3.3. Experiential

The Reinforced Concrete Structure course should also focus on personal experiences. Through practical activities, students can personally engage with and experience the development of knowledge, apply critical thinking, and thereby gain a deeper understanding and mastery of how to use that knowledge. Experiential learning enhances their sense of connection and identification with the knowledge they acquire.

3.4. Diversity of teaching methods

To better impart knowledge and skills during the teaching of reinforced concrete structures, it is important to accommodate individual differences among students. Embracing diverse teaching methods is essential like integrating lectures, demonstrations, hands-on practice, and case studies. Additionally, leveraging information technology tools such as online teaching, flipped classrooms, and artificial intelligence can further stimulate students' interest and motivation to learn. These approaches aim to deepen students' understanding of knowledge and skills effectively.

4. Research on the teaching strategies Reinforced Concrete Structure in relation to engineering capability cultivation

4.1. Strengthening the connection between the knowledge system and practical projects

When designing the curriculum for Reinforced Concrete Structures, teachers should identify the key knowledge points that the course should cover. These include fundamental aspects such as the basic types of reinforcement, their physical and mechanical properties (hardness, strength, ductility, plasticity, etc.), surface characteristics, specifications, weights, and the compatibility between concrete and reinforcement. Subsequently, each major knowledge point should be linked to practical reinforced concrete structure projects.

While teaching the theories, teachers can start by discussing the basic types of reinforcement. They can introduce commonly used types such as prestressed reinforcement, hot-rolled reinforcement, and cold-drawn reinforcement in the fields of building and bridge engineering. Simultaneously, through associated analysis with practical projects, students can observe and identify different types of reinforcement materials used in engineering projects and understand how they are used. When describing the physical and mechanical properties of reinforcing steel, teachers can elaborate on the definition of each property (hardness, strength, ductility, plasticity, etc.), testing methods, and the practical impact of these properties on the overall quality and stability of reinforced concrete structures. After learning the theories, students should engage in related practical project analysis. This involves conducting mechanical performance tests on samples prepared by the instructor during class, observing, and recording experimental data. This process helps them further understand the correlation between these physical and mechanical properties and the performance of reinforced concrete structures.

For example, when teaching about the surface characteristics, specifications, and weight of reinforcement, the teacher can explain the related standards and requirements. During project analysis, students can engage in actual measurement activities. Using their theoretical knowledge, students calculate the specifications and weight of reinforcement. Subsequently, they compare their measured results with the standard requirements, deepening their understanding of the significance of these measurements in real engineering applications.

When explaining the compatibility between concrete and reinforcement, the teacher can discuss how concrete and reinforcement interact and the direct impact of this interaction on structural performance. In the associated practical project analysis phase, instructors can lead students to internship sites. Here, students are required to cut, bend, and tie reinforcement according to project design requirements. They then prepare concrete and fabricate reinforced concrete test specimens, followed by conducting subsequent mechanical performance tests.

The course design described above tightly integrates theoretical knowledge with practical projects, enabling students to better understand and apply the physical and mechanical properties of reinforcement. This approach enhances the practical utility of engineering capability development.

4.2. Strengthening classroom practice

To better integrate theoretical knowledge with practical skills in teaching Reinforced Concrete Structures, in-class practical activities can be emphasized further [2]. After covering foundational theories from the textbook, teachers can introduce various hands-on activities. These could involve creating physical models, organizing group competitions, conducting field experiments, and preparing project reports. These diverse activities aim to engage students actively and demonstrate how theoretical concepts apply in real-world scenarios. This approach enhances learning by connecting theory with practical applications in the context of reinforced concrete structures.

In the aspect of creating physical models, teachers can encourage students to construct their own steel reinforcement models corresponding to different concrete structures. After explaining the theoretical knowledge

and requirements of reinforcement performance, teachers can instruct students to simulate basic structures of actual high-rise buildings, bridge structures, and tunnel structures based on these models. This hands-on approach allows students to intuitively understand the practical application of reinforcement and performance control schemes in various concrete structures. As for the group competition strategy, teachers can divide their students into groups and task them on building models. Each group gets to present their models while other classmates get to raise questions and provide feedback. Competition between different groups method effectively enhances students' practical skills, communication skills, and teamwork abilities [3]. For field experiments and site inspections, teachers can select construction sites near the school or completed building projects based on regional characteristics. Leading students on-site allows them to closely observe the specific requirements of reinforcement performance in concrete structures, thereby deepening their understanding and application of their knowledge. After each activity, teachers can require each group to submit a comprehensive report. The report should include the process of the activities, observations, personal experiences, and personal reflections related to the course material.

