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Advantages and Development Prospects of Building Information Modelling (BIM) Technology Application in Highway Engineering

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Abstract: Based on the advantages of the application of Building Information Modelling (BIM) technology in highway engineering, this paper analyzes the difficulties of its in-depth application, grasps the pain points of the application of BIM technology in practice, and approaches from the integration of BIM design-construction. This paper also puts forward the integration of cross-stage information based on the BIM + Geographic Information System (GIS) construction information management system to realize the BIM whole life cycle management, and provides directional support for the continuous and efficient application of BIM technology in engineering practice.

Keywords: BIM technology; Highway engineering; Application advantages; Development prospects

Online publication: November 28, 2023

1. Introduction

With the increasing scale of highway project management system, the traditional information management platform inevitably generates problems such as performance degradation, expandability deterioration, and operation and maintenance difficulties when coping with such a complex system, thus limiting the adaptability and practicability of the system platform [1]. Although the state has put forward a clear deployment and policy orientation for the application of Building Information Modelling (BIM) technology, compared with foreign developed countries, there is still a certain gap in the application of BIM in China. On the one hand, relevant domestic departments should further strengthen the policy guidance and support to promote the popularization and application of BIM technology. On the other hand, construction industry enterprises should actively innovate, perform research and development, increase the promotion of BIM technology, improve the application level, and improve the technology chain [2]. Highway engineering construction process management based on BIM technology can improve the quality of the project, reduce the construction cost, and optimize the construction progress, which is an opportunity for change in the field of highway engineering management [3]. There is still a big gap between digital transformation and informatization construction in the field of domestic highway construction, and it is necessary to further strengthen forward-looking technical research and policy guidance [4].

BIM technology, as a fundamental application, will provide strong technical support for engineering BIM application and intelligent transportation due to its three-dimensional (3D) visualization and data integration capabilities. This paper takes the highway engineering design-construction process as the research object, carries out the application research in the construction phase of highway engineering, and explores its application advantages and development prospects.

2. Advantages of BIM technology application on highway engineering

2.1. Data synergy and interactivity

Synergistic interaction is an important part of the management process of all construction projects, and it is also necessary to form a positive and cooperative relationship between the construction company, designers, and direct participants in the construction project. However, with the development of information technology, the shortcomings of Computer-Aided Design (CAD) technology have been gradually exposed, and the synergistic relationship between the various links and roles in highway construction has not been effectively established. BIM technology, as a new technology, a new space, a new way of thinking, and a new program, encompasses the information model of the whole life cycle of highway construction, and at the same time, it covers all the data of the behavior of project management. The perfect integration of the two has brought about sweeping changes in information technology to the highway construction industry. For example, BIM technology can discover relevant conflict problems in the design stage of construction project in advance, report the conflict of each specialty in the pre-design stage through collision detection, and further optimize the design by discovering the corresponding conflict location through the conflict report. With BIM technology as a tool for information support, project participants using BIM technology can realize data sharing and business exchange in a unified information platform. BIM integrates project-related information in all stages of the project, which can prevent the occurrence of information complexity, loss, and reduced exchange efficiency that are easy to occur in traditional project management.

2.2. Visualization

The different BIM dimensions such as 3D solid model, 4D progress model, 5D cost control, 6D quality management, 7D safety control, and N^{th} generic dimension (nD) management application comprehensively show the whole picture of the project site, and at the same time, each component is detailed, so that the project management becomes clear and visible. It can also realize the whole process of bidding, tendering, planning, construction, and operation, as well as the visualization of communication, discussion, and decision-making.

For example, after the application of BIM technology in the process of investigation, design, and construction of highway projects, it can significantly improve and enhance the visualization effect of the results, improve the level of design and construction quality, and facilitate the effective connection of all parties involved in the construction project. Moreover, the formation of the BIM data system is conducive to the project owner's operation and management in the later stage, and to the construction of the whole life cycle of transportation construction projects and the building of the system, which saves the national investment and construction funds, shortens the construction period, and guarantees the operation and maintenance of the project [5-7].

2.3. Facilitating information management

In traditional construction management, various problems in the project will usually be categorized according to quality, progress, cost, and safety categories. However, BIM technology directly connects the above problems with the names of model component locations, which is not only well done, but also well done in the later work.

2.4. Integration

BIM technology can help highway projects to achieve integrated management of the whole life cycle, from design and construction to operation and maintenance, and provide efficient, accurate, and reliable decision support for highway construction, so as to optimize the management and control of the whole project.

3. Difficulties in the application of BIM technology on highway projects

3.1. BIM system application requires a high degree of technical integration

BIM application needs to be seamlessly connected with the industry's technical knowledge system, the synergy of information and data is particularly important, but it also needs to integrate Geographic Information System (GIS), Internet of Things (IoT), Information and Communications Technology (ICT), big data, cloud computing, and other new technologies. However, many new technologies are still in the development stage and cannot efficiently support the BIM model of high-efficiency, high-precision, real-time application of the data requirements, so the application of BIM technology in the management level needs to be explored. Moreover, the development of highway engineering is lagging due to its larger span, more complex influencing factors, and higher technical requirements, and many application practices have transferred technical difficulties.

3.2. Lack of software development and application standards and specifications

BIM technology in the field of highway construction is in the process of gradual development and promotion, and application of practice, data silos, and data exchange problems gradually emerged. The domestic application and promotion of standards such as Information for Construction (IFC), National Building Information Model Standard (NBIMS), and other standards still have a long way to go, and the expansion of standards from the construction engineering field is also progressing slowly. Therefore, to pursue the application of BIM technology in the field of highway engineering or even the construction industry, comprehensive and feasible standard specifications should be formulated.

3.3. Difficulty of cross-stage information integration

From pre-decision-making to investigation and design, to construction management and lastly to the operation and maintenance stage, BIM has a good application prospect in the field of highway engineering, but the parties involved in the construction of BIM application at different stages have different concerns. There is a disconnect between the design-construction and the two major phases of the construction, how to effectively promote the transformation of the construction management model to break the traditional stage of the "information island" and "data," and "data integration," as well as breaking the "information silo" and "data barriers" between the traditional stages is crucial.

4. Development prospects of BIM technology in highway engineering

4.1. BIM design-construction integration

The first step of BIM design-construction integration is the analysis of information needs, in the understanding of the construction of the different concerns of all parties to the project, clear information is needed at each stage. According to the content of the demand, the data format will store different information according to the pyramid format, from top to bottom, from new to old. Data that is more recent or used more frequently is placed on the top level of the table for easy extraction and use, and old data is placed in the lower level, until the last permanent storage table, the efficiency of data processing can be effectively improved through the conversion of old and new tables.

Next, the design unit needs to utilize the BIM + GIS platform as a tool to integrate the results of the design phase, and transfer the relevant data and information generated from the project decision-making to the construction, and operation and maintenance to ensure that all parties involved in the construction of the project can maintain efficient communication, but also to provide first-hand design documents for construction, and operation and maintenance phases. The construction unit should fully understand the designer's design intent, combined with the owner's comments, and subsequent operation unit needs to organize the construction program, part of the construction phase monitoring, and long-term monitoring, for the operation period of the operation, management, and maintenance work in order to provide convenience.

Lastly, a large amount of data will be generated during the management and construction process. The method to filter out information that can help different stages of design, construction, and post-operation is the focus of cross-stage integration. The collection path and the characteristics of different information should be analyzed to find the rules of summary processing.

4.2. Cross-stage information integration

The research and development and application of BIM + GIS construction information management system will provide a macro integration platform for the overall project for multiple participants, and each participant in the project can use the digital sand table to carry out practical applications in the following scenarios. The overall project overview browsing, construction program display, and engineering construction overall construction report can be achieved; the platform is used to realize research and discussion of part of the construction program; on-site analysis and evaluation of the positional relationship between the entire project and environmentally sensitive parts can be conducted.

BIM + GIS technology has a powerful data fusion function, which can be used to collect and summarize the data volume of the whole life cycle of highway engineering, but the data volume of the whole life cycle are massive, heterogeneous, and multi-source, and how to effectively divide the data and manage it scientifically requires the construction of a whole life cycle information storage platform based on BIM + GIS. At present, although the development of domestic BIM + GIS construction intelligence platform is in full swing, many of them are only cross-phase integrated storage of information, in which the information collection process lacks the BIM + GIS platform as a basis. The information collected in this way is difficult to play a role in project target control, therefore, BIM technology is integrated and penetrated into all aspects of the highway engineering construction process to achieve project-level full life cycle control, thus the BIM-based information collection methods need to be further researched.

5. Conclusion

The low degree of informatization of the whole life cycle of traditional highway engineering projects, the lack of electronic information, and the difficulty of accessing paper information are the major problems that restrict the intensive and intelligent development of engineering project management. With the in-depth development of BIM + GIS technology, a design-construction integrated information data storage platform is constructed. Through the BIM + GIS integrated information platform integration, this paper analyzed and put forward the difficulties in information integration, proposed a cross-stage information collection method, and realized the design and construction based on the web side of the data integration, and built the design and construction of the integrated application based on the same data source.

In the future, during the operation phase of the project, the engineering data required during the operation and maintenance period can be extracted by means of the “data pump” of the BIM + GIS platform in order to carry out the overall digital handover of the project. Combined with the needs of inspection, maintenance, scheduling, and operation during the operation and maintenance period, various technical means such as Internet of Things (loT) and Artificial Intelligence (AI) can be adopted to play a valuable role in project management.

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Revitalizing Island Villages: A Comprehensive Analysis of Sustainable Landscape Renewal Strategies Through the Three-Pillar Conception

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Abstract: In recent years, the study of production-living-ecological space has progressively expanded from urban to rural areas. With the onset of a new era in rural development, diverse requirements for rural landscapes have emerged. Consequently, rural landscape planning in this new era is incorporating the three-pillar conception of sustainability. Island villages, with their distinct natural ecology and marine resources compared to inland villages, offer unique conditions, resulting in the production of diversified landscape types with significant development potential. Despite the limited attention given to the domestic development of island villages, this paper delves into the analysis of the three-pillar conception of sustainability and explores landscape protection strategies and renewal modes specific to island villages. To illustrate these concepts, East Xiaoqing Island Village in Rushan City, Weihai City serves as a case study.

Keywords: Island villages; Rural landscape; Production-living-ecological space; Rural revitalization.

Online publication: November 28, 2023

1. Introduction

China boasts a coastline stretching over 32,000 kilometers and is home to more than 7,000 islands covering an area of 500 square meters or more. Island villages, serving as vital repositories of coastal residential culture, are scattered along the coastline within a few kilometers of each other [1-4]. Island villages exhibit substantial differences in ecological resources, production, life, and cultural heritage when compared to inland villages. Their distinctive landscape types not only reflect unique multicultural values but also hold considerable development potential.

While recent years have witnessed a focus on the development of tourism resources and economic benefits in island villages, research on the construction of their landscape layout has been comparatively limited. Consequently, some island villages have experienced a significant loss of authenticity, uniqueness, and even ecological damage. Weihai City, situated in Shandong Province as the easternmost city of the Shandong Peninsula, exemplifies a typical coastal city. The advantages of its coastal zone have given rise to numerous fishing and aquaculture-led coastal villages with unique natural scenery, fostering a distinct village culture [5].

Building upon this backdrop, this paper explores the three-pillar conception of sustainability within the context of an island village, using East Xiaoqing Island Village in Rushan City, Weihai City, as an illustrative example. The study delves into the three-pillar conception of sustainability, emphasizing the need for a comprehensive approach to sustainable development. Taking East Xiaoqing Island Village as a case study, the paper investigates the landscape renewal model based on the three-pillar conception of sustainability. The findings aim to provide valuable insights and a decision-making foundation for the sustainable and high-quality development of other island villages.

2. Relevant concepts and explanations

2.1. Island village landscape

Island villages distinguish themselves from their inland counterparts by being enveloped by seawater, offering splendid coastal scenery and abundant marine resources. For generations, island residents have relied on fishing as a way of life [6], resulting in a landscape dominated by aquaculture and fisheries. The absence of bridges and transportation channels around these islands necessitates daily travel by boats, which also serve as essential tools for the residents' fishing activities.

Island villages exhibit distinct regional environmental characteristics shaped by latitude and climate, predominantly featuring an oceanic climate. Although their ecosystems often display noticeable differences between the northern and southern regions, they generally experience four distinct seasons, uniform precipitation, and a regional variation in vegetation. However, despite the superior ecological landscape of these villages, their ecosystems are frequently less diverse, making them more susceptible to disruption and damage.

Island villages, situated away from the hustle and bustle, boast honest and enthusiastic villagers. The captivating natural scenery has fueled the recent rise of the countryside tourism industry. This surge in rural tourism has, in turn, spurred the enhancement and renewal of village infrastructure and public services. Consequently, the living landscape of these villages is gradually undergoing adaptive adjustments from traditional to modern, marking a transformative process driven by the evolving demands of the tourism industry and the changing needs of the villagers.

2.2. Production-living-ecological space and the three-pillar conception of sustainability

Currently, research on production-living-ecological space (PLES) in the domestic context has expanded across various fields since its inception. However, the majority of this research focuses on larger-scale entities such as cities or counties, with relatively limited exploration into smaller scales like the countryside [7].

PLES encompasses ecological, production, and living spaces. Rural ecological space amalgamates natural attributes, providing environments that yield ecological products and services for the countryside. Rural production space serves as a spatial carrier with economic benefits, contributing to the production of agricultural goods. Meanwhile, rural living space functions as a public facility, serving as a place for villagers to reside and utilize in their daily lives.

The three-pillar conception of sustainability entails viewing the social, economic, and environmental factors of the countryside holistically, facilitating unified and coordinated planning. This involves refining resource elements and integrating the natural and humanistic environment of the countryside in a multifunctional manner. The aim is to rectify the structural imbalance stemming from the original single-function approach and realize the sustainability of rural areas [8].

3. Exploration of a landscape revitalization strategy for island villages based on the perspective of the three-pillar conception of sustainability

3.1. The application value of the three-pillar conception of sustainability in island village landscape revitalization and renewal design

The development of traditional Chinese villages adheres to a logical structure where three interconnected spaces – ecology, life, and production – form an organic system with wholeness. In the context of the proposed rural revitalization strategy, villages are undergoing design and transformation trends aligned with the principles of the three-pillar conception of sustainability. This approach emphasizes the ecological environment as the foundation, industrial development as the driving force, and living services as the content to achieve the goals of village revitalization and de-hollowing.

The three-pillar conception of sustainability signifies a profound integration of social, economic, and environmental factors, creating a place where humans and nature coexist harmoniously. In the case of island villages, it involves leveraging the natural resources of the island to craft a comfortable ecological environment for residents to enjoy life and work. The cultural aspect is vital for sustaining a space over generations and encapsulates the daily life of villagers, contributing to the preservation of the wholeness of the village space. When transforming unused or dilapidated spaces, careful consideration should be given to maintain their original style and overall landscape pattern. The transformed village becomes a hub for new forces of development.

The core of the three-pillar conception of sustainability should encompass three key elements: nature, economy, and society, all of which aim to foster a balanced integration of social, economic, and environmental considerations in the design and development of island villages.

3.2. Basic principles of island village landscape revitalization and renewal

Considering the current state of island development, the successful revitalization of an island village landscape hinges on several key factors. Firstly, there is a need to prioritize ecological environmental protection by respecting and safeguarding the natural resources of the island. This involves maximizing the utilization of the island's ocean, land, and climate resources to foster sustainable development. Secondly, a comprehensive approach involves delving into the cultural heritage of the island village, shaping the characteristics that define the memories unique to the island. Thirdly, diversifying economic sources for island villagers is essential. Beyond traditional fisheries, attention should be directed towards innovating and ensuring the sustainability of the tourism industry. This is crucial for maintaining the originality, integrity, and sustainability of the island village landscape.

Moreover, in the planning and design of island village landscapes, beyond the focus on nature, culture, and economy, the distinctive sense of place the island villages offer deserves careful consideration. The sense of place experienced by individuals can vary, and analyzing the uniqueness of this island's sense of place can further enhance the synergy of the production-living-ecological space within the village (**Figure 1**).