Additionally, teachers can schedule academic seminars during class to discuss specific points of knowledge. After the course, arranging these seminars allows each student to present their insights on the performance of reinforced concrete structures. At this moment, teachers should respond to students' viewpoints and questions effectively, facilitating a deeper understanding of both theoretical concepts and practical applications through interactive learning [4].

4.3. Enriching teaching methods

Diverse teaching methods are crucial means to effectively promote students' deep understanding of knowledge and skills, thereby further enhancing their interest in learning. Building upon strategies that integrate theoretical knowledge with practical projects and enhance in-class practical activities, teachers should further diversify teaching methods by integrating technologies that align with the preferences of modern youth and have shown significant results in the field of education [5]. For instance, teachers can leverage information technology to create online learning platforms, allowing students to engage in remote learning outside class hours, thus overcoming limitations of time and space. Additionally, integrating artificial intelligence technology into classrooms is also a highly suitable method that matches the preferences and psychological needs of modern youth.

On the one hand, teachers can leverage information technology to establish an integrated online learning platform. This platform aims to provide students with avenues for self-study and knowledge acquisition outside of class hours. When developing the platform, it is essential to incorporate a feedback mechanism tailored for student self-learning. This includes integrating artificial intelligence algorithms that enable students to engage in independent study, review materials, and actively test themselves based on platform feedback. By leveraging these capabilities, students can assess their own knowledge levels and identify areas of weakness in their knowledge structure, thus facilitating targeted learning efforts moving forward [6].

On the other hand, teachers can introduce artificial intelligence teaching assistants during the teaching period to provide personalized learning suggestions. These teaching assistants can tailor learning resources and paths based on each student's learning progress. Additionally, virtual reality (VR) and augmented reality (AR) technologies can be utilized to simulate complex reinforced concrete structures and rebar arrangements. This allows students to personally operate in a virtual environment, experiencing the physical and mechanical properties as well as structural characteristics of reinforced concrete structures, thereby enhancing their understanding and memory retention.

Furthermore, teachers can apply big data analytics by collecting and analyzing students' online learning data. This enables them to grasp the learning progress of each student and adjust their lessons accordingly in later stages [7].

4.4. Strengthening communication with experts

Facilitating exchanges between students and industry experts helps students gain a deeper understanding of reinforced concrete structures. At the same time, schools can leverage the experience and wisdom of the experts to enhance the quality of the course. Exchanges between experts and students can be carried out in three ways: imparting experience, sharing professional knowledge, and assessing skills.

In terms of imparting experience, schools can have experts share challenging problems encountered in practice and their thought processes in resolving these issues. This approach inspires students to propose innovative solutions and approaches when facing various engineering problems [8]. For sharing professional knowledge, schools can invite experts to share practical knowledge and theories beyond the scope of textbooks and guide students' thinking by addressing their questions, thereby deepening students' understanding of professional knowledge. Regarding skills assessment, experts can evaluate the effectiveness of students' solutions, work efficiency, and multidimensional engineering competencies such as teamwork, and provide valuable feedback to help students gain a comprehensive understanding of their engineering capabilities for their future careers.

4.5. Optimization of school-enterprise collaborative graduation internship programs

School-enterprise collaborative graduation internship programs serve as the final preparation for graduates. Optimizing internship projects will further promote the enhancement of engineering capabilities in talents. Teachers should assist students in establishing clear internship objectives. This ensures that students gain a deep practical understanding of reinforced concrete during the internship, including mastering key technologies, understanding potential challenges in actual engineering, and learning how to address problems [9]. Subsequently, in the graduation internship project, real engineering projects should be created where students participate in the design, construction, and management of reinforced concrete structures within enterprises. Through involvement in actual projects, students can better understand and master the entire process of construction engineering, as well as the related design and construction processes of reinforced concrete structures.

In addition, the graduation internship project should involve enterprise instructors and invite engineering professionals from relevant fields within the industry. These professionals can assess and provide feedback on students' practical engineering capabilities during their participation in the projects. Through close interaction with students and teachers, both parties gain a deeper understanding of the industry's and enterprises' demands for their engineering capabilities. This feedback loop accelerates the students' further enhancement of their knowledge structure and practical skills [10].