3.3. Exploration of the revitalization and renewal strategy for the island village landscape under the perspective of the three-pillar conception of sustainability

For the landscape design of island villages to undergo true revitalization and renewal, it must fully leverage the natural and human resources of the island, prioritize the sustainability of economic development, and achieve a delicate balance among nature, culture, and economy. In pursuit of this goal, three key aspects of revitalization and renewal strategies – exploring the source, tracing the flow, and continuation – are proposed to delve into the conditions of the three-pillar conception of sustainability for island villages.

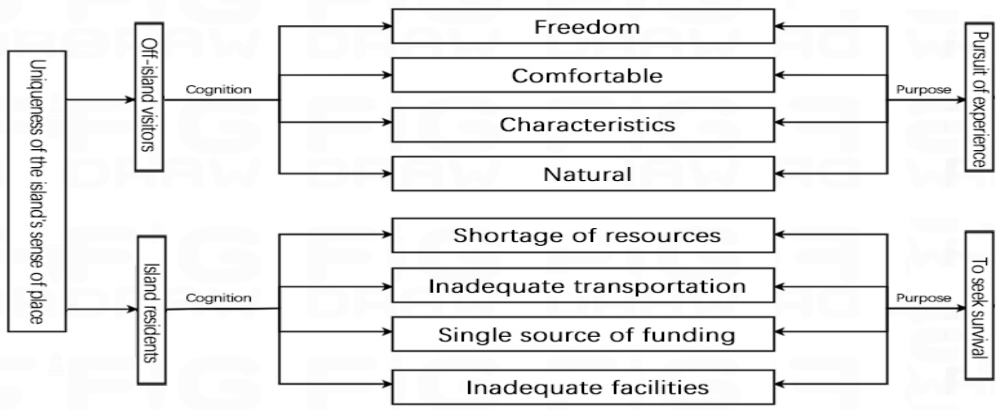

Figure 1. Analysis of the uniqueness of the island's sense of place

3.3.1. Exploring the origin: Respecting the original conditions of the site

The foundation of the three-pillar conception of sustainability rests on respecting the original conditions of the site. This involves a focus on the site's ecology, conducting thorough research, and analyzing the characteristics of the local natural environment, embodying the concept of 'exploring the source.' By maintaining respect and reverence for the site, this nature-centric design not only reduces resource waste but, more importantly, fosters a more coordinated countryside and environment, creating harmony among people, nature, and places.

3.3.2. Traceability: Creating spatial landscape media

At the heart of the three-pillar conception of sustainability lies the creation of spatial landscape media, emphasizing the shaping of suitable landscape spaces that integrate nature and human life. This is achieved through the concept of 'traceability,' which involves focusing on villagers' lives and "backstreaming" nature into the design. The creation of spatial landscape media prioritizes flexibility and innovation. Given the unique natural advantages of island villages, landscape design should explore materials and forms in the natural environment, combining them with the island's unique elements to infuse the landscapes with distinct island characteristics.

3.3.3. Continuation: Optimizing industrial spatial layout

The key to the three-pillar conception of sustainability lies in optimizing the spatial layout of industry, focusing on village production, and providing robust support for local construction and development, encapsulated in the concept of "continuation." The optimization of the island village's spatial layout is a crucial aspect of the island's industrial development, requiring alignment with the specific circumstances of the island village.

4. East Xiaoqing Island Village landscape design and renovation practice and exploration

4.1. Project overview

Situated in the eastern part of Rushan City, Weihai City, East Xiaoqing Island Village is a traditional fishing village intimately connected to the sea. Separated from the mainland by 4.7 nautical miles, the village spans a total area of 0.56 square kilometers on the island. On a macroscopic scale, China's islands exhibit a characteristic distribution of "more in the south and less in the north, more in the near shore and less in the far shore." East Xiaoqing Island Village, being secluded from the hustle and bustle, provides an excellent opportunity to experience the lifestyle of the northern islands' fishermen. On a meso level, Weihai City has strategically planned the "Thousand Mile Mountain and Sea Self-Driving Tourism Highway Route" (refer to **Figure 2**), showcasing captivating coastal scenery, mountains, seas, islands, and bays. East Xiaoqing Island Village falls along one of the routes, positioning it advantageously as a potential tourist attraction in Weihai City. Microcosmically, East Xiaoqing Island Village boasts a unique natural environment, with hospitable islanders and low overall development, embodying a paradise-like setting floating in the sea. Hence, this village is chosen as the subject for designing and exploring the revitalization and renewal of island village landscapes through the lens of the three-pillar conception of sustainability.

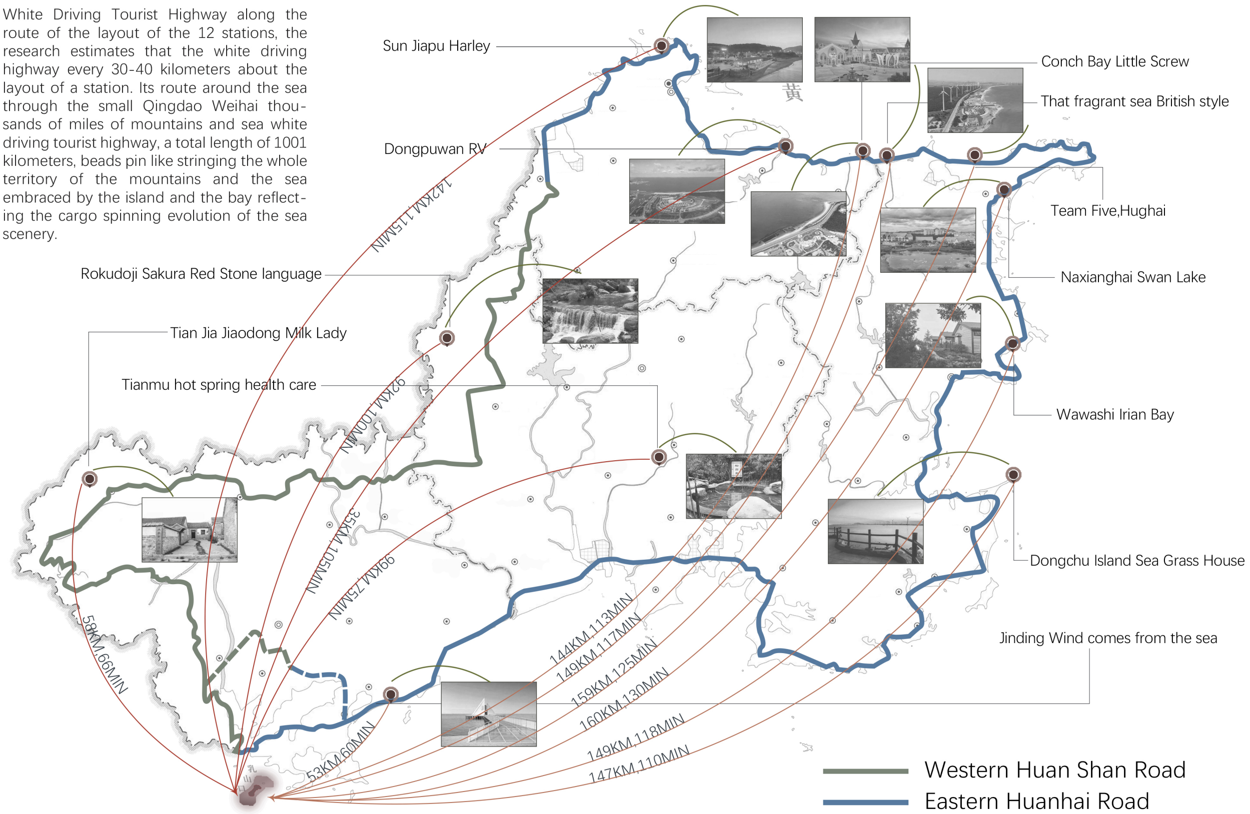

Figure 2. Traveling route of Weihai's "Thousand Mile Mountain and Sea Self-Driving Tourism Highway"

4.2. Problems of the current situation of the site

Through preliminary research and analysis of site factors such as roads, vegetation, facilities, and buildings (refer to **Figure 3**), several issues have been identified within East Xiaoqing Island Village. Firstly, regarding the ecological environment, abandoned aquaculture ponds have adversely affected the pristine coastal ecology, and indiscriminate disposal of domestic waste has further impacted the coastal landscape. Secondly, concerning cultural memory, there is a disconnect in the transmission of the island's sea defense culture, fishery culture, and folklore, particularly evident in the younger generation's limited understanding of fishery culture. Thirdly, in the realm of the production industry, problems include damaged wharves and breeding ponds, along with depleted soil fertility on the island's terraces. Fourthly, in terms of life and recreation, there is surplus unused space in the village with insufficient leisure areas and imperfect recreational facilities. Lastly, regarding transportation, rational path planning is absent, necessitating additional transportation facilities on the existing foundation to enhance the overall transportation experience and achieve an effective synergy between production and excursion routes.