5. Conclusion

Engineering capability is a crucial factor for engineering professionals to adapt to industry developments, enhance employability, and increase competitiveness. Using the teaching of the Reinforced Concrete Structures as an example, this paper explores strategies to effectively improve students' engineering capabilities during the teaching process. This paper can be used as a reference to create a curriculum focused on developing these skills. These teaching practices aim to foster and enhance the engineering capabilities of engineering students

and provide them with the tools to solve real-world problems and demonstrate their abilities in future careers and projects.

Disclosure statement

The author declares no conflict of interest.

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Research on Key Points of Design of Standard Plants in Modern Industrial Parks Under the Background of Promoting the Development of New Quality Productive Forces

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Abstract: With the progress of science and technology and the acceleration of industrialization, the modern industrial park is an important carrier of industrial development. The importance of its standard plant design has become increasingly prominent. With the development of new quality productive forces as the background, this research deeply discusses the key points of standard plant design in modern industrial parks. This paper uses literature review and case analysis to systematically analyze the important role of standard plant design in developing new quality productive forces in modern industrial parks and puts forward suggestions for optimizing design. It is found that the rationality, intelligence, and environmental protection of plant design are the key factors affecting the development of new quality productive forces. The paper summarizes the core points of modern industrial park standard plant design to provide a reference for the future development of related industries.

Keywords: New quality productive forces; Modern industrial park; Standard plant design; Intelligent; Environmental protection

Online publication: July 11, 2024

1. Introduction

With the continuous development of the global economy, science, and technology, new quality productive forces have become a key driving force to promote economic growth. With technological innovation and industrial upgrading as the core, the new quality productive forces have the characteristics of strong technological innovation, obvious industrial upgrading, high production efficiency, and optimization of production structure. It is an important force to promote sustainable, healthy, and high-quality economic and social development. It is also an important leading force to guide the future development direction of productivity. As an important carrier of new quality productive forces, a modern industrial park's standard plant design is prominent for improving production efficiency, reducing cost, and promoting sustainable development. Modern industrial

parks play an important role in developing new quality productive forces such as gathering innovative resources, promoting industrial upgrading, providing efficient services, cultivating emerging industries, and strengthening international cooperation [1].

With the continuous development of new quality productive forces, modern industrial parks will continue to give play to their unique advantages and inject new vitality into economic and social development. This study uses various research methods, such as literature review and case analysis. By reviewing local and international literature, the latest theoretical and practical achievements in the standard plant design of modern industrial parks were understood. Additionally, through case analysis, the successful experiences and existing problems of typical modern industrial parks were analyzed. Through in-depth research on the design of standard workshops in modern industrial parks, key design factors affecting the development of new quality productive forces are identified. Optimization suggestions, aligned with the development trends of modern industry, are proposed to provide theoretical support and practical guidance for improving new quality productive forces and optimizing industrial structure.

2. Definition and characteristics of new quality productive forces

2.1. Definition of new quality productive forces

New quality productive forces are those that enhance production quality and efficiency through scientific, technological, institutional, and management innovations. It represents a brand new and high-quality development model, aiming to realize the transformation of economic growth mode and optimize economic structure. The core symbol of new quality productivity lies in its innovation and efficiency. Innovation is reflected in continuously adopting new technologies, processes, and formats to promote the production process's intelligence, greening, and flexibility. Efficiency is reflected in the optimization of the allocation of production factors and the improvement of input-output efficiency, which realizes the double improvement of the quality and efficiency of economic growth. The key to new quality productivity lies in innovation drive. Through scientific, technological, institutional, and management innovation, we will break away from traditional development models and promote the rapid advancement of productive forces. Simultaneously, it is necessary to strengthen the support of talents and cultivate a high-quality and innovative workforce. The essence of new quality productivity lies in upgrading and transforming productivity. The emergence of new productive forces marks another historic leap in developing productive forces in human society [2].

2.2. Characteristics of new quality productive forces

Compared with the traditional productive forces, the new quality productive forces rely on technological breakthroughs and innovation to improve productivity that is characterized by strong technological innovation, obvious industrial upgrading, high production efficiency, and optimized production structure (as shown in **Figure 1**). The specific characteristics of new quality productive forces are as follows:



Figure 1. Characteristics of new quality productive forces

(1) Strong technological innovation

New quality productive forces take technological innovation as the core and constantly promote technological progress and application innovation. This includes the introduction of advanced production technologies, processes, and equipment, improving the automation and intelligence level of the production process, as well as the development and application of new technologies, new processes, and new materials. Technological innovation is the fundamental driving force of new quality productive forces and the key to its difference from traditional productivity.

(2) Obvious industrial upgrading

New quality productive forces focus on both technological innovation in individual production steps and the overall upgrading of the industrial chain. This involves transforming traditional industries to become high-end, intelligent, and green, developing emerging industries, and promoting integration and coordinated development among various sectors. Industrial upgrading is an important embodiment of new quality productive forces and an important means to promote the optimization and upgrading of economic structure.

(3) High production efficiency

New quality productive forces significantly enhance production efficiency through technological innovation and industrial upgrading. This includes reducing energy and material consumption, lowering labor costs, improving product quality and added value, and shortening the product development to market cycle. Improved production efficiency is a key goal of new quality productive forces and a crucial support for promoting economic and social development [3].

(4) Production structure optimization

The new quality productive forces are committed to optimizing the production structure and promoting the transformation and upgrading of the industrial structure. This includes developing new industries such as high-tech industries, green economy, and modern service industries, transforming and upgrading traditional industries, and promoting the coordinated development of regional industries. The optimization of production structure is one of the important tasks of new quality productive forces and the key to promoting the sustainable development of the economy and society.

3. The role of modern industrial parks in the development of new quality productive forces

With the continuous progress of science and technology and the profound adjustment of global industrial structure, new quality productive forces have become the core driving force for economic and social development. In this context, modern industrial parks play an increasingly important role as an important platform for centralized display and cultivation of new quality productive forces. The following are some key roles of modern industrial parks in the development of new quality productive forces (as shown in **Figure 2**).

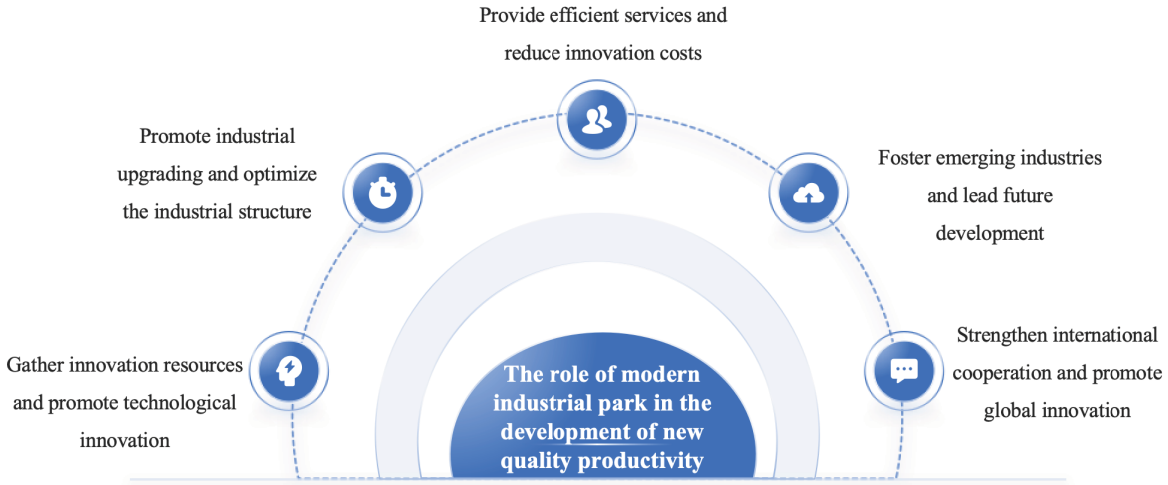


Figure 2. Key roles of modern industrial parks in the development of new quality productive forces

3.1. Gather innovation resources and promote technological innovation

Modern industrial parks usually gather a large number of research and development institutions, universities, innovative enterprises, and other innovative resources. These resources, through cooperation and exchange, form a strong innovation force. Enterprises in the park can make full use of these innovative resources to carry out technological research and development, product innovation, and other activities, to promote the formation and development of new quality productive forces [4].