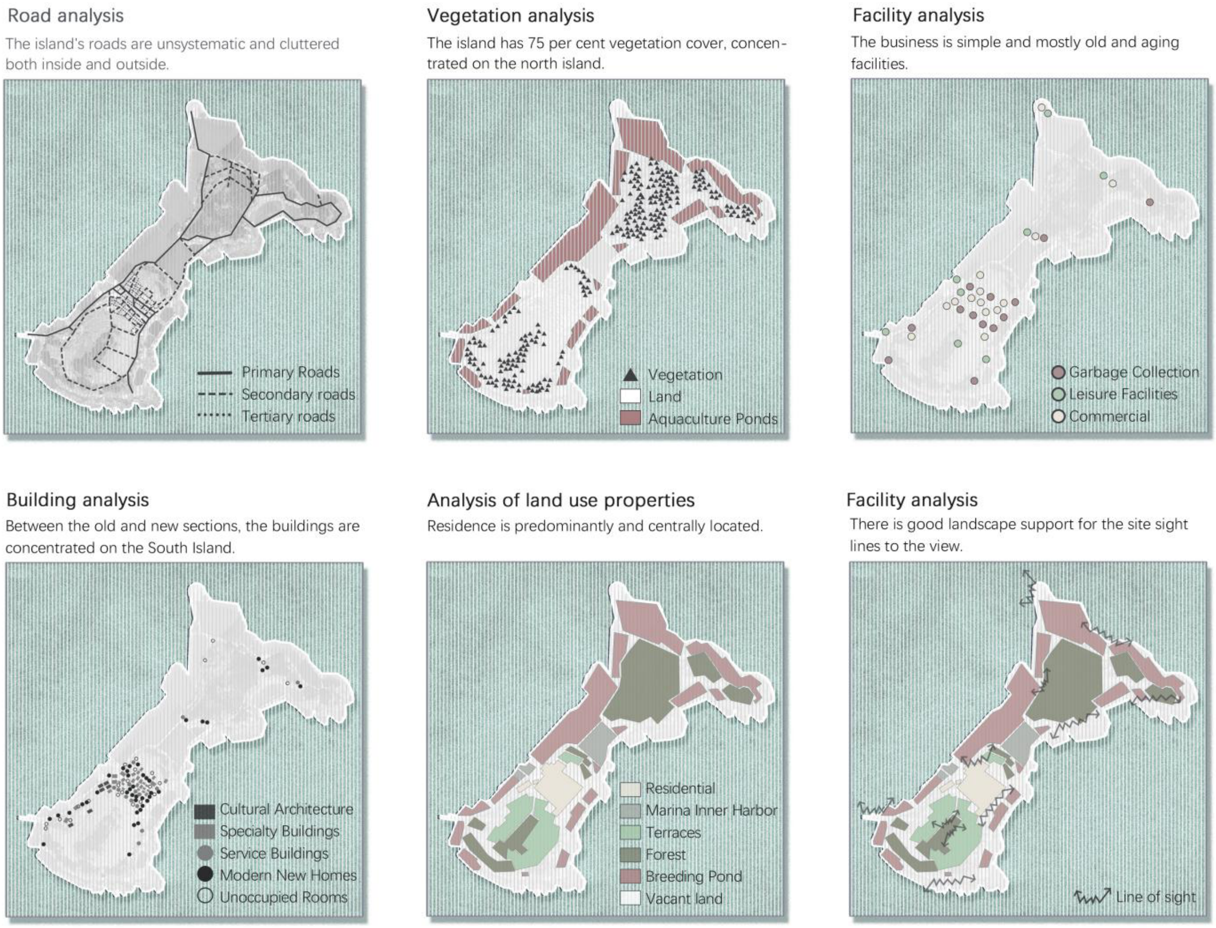

Figure 3. Factor analysis of the site

4.3. Design strategy

In the course of rural revitalization, the primary focus of the design revolves around the production function, ecological function, and life function inherent in the island fishing village. Designing for island empowerment involves three key aspects: environmental empowerment, spatial empowerment, and power empowerment.

Firstly, environmental empowerment emphasizes ecological sustainability, prioritizing respect for the site's native natural resources and maintaining the balance of the site's ecological structure. This involves the preservation of the island's environmental integrity and the responsible use of its natural assets. Secondly, spatial empowerment emphasizes design activation. Recognizing the irrational design and planning of unused space, the approach involves a people-oriented use of design empowerment. Thirdly, power empowerment centers on industrial development. The hollowing out of villages often results in the idleness of village space. Consequently, the development of industry serves to give purpose and vitality to these underutilized spaces. In essence, the development of industry provides power to the previously unused village areas, contributing to the overall empowerment and revitalization of the island community.

4.3.1. Exploring the source: Blue and green concepts interweaving to maintain the native environment

This strategy centers on the symbiotic relationship between the artificial environment and nature in the design process. Leveraging East Xiaoqing Island Village's significant resources – the ocean and the lush black pine forests (**Figure 4**) – the ecological concept of "interweaving blue and green" is proposed.

Figure 4. Scenery of East Xiaoqing Island Village, Rushan City, Weihai City, China.

The blue concept (**Figure 5**) entails marine ecological restoration, encompassing oyster shell beaches, reef beaches, and abandoned breeding ponds along the ecological coast. Oyster shell beaches stabilize the coastline, reduce erosion, and enhance the site's attractiveness as a tourist destination.

Figure 5. The blue concept

The green concept (**Figure 6**) focuses on terraces, ecological agriculture, and forest protection. The naturally occurring black pine forests on the north of the island are preserved with minimal artificial intervention. The south of the island features expansive terraced rice fields, cultivated with ecological agriculture techniques that promote sustainability. The renovation process involves publicizing and popularizing ecological agriculture concepts among the island villagers, encouraging the resourceful use of biochar and organic waste materials such as straw, seed husk, and dung to increase carbon sinks in farmland.

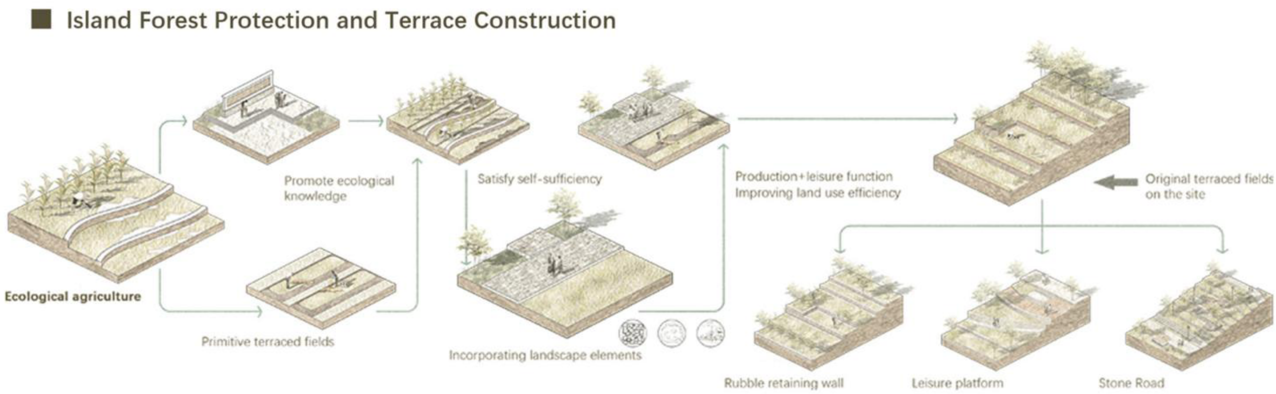

Figure 6. The green concept

In essence, the strategy of blue-green intertwining maximizes the utilization of the natural environment and resources. Through complementary cooperation between marine ecological restoration and terraced eco-agriculture, a sustainable island ecosystem is created, contributing to the overall revitalization and renewal of East Xiaoqing Island Village.

4.3.2. Retrospective: Reshaping and optimizing residents' unused space

The island's historical buildings are primarily concentrated at the village entrance facing the seaside. The sea defense legacy structures have created a unique courtyard space, and the design process will emphasize the protection and utilization of these unused legacy buildings. The reuse of on-site buildings falls into two categories: replacement and juxtaposition.

In the replacement type, unused or dilapidated building space retain their main structural framework or continue their original function, with modifications to align with contemporary lifestyle needs. The juxtaposition type involves the optimization of original functions in unused spaces. New functions are introduced based on usage demands or development needs, enabling the juxtaposition of different functions.

For instance, the spatial transformation of the village entrance square (**Figure 7**) utilizes a blend of old and new spaces, integrating the original single leisure space with viewing and cultural spaces. This approach achieves a transformation and upgrade of spatial functions.

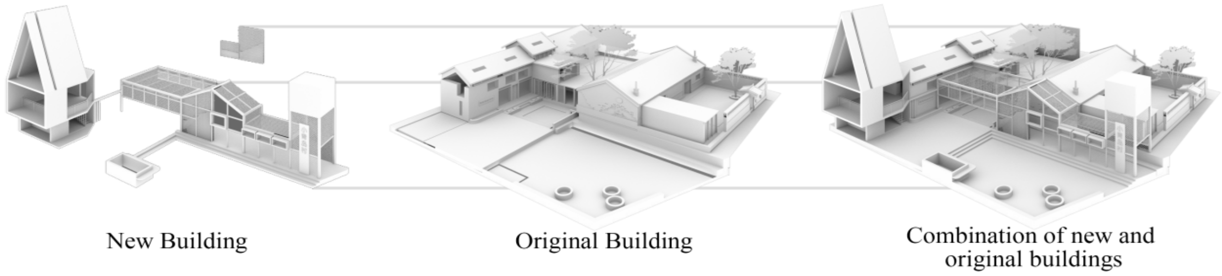

Figure 7. Spatial transformation of the village entrance square

Additionally, emphasis is placed on the recycling of waste materials, such as oyster shells used as construction materials. Due to their natural texture and excellent corrosion resistance, oyster shells serve as construction materials. New or renovated buildings are constructed with a steel frame to ensure structural stability, while decorative materials made from discarded oyster shells replace traditional options. This not only safeguards the buildings but also showcases the texture of local materials, seamlessly blending the structures into the local scenery and promoting sustainable development.

4.3.3. Continuation: Activating elements of island culture and tourism development

Weihai, renowned as the hometown of oysters, boasts a rich tradition of fisheries in East Xiaoqing Island Village. The village's mariculture has established a stable economic model, yet cultural tourism remains underexplored. In planning the island's tourism landscape space, unique cultural factors from the island are extracted, focusing on the fishery culture of East Xiaoqing Island Village and the culture of sea defense. The Fishery Custom Experience Area and the Sea Deferense Culture Study Area are established (**Figure 8**). Simultaneously, utilizing local characteristic culture as the source of elements, various signs and symbols are designed in the landscape of the site and applied throughout the entire space. This approach fully considers the requirements of island culture inheritance and development, aligning with the needs of villagers' residences to craft a distinctive island village landscape and cultural atmosphere. In doing so, the local culture empowers the industry, and the industry, in turn, propels the development of the village.

5. Conclusion

In conclusion, the practical significance of the three guiding principles in island village landscape revitalization and renewal design manifests in three main aspects. First, by incorporating the concept of blue-green intertwining through environmental empowerment, the design better captures the natural environment and humanistic history of the island. Second, through spatial empowerment, delving into the cultural heritage of island villages enhances landscape space to contribute to the island economy's prosperity. Third, via industrial empowerment, understanding the unique sense of place on the island, combined with island culture, propels the development of cultural tourism, enhancing the island village landscape to offer an enriched life experience.

Illustrated by the design example of East Xiaoqing Island Village, the changing landscape due to urbanization and evolving production modes in island fishing villages necessitates the integration of ecological,

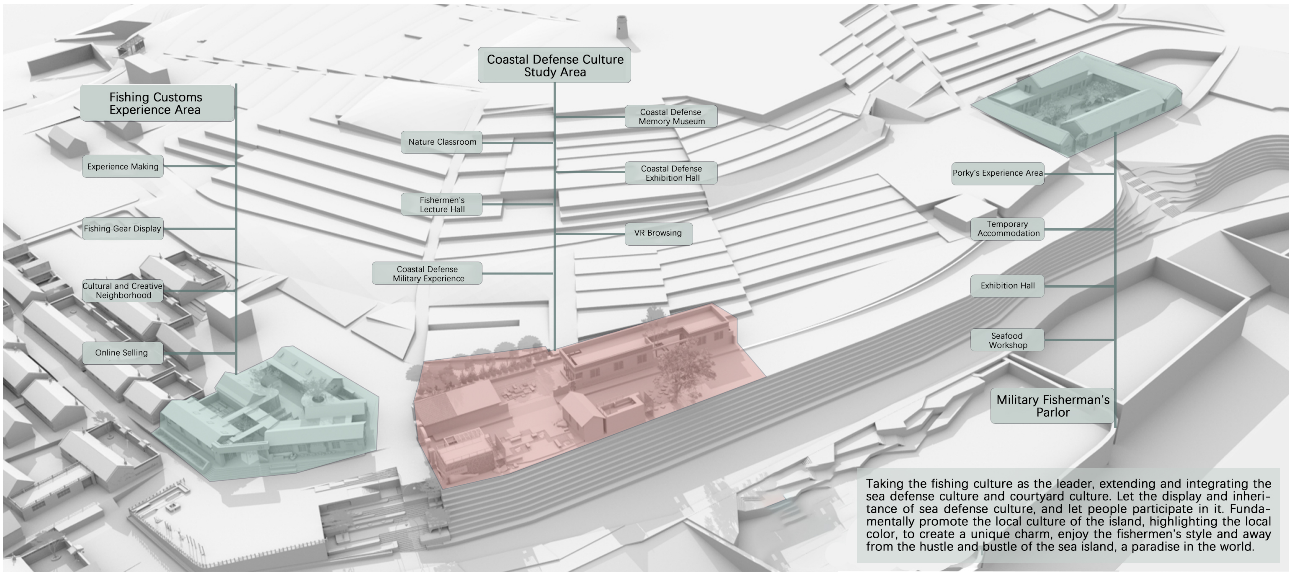

Figure 8. Cultural and tourism functional area plan

life, and production landscape resources for sustainable development. Utilizing the three-pillar conception of sustainability, the essence of the site is extracted, comprehensively considering the site's current state. Through the integration of island landscape elements, a framework for the three-pillar conception of sustainability is constructed. This provides theoretical and practical guidance for rebuilding the island village's sense of wholeness and belonging, facilitating the revitalization and renewal of island space.

Disclosure statement

The authors declare no conflict of interest.

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The Evaluation of Alternative Risk Control Schemes Based on Cumulative Prospect Theory

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Abstract: Based on the analysis of the evaluation problems associated with the risk control scheme for major engineering projects, the evaluation method of the risk control scheme considering the irrational behavior of evaluation members in fuzzy random environment is proposed. Firstly, a maximum entropy model corresponding to any evaluation member is established by using triangular fuzzy random variables and grey correlation coefficient in order to obtain the weight of each risk factor of the member. Secondly, a nonlinear programming model is established according to the principle of minimizing deviation to estimate the weight of different evaluation members on the evaluation of alternative risk control schemes. Lastly, the cumulative entropy model is used to calculate the weight of risk control schemes. Cumulative prospect theory obtains the comprehensive prospect utility value of each alternative to determine the optimal alternative.