3.2. Promote industrial upgrading and optimize industrial structure

Modern industrial parks often take a leading industry or industrial chain as the core and promote the overall upgrading of the industry by introducing and cultivating high-quality enterprises and optimizing the industrial chain structure. This not only improves the production efficiency of enterprises in the park but also optimizes the industrial structure and provides strong support for the development of new quality productive forces.

3.3. Provide efficient services and reduce innovation costs

Modern industrial parks usually have the advantages of perfect infrastructure and efficient government services, providing enterprises with a good environment for innovation. Enterprises can enjoy convenient services such as policy consultation, financing support, and personnel training in the park, which reduces innovation costs and improves innovation efficiency.

3.4. Foster emerging industries to lead future development

The modern industrial park not only focuses on the transformation and upgrading of traditional industries but also focuses on the cultivation and development of emerging industries. Through the introduction and cultivation of emerging industrial enterprises and the construction of relevant innovation platforms, modern industrial parks have injected new vitality into the sustainable development of new quality productive forces.

3.5. Strengthen international cooperation and promote global innovation

Modern industrial parks are usually characterized by openness and internationalization. This is done by strengthening cooperation and exchanges with international innovation resources, introducing international advanced technology and management experience, promoting the integration and sharing of global innovation

resources, and providing broader space and opportunities for the development of new quality productive forces.

4. The development trend of modern industrial parks under the background of new quality productive forces

4.1. Transformation and upgrading of industrial structure

Firstly, driven by new quality productive forces, modern industrial parks will pay more attention to the development of high-tech industries. The high-tech industry, with its high added value, high innovation, and high growth characteristics, has become an important engine to promote the transformation and upgrading of modern industrial parks. The park will actively introduce and cultivate high-tech enterprises, build high-tech industrial clusters, and enhance overall industrial competitiveness. Secondly, the modern industrial park will pay more attention to the collaboration and innovation cooperation of the industrial chain. By strengthening the cooperation and exchanges between upstream and downstream enterprises in the industrial chain, the integration and optimization of the industrial chain are promoted, improving overall industrial competitiveness. Thirdly, the park will also actively build an innovation platform, promoting integration between industry, university, and research, fostering the cooperation of innovation resources, and providing strong support for the transformation and upgrading of industrial structures. Fourthly, with the acceleration of globalization, modern industrial parks will pay more attention to internationalization and global development. The park will actively introduce international advanced technology and management experience, strengthen cooperation and exchange with international innovation resources, and promote the international development of the industry. Finally, the park will also actively participate in the global industrial division of labor and cooperation to promote the global layout and development of the industry (as shown in **Figure 3**).

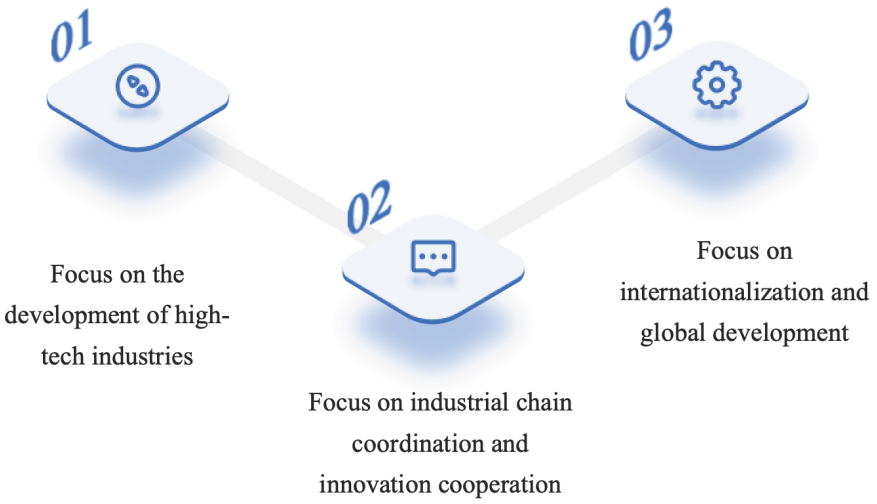


Figure 3. Future industrial development trends

4.2. Application of intelligent technology

With the rise of new quality productive forces, intelligent technology is gradually becoming the core driving force for the development of modern industrial parks. Modern industrial parks are actively introducing and cultivating intelligent production lines to improve production efficiency and product quality through automation, information technology, and intelligent technical means. The popularization of intelligent production lines will help reduce production costs and human error, and provide enterprises with more accurate and efficient