Keywords: Major project; Risk assessment; Cumulative prospect theory

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1. Introduction

The implementation of major engineering projects is a typical high-risk operation, therefore, the safety management of major engineering projects is exceptionally challenging [1]. The implementation unit of major engineering projects should actively carry out the construction of risk investigation and control system in accordance with the relevant national and local requirements. The evaluation of the risk control scheme is an important link in the process of risk investigation and control, and the selection of a reasonable risk control scheme is of great significance for enterprise security management.

The expert scoring method was used to represent the preference information of evaluation objects [2]. This method is easier to use, but in the actual operation process, evaluation members often prefer to give higher scores in risk evaluation, resulting in low accuracy of conclusions obtained by this method [3]. The analytic hierarchy process (AHP) was introduced to require evaluation members to make pound-to-pair comparisons of evaluation objects, which improved the consistency of evaluation conclusions [4]. However, there are many uncertain and complex information in the decision-making process of the risk control scheme, which increases the difficulty of the popularization and application of AHP and network analysis [5]. Some scholars have introduced the fuzzy method and multi-attribute decision-making method to study the evaluation of risk control schemes [6]. The decision-making method based on fuzzy theory can better reflect the fuzziness of preference information, and the decision-making method based on multi-attribute is very consistent with the multi-factors of the evaluation of risk control schemes, and the conclusions obtained are more in line with the actual situation. These methods of evaluating risk control schemes are becoming new research topics.

It should be further considered that empirical expectations are often present in the evaluation of risk control schemes of major engineering projects by evaluators. In the actual evaluation process of risk control schemes, the importance and relevance of each key indicator are the key factors affecting the determination of the weight of the indicator. In addition, the re-evaluation process is complicated by varying circumstances of different evaluation members with correspondingly distinct levels of importance, which increases the difficulty in forming the evaluation conclusion. However, the traditional expected utility theory cannot explain the reference dependence existing in the evaluation process of evaluators. Therefore, the prospect theory is applied in this paper to solve the above problems [7]. In this paper, by using triangular fuzzy random variable, we can accurately describe the relationship of redundancy, complementarity, and preference among evaluation indicators under different alternative schemes, and use the cumulative prospect theory to describe the different risk preferences and reference dependencies of evaluation experts, so as to select the best risk control scheme for major engineering projects.

2. Proposed approach

2.1. Estimating marginal expectation and variance decision matrix of alternative risk control schemes for major engineering projects

Assuming that the evaluation value of evaluation indicators of alternative risk control schemes by evaluation members is triangular fuzzy random variable, a decision matrix corresponding to evaluation members is constructed:

$$\begin{cases} \chi^k = [\chi_{ij}^k(\beta_{ij}^k)]_{m\times n} \\ \chi_{ij}^k(\beta_{ij}^k) = [\gamma_{ij}^k(\beta_{ij}^k) - a_{ij}^k, \gamma_{ij}^k(\beta_{ij}^k), \gamma_{ij}^k(\beta_{ij}^k) + b_{ij}^k] \end{cases} \quad (1)$$

The expectation and the variance of the triangular fuzzy random variable are determined by (2) and (3), respectively.

$$E^k = [E(\chi_{ij}^k)]_{M\times N} \quad (2)$$

$$V^k = [V(\chi_{ij}^k)]_{M\times N} \quad (3)$$

According to the corresponding decision matrix, the expectation and the variance of the triangular fuzzy random variable are determined as $E(x_{ij}^k)$ and $V(x_{ij}^k)$, respectively. The expected mean value of alternative risk control schemes for major engineering projects can be obtained by (4):

$$\overline{E}_{ij} = \frac{E(\chi_{ij}^1) + E(\chi_{ij}^2) + L + E(\chi_{ij}^l)}{l} \quad (4)$$

2.2. Obtaining the evaluation member weights of alternative risk control schemes for major engineering projects

The maximum entropy model based on the objective weight of the grey correlation coefficient is used to solve the weight of the evaluation members on different evaluation indicators.

The grey correlation coefficient matrix corresponding to the weight of key indicators can be obtained by equation (5):

$$\xi^k = \begin{bmatrix} \xi_1^k(1) & \xi_1^k(2) & \ldots & \xi_1^k(N) \\ \xi_2^k(1) & \xi_2^k(2) & L & \xi_2^k(N) \\ M & M & O & M \\ \xi_M^k(1) & \xi_M^k(2) & L & \xi_M^k(N) \end{bmatrix} \tag{5}$$

According to the decision matrix of each evaluation members, the weight variance of evaluation members for alternatives is determined as:

$$D_2^k(i) = \frac{1}{N}\sum_{i=1}^{N}\left(\pi_j^k(i) - \frac{1}{N}\right)^2 \tag{6}$$

Assuming that the weight of the evaluation members for the alternative project is w_k. According to the principle of the deviation minimization between the comprehensive expected value of each alternative and the mean of the comprehensive expected value of the evaluation team, a deviation minimization model is established as follows to determine the weight corresponding to each evaluation member:

$$\min R = \sum_{i=1}^{M}\sum_{k=1}^{L}\left[w_k\left(M(E_i^k) - \overline{M}(E_i^k)\right)^2\right] \tag{7}$$

$$\begin{cases} M(E_i^k) = \sum_{j=1}^{N}\pi_j^k E[\chi_{ij}^k]; \\ \overline{M}(E_i^k) = \sum_{j=1}^{N}\pi_j^k \overline{E}_{ij}; \\ \sum_{k=1}^{L} w_k = 1; \end{cases}$$

Through solving the above model, the weight vector of the key indicators of the risk control scheme of major engineering projects corresponding to the evaluation members is determined as $\pi^k = \{\pi_1^k, \pi_2^k, \cdots, \pi_N^k\}$.

2.3. Determining the combined marginal utility of alternative risk control schemes

According to the value function formula in prospect theory, the positive prospect value function and negative prospect value function of triangular fuzzy random variables are defined as:

$$v^+\left(\xi_{ij}^k\right) = \left(E(\xi_{ij}^k) - \mu_j^k\right)^\alpha \tag{8}$$

$$v^-\left(\xi_{ij}^k\right) = -\lambda\left(\mu_j^k - E(\xi_{ij}^k)\right)^\beta \tag{9}$$

In (8) and (9), α and β represent the degree of perception of "gain" and "loss" of each index by members of the risk control scheme evaluation of major engineering projects, respectively.

According to the weight vector of key indicators, the marginal value of each alternative corresponding to the evaluation members is defined as:

$$u_i^k = \sum_{j=1}^{p} v^+\left(\xi_{ij}^k\right)\pi_j^k + \sum_{j=p+1}^{N} v^-\left(\xi_{ij}^k\right)\pi_j^k \tag{10}$$

According to the decision weight of members, the comprehensive marginal utility of each evaluation member for alternative solutions can be obtained as follows:

$$U_i = \sum_{k=1}^{L} w_k u_i^k \tag{11}$$

Lastly, each alternative scheme can be properly sorted to obtain the best alternative by the triangular fuzzy random variable order relation.

3. Steps of selecting the alternative risk control scheme

In order to make full use of water resources in a certain area of southwest China, a major project was approved by relevant government departments. An evaluation team including three safety management experts was set up to select the risk control scheme, which has preliminarily drawn up four alternative risk control schemes, and the evaluation team needs to select an optimal risk control scheme from the four schemes for risk management. The selection is according to four indicators: personnel allocation, personnel behavior habit, usage of equipment, and organization and management of project implementation.

Step 1: The evaluation members evaluated the performance of alternative risk control schemes on various evaluation indicators using triangular fuzzy random variables with real value random variables.

Step 2: By (2) and (3), the expectations and variances of the evaluation members for the four alternative risk control schemes are calculated respectively, then the expected mean for the evaluation team is available by (4) as follows.

$$E^1=\begin{bmatrix}0.7887 & 0.6685 & 0.7282 & 0.6398\\ 0.8197 & 0.7513 & 0.8062 & 0.5880\\ 0.7950 & 0.7346 & 0.7253 & 0.5899\\ 0.7478 & 0.7067 & 0.7093 & 0.5893\end{bmatrix},\ V^1=\begin{bmatrix}1.6598 & 2.4375 & 1.8249 & 2.6276\\ 1.4888 & 1.7977 & 1.5887 & 2.9941\\ 1.5646 & 1.9066 & 1.8523 & 2.7600\\ 1.8526 & 2.0174 & 1.9627 & 3.1705\end{bmatrix},\ E^2=\begin{bmatrix}0.8025 & 0.7267 & 0.8300 & 0.7044\\ 0.7526 & 0.6782 & 0.8514 & 0.6423\\ 0.8408 & 0.7446 & 0.7899 & 0.5789\\ 0.7296 & 0.6498 & 0.8075 & 0.6136\end{bmatrix},\ V^2=\begin{bmatrix}1.5639 & 2.0202 & 1.3955 & 2.0758\\ 1.7457 & 2.1908 & 1.4670 & 2.2829\\ 1.4410 & 1.9072 & 1.6153 & 2.9598\\ 1.9060 & 2.2808 & 1.5662 & 2.7285\end{bmatrix},$$

$$E^3=\begin{bmatrix}0.7694 & 0.6611 & 0.7937 & 0.6594\\ 0.7196 & 0.6869 & 0.7682 & 0.6943\\ 0.7652 & 0.6828 & 0.7726 & 0.6088\\ 0.7842 & 0.6548 & 0.7067 & 0.6289\end{bmatrix},\ V^3=\begin{bmatrix}1.7697 & 2.3419 & 1.5884 & 2.3728\\ 1.9056 & 2.0750 & 1.8279 & 2.0470\\ 1.6674 & 2.1653 & 1.7441 & 2.7945\\ 1.6922 & 2.2808 & 1.9883 & 2.5297\end{bmatrix},\ \overline{E}=\begin{bmatrix}0.7869 & 0.6954 & 0.7840 & 0.6679\\ 0.7639 & 0.7055 & 0.8086 & 0.6415\\ 0.8003 & 0.7113 & 0.7626 & 0.5925\\ 0.7539 & 0.6704 & 0.7412 & 0.6106\end{bmatrix}.$$

Step 3: In order to determine the subjective weights of the evaluation members on the four evaluation indicators of the project risk control scheme, the following nonlinear planning corresponding to the first evaluation member was established as follows by (5):

$$\max T^1=-\left(\pi_1^1\ln\pi_1^1+\pi_2^1\ln\pi_2^1+\pi_3^1\ln\pi_3^1+\pi_4^1\ln\pi_4^1\right)$$

$$s.t.\begin{cases}\pi_1^1+\pi_2^1+\pi_3^1+\pi_4^1=1;\\ 0.1891<\pi_1^1<0.2703;\\ 0.1442<\pi_2^1<0.3674;\\ 0.2149<\pi_3^1<0.2911;\\ 0.2387<\pi_4^1<0.2664;\\ 0.0001<\dfrac{1}{4}\sum\limits_{j=1}^{4}\left(\pi_j^1-\dfrac{1}{4}\right)^2<0.0063.\end{cases}$$

Using the nonlinear programming software package of Matlab to solve the above model, the subjective weights of the evaluation members on the four evaluation indicators can be obtained as follows:

$$\pi^1=(0.2515\ \ 0.2500\ \ 0.2504\ \ 0.2481),\ \pi^2=(0.2506\ \ 0.2487\ \ 0.2551\ \ 0.2456),\ \pi^3=(0.2536\ \ 0.2485\ \ 0.2524\ \ 0.2455).$$

Step 4: Based on the expectations and subjective weights of the above three assessment members, the comprehensive marginal expectation and the average comprehensive marginal expectation of the assessment members, and the four alternative risk control schemes were obtained as shown in **Table 1**.

Table 1. The combined marginal expected value and the mean combined marginal expected value of the alternative

	$M(E_1^k)$	$M(E_2^k)$	$M(E_3^k)$	$M(E_4^k)$	$M(E_5^k)$
$k=1$	0.6993	0.7337	0.7043	0.6815	0.7047
$k=2$	0.7666	0.7322	0.7396	0.7011	0.7351
$k=3$	0.7216	0.7175	0.7082	0.6944	0.7105

Step 5: According to the principle of the deviation minimization between the comprehensive expected value of each alternative risk control scheme and the mean of the comprehensive expected value of the evaluation team, a deviation minimization model is established to determine the evaluation weight of the evaluation members to the alternative risk control scheme.

$$\min R = 0.0014w_1^2 + 0.0022w_2^2 + 0.0004w_3^2$$

$$\begin{cases} w_1 + w_2 + w_3 = 1 \\ w_1 > 0, w_2 > 0, w_3 > 0 \end{cases}$$

Using the nonlinear programming software package of Matlab to solve the above model, it can be obtained that the evaluation weights of each evaluation member on the alternative risk control schemes of water conservancy projects are $w_1 = 0.3833$, $w_2 = 0.3325$, $w_3 = 0.2843$.

Step 6: According to the experience and preference of evaluation members, the psychological expectation reference point matrix of evaluation indicators of alternative risk control schemes for the project is determined as follows:

$$\mu = \begin{bmatrix} 0.7878 & 0.7153 & 0.7423 & 0.6018 \\ 0.7814 & 0.6998 & 0.8197 & 0.6348 \\ 0.7596 & 0.6714 & 0.7603 & 0.6479 \end{bmatrix}.$$

By using the value functions (8) and (9) of the prospect theory, the prospect value function matrix of the triangular fuzzy random variable corresponding to the evaluation members' key indicators of alternative risk control schemes is estimated as follows:

$$V^1 = \begin{bmatrix} -0.0047 & 0.0676 & 0.0235 & -0.1266 \\ -0.1085 & -0.1207 & -0.2000 & 0.0231 \\ -0.0293 & -0.0697 & 0.0277 & 0.0203 \\ 0.0589 & 0.0152 & 0.0497 & 0.0211 \end{bmatrix}, V^2 = \begin{bmatrix} -0.0754 & -0.0934 & -0.0401 & -0.2156 \\ 0.0441 & 0.0342 & -0.1079 & -0.0304 \\ -0.1875 & -0.1463 & 0.0454 & 0.0790 \\ 0.0739 & 0.0716 & 0.0207 & 0.0337 \end{bmatrix}, V^3 = \begin{bmatrix} -0.0384 & 0.0178 & -0.1130 & -0.0442 \\ 0.0589 & -0.0575 & -0.0318 & -0.1509 \\ -0.0235 & -0.0439 & -0.0469 & 0.0577 \\ -0.0863 & 0.0271 & 0.0761 & 0.0306 \end{bmatrix}.$$

Step 7: The marginal utility decision matrix corresponding to each evaluation member regarding the four alternative risk control schemes is determined by (10).

$$U^1 = [-0.0100\ \ \text{-}0.0998\ \ \text{-}0.0131\ \ 0.0358],\ U^2 = [-0.1053\ \ \text{-}0.0154\ \ \text{-}0.0524\ \ 0.0499],\ U^3 = [-0.0447\ \ \text{-}0.0444\ \ \text{-}0.0145\ \ 0.0116].$$

Step 8: The comprehensive prospect utility vector of the evaluation team for the four alternative risk control schemes is estimated by (11) as follows: $U = [-0.0532\ \ \text{-}0.0533\ \ \text{-}0.0267\ \ 0.0324]$.

From the comprehensive prospect utility ranking of the four alternatives, it can be seen that the fourth alternative risk control scheme has the highest comprehensive prospect utility value, and the comprehensive prospect value is greater than 0, indicating that the scheme can meet the expectations of the evaluation members on the whole.

4. Conclusion

Aiming at the irrationality and fuzzy randomness of evaluation members, this paper proposes a risk control scheme selection method for major engineering projects based on cumulative prospect theory and triangular fuzzy random variables. Firstly, the triangle fuzzy random variables are used to describe the interrelation of each evaluation index, and the marginal expectation and variance decision matrix of alternative risk control schemes for major engineering projects are obtained. Secondly, a maximum entropy model corresponding to any evaluation member is established by using the grey correlation coefficient to obtain the evaluation index weight corresponding to the evaluation member. Thirdly, based on the principle of deviation minimization, a nonlinear programming model is established to estimate the weight of different evaluation members to the evaluation of alternative risk control schemes for major engineering projects. Lastly, the cumulative prospect theory is used to obtain the comprehensive prospect utility values corresponding to each alternative risk control scheme of the evaluation team to determine the optimal alternative.