production methods. Concurrently, the Internet of Things technology is the key to achieving equipment interconnection and intelligent production. The modern industrial park will widely use this technology to connect various devices to form an intelligent system and realize the interconnection between devices. Through the application of the Internet of Things technology, enterprises can monitor the operating status of equipment, production data, and other information in real-time, providing strong support for production decisions. Additionally, artificial intelligence, as one of the fastest-developing technologies in the current field of intelligence, is achieving deep integration with modern industrial parks. The modern industrial park will use artificial intelligence technology to realize the rapid processing and analysis of big data and predict future trends according to the trend of the data. In the production planning and material management of enterprises, artificial intelligence will play an important role in helping enterprises achieve intelligent management and decision-making. Cloud computing technology can integrate and manage the data of various enterprises to achieve centralized data management and sharing. The modern industrial park will widely use cloud computing technology to provide enterprises with efficient and convenient data storage, analysis, and application services. Through the application of cloud computing technology, enterprises can improve data utilization efficiency, reduce data management costs, and further improve the overall efficiency and management level of enterprises. Finally, with the continuous development of intelligent technology, the modern industrial park will establish a more perfect intelligent service system. This system will cover intelligent consulting, intelligent training, intelligent maintenance, and other aspects to provide enterprises with a full range of personalized intelligent services. Through the establishment of an intelligent service system, the modern industrial park will further enhance the intelligent level of enterprises and promote the sustainable development of new quality productive forces (as shown in **Figure 4**).

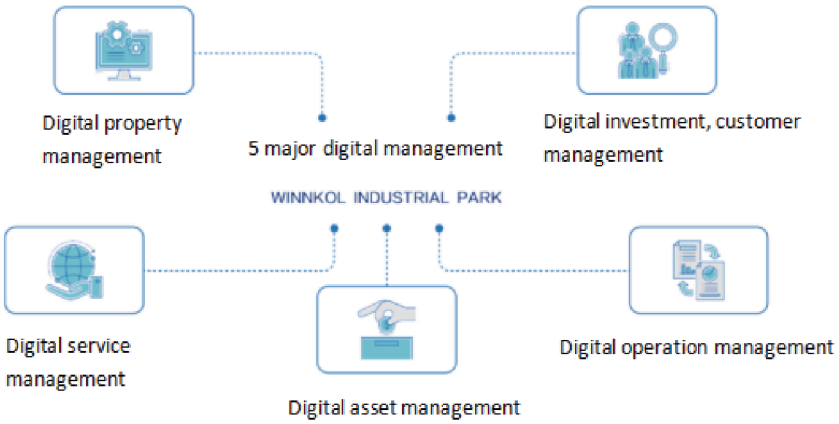


Figure 4. New quality productive forces contribute to the digital management of industrial parks

4.3. Green and sustainable development concept

With the rise of new quality productive forces, the concept of green sustainable development is gradually becoming the core guiding ideology of modern industrial park development. Modern industrial parks are vigorously promoting green production methods to reduce the impact of industry on the environment by adopting advanced energy-saving and emission-reduction technologies and improving resource utilization efficiency. At the same time, the park also encourages enterprises to carry out a circular economy, achieve waste reduction, resource, and harmless treatment, and promote the coordinated development of industry and the environment. Simultaneously, the modern industrial park pays attention to the construction of green buildings and promotes the design, construction, and operation of buildings in the park following green

building standards. Green buildings use energy-saving, environmentally friendly, and sustainable materials and technologies to reduce the impact of buildings on the environment, improve the energy efficiency and comfort of buildings, and create a greener and healthier working and living environment for enterprises and employees in the park. Moreover, the modern industrial park attaches great importance to the protection and management of the ecological environment and takes a series of measures to protect it. The park will strengthen ecological restoration and environmental governance, promoting biodiversity and ecological environment protection. The park also pays attention to the monitoring and assessment of the environment to promptly identify and address environmental issues, ensuring continuous improvement of the ecological quality of the park. Furthermore, the modern industrial park prioritizes green supply chain management, encouraging enterprises and suppliers to collaborate on achieving green procurement, production, and logistics. This optimizes supply chain management to reduce the environmental footprint and impact of products. Lastly, the park encourages enterprises to carry out green certification and labeling and promote the popularization and application of green products. By organizing green theme activities, training, and other awareness programs, enterprises and employees will engage in environmental protection activities, fostering a green, low-carbon, environmentally friendly production and lifestyle.