Disclosure statement

The authors declare no conflict of interest.

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Analysis of the Architectural Design Talent Development Direction by Investigating the Employment Status of Architectural Design Graduates

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Abstract: Based on a comprehensive investigation of the employment status of architectural design graduates at a certain university, this paper analyzes the correctness of the talent development direction of architectural design in hopes of providing a valuable reference for further teaching reform and strengthening school-enterprise collaboration. The research results show that architectural design is the main choice of graduates, accounting for as high as 63%, and traditional architectural design skills continue to be in demand in the market. Employment in fields such as interior design, BIM design, and green architecture is also included. The distribution of job positions for graduates is mainly in the areas of scheme design assistants and construction drawing design, requiring software operation, communication, scheme design, and construction drawing skills. This paper also proposes talent development measures such as optimizing the curriculum, strengthening faculty construction, and deepening school-enterprise collaboration, in order to improve the quality of talent development and the competitiveness of graduates.

Keywords: Employment Investigation; Architectural Design; Talents Development; Teaching Reform

Online publication: November 28, 2023

1. Introduction

In the context of globalization, the development trend and talent demand of the architectural design industry are becoming increasingly diversified. As an important base for training architectural design talents, the talent development direction of vocational college architectural design majors not only directly affects individuals' career development, but also influences the progress of the entire industry and the sustainable development of society.

Architectural design, as a multidisciplinary field combining art and science, requires designers not only to possess solid professional knowledge but also innovation awareness, teamwork abilities, and technical skills. Despite extensive discussions on the talent development direction in recent years, there are evident research gaps in practical application. Architectural design has evolved beyond a single discipline, becoming a comprehensive field that necessitates integration across disciplines [1]. This complexity has diversified talent development, with the integration of climate change and sustainability into architectural design education crucial for addressing environmental challenges and building a sustainable future [2]. Regarding teaching methods, it has been proposed that practical activities enable students to master job skills, enhance innovation awareness, and improve problem-solving abilities [3,4]. Architectural design talents should possess diverse skills, including urban planning, environmental protection, and social innovation [5]. However, there is lack of empirical research combined with field investigations, limiting the practicality and depth of these theories. While research mainly focuses on theoretical discussions and innovative teaching methods, there is a shortage of tracking research on actual teaching effects and long-term student development. To better cultivate architectural design talents, it is imperative to strengthen interdisciplinary research cooperation, conduct in-depth investigations of actual teaching needs, and integrate practice to verify and improve existing educational theories and methods.

This will not only help improve the quality of architectural design education, but also provide a solid talent foundation for building a sustainable future. Therefore, this paper aims to explore the reform strategies of the talent development direction of architectural design majors in vocational colleges through employment investigation, in order to meet market demand and improve the employability of graduates.

2. Research method

2.1. Research purpose

This study aims to comprehensively assess the alignment between vocational college architectural design programs and industry demands. It involves gathering and analyzing data related to available jobs in the architectural design field, talent requirements, and employment outcomes of graduates. The goal is to provide reference for the reform of vocational college architectural design education, fostering a tighter connection between academic training and market needs. Additionally, this research aims to identify existing issues and shortcomings in talent development within these programs, propose specific strategies for improvement, enhance graduate employability, and contribute to the long-term growth of the architectural design industry.

2.2. Research subjects

Conducted through online questionnaires, the study gathered 716 valid responses. **Figures 1** and **2** reveal that the majority of participants graduated more than 8 years ago, boasting substantial work experience that enhances their precision in discerning talent demand trends. The data spanned various graduation stages, from 0 to 6 years, offering a nuanced understanding of employment demand and talent development trajectories. The gender distribution was 66% male and 34% female, showcasing diversity in both graduation years and gender, strengthening the accuracy of the collected data.

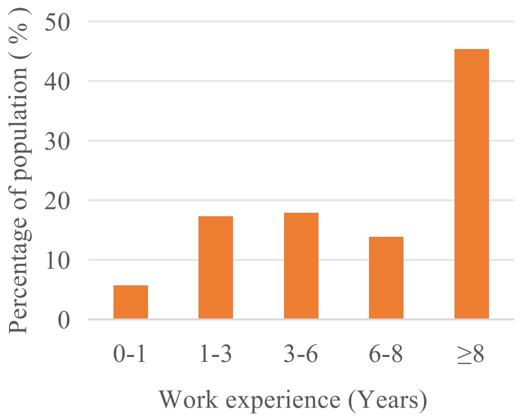

Figure1. Work experience for surveyed graduates

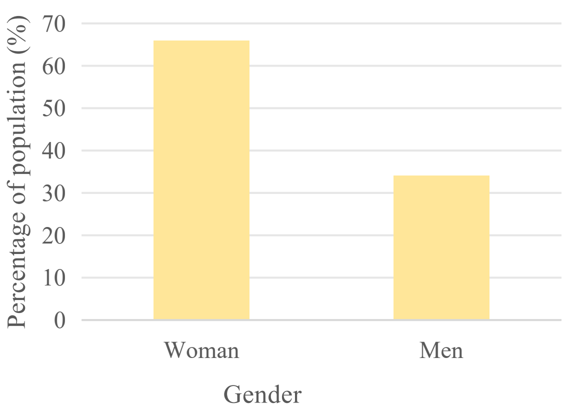

Figure2. Gender of surveyed graduates

3. Results and discussions

3.1. Employment opportunities of graduates

Figure 3 illustrates that 63% of graduates opted for architectural design employment, indicating sustained demand for traditional architectural roles. Interior design, BIM design, and green building design accounted for 6%, 3%, and 1%, respectively. While architectural design remains predominant, the presence of graduates in alternative fields suggests program efficacy. The lower proportions in emerging design areas may stem from limited student awareness. Schools can further promote these fields to broaden student understanding, encouraging interdisciplinary learning for comprehensive design skills. Strengthening architectural design talent development by fostering cross-disciplinary abilities, guiding diversified learning paths, and cultivating versatile thinking can enhance graduates' competitiveness in evolving markets.

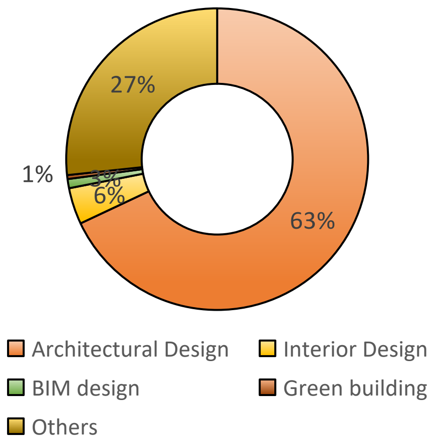

Figure 3. Distribution of employment opportunities

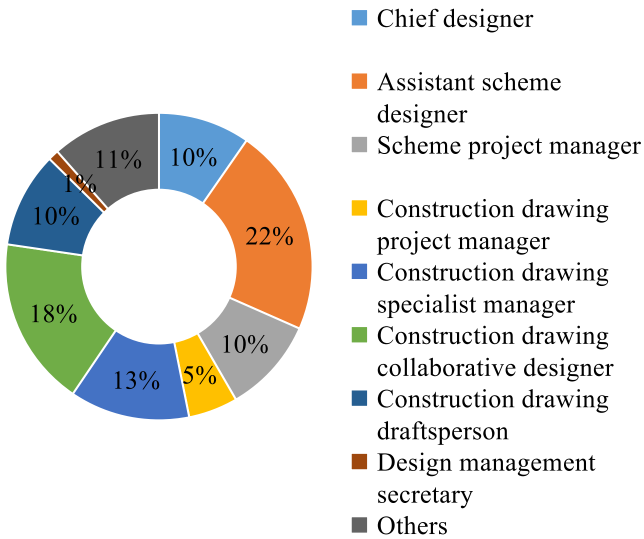

Figure 4. Job positions for architectural design graduates

3.2. Job positions of graduates

In **Figure 4**, scheme design assistants had the largest