5. Analysis of key points of modern industrial park standard plant design

5.1. Reasonable function layout

The functional layout of the standard factory should fully consider the production process, material flow, personnel flow, and other factors to ensure that the production process is smooth and efficient. A reasonable functional layout can not only improve production efficiency, but also reduce the ineffective movement of materials and personnel, and reduce production costs. The standard plant design should fully consider the needs of logistics and people flow, set up reasonable channels, freight elevators, people flow channels, etc., to ensure the smooth flow of traffic [5].

5.2. Environmental protection and energy-saving requirements

Modern industrial park standard plant design should follow the principle of environmental protection and energy saving. The use of advanced energy-saving technology and equipment such as energy-efficient air conditioning systems, lighting systems, energy-saving building materials, etc., can reduce energy consumption and pollution. Concurrently, the plant design should also consider the use of natural conditions such as natural ventilation and lighting to reduce the dependence on artificial energy. In addition, the choice of building materials directly affects the service life, safety, and environmental performance of the plant. The standard plant design should choose high-performance and environmentally friendly building materials, such as external wall materials with strong weather resistance and internal wall materials with good thermal insulation performance to improve the overall performance of the plant [6].

5.3. Safety specifications

Safety is the top priority in plant design. Standard plant design should meet the national and industry-related safety specifications and standards to ensure the safety of plant structure, fire safety, electrical safety, and other requirements. Furthermore, the factory should also set up safety facilities and signs to improve the safety awareness of employees. Based on safety standards, space utilization efficiency is one of the important indicators to measure the design level of a plant. Standard plant design should fully consider the use of space, through reasonable column network layout, floor height design, equipment layout and other means to improve

the space utilization efficiency of the plant.

5.4. Complete equipment

The modern industrial park should be equipped with perfect production equipment and living facilities to meet the needs of production and staff life. Production equipment should be advanced and efficient equipment to improve productivity. Living facilities such as restaurants, rest areas, bathrooms, etc. should be fully equipped to meet the basic living needs of employees. Moreover, it is also necessary to consider humanized design. Plant design should fully consider the physiological and psychological needs of employees, and create a comfortable and healthy working environment. For example, setting up reasonable lighting and ventilation systems, providing comfortable working temperature and humidity, setting up staff rest areas, etc., to improve staff efficiency and satisfaction [7].

6. Conclusion

In summary, the development trend of modern industrial parks under the background of new quality productive forces shows that high-tech industries are led by green and sustainable development, digital transformation and intelligent upgrading, industrial chain coordination and innovation cooperation, and internationalization and globalization. These trends will jointly promote the transformation and upgrading of the industrial structure of modern industrial parks and inject new vitality into economic and social development. The main points of modern industrial park standard plant design involve many aspects, which need to consider factors such as functional layout, environmental protection and energy saving, safety norms, traffic flow, building materials, equipment support, space utilization, and humanized design. Through scientific and reasonable design, it can create an efficient, environmentally friendly, and safe modern industrial park standard factory building to provide strong support for industrial development. With the development of new quality productive forces as the background, this research deeply discusses the key points of standard plant design in modern industrial parks. Through literature review and case analysis, it is concluded that standard plant design of modern industrial parks plays an important role in developing new quality productive forces. At the same time, the key points of plant design should pay attention to reasonable layout, intelligent design, green environmental protection, flexibility, and scalability. These suggestions have important guiding significance for the construction and development of modern industrial parks in the future.

Disclosure statement

The author declares no conflict of interest.

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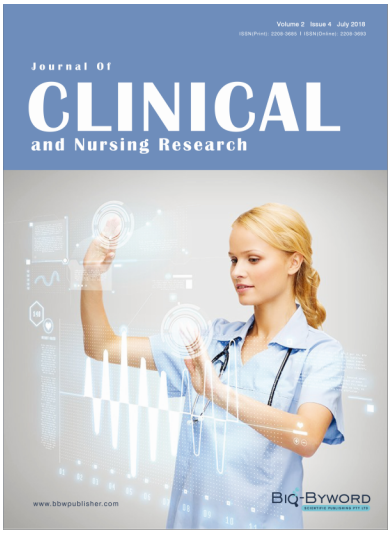
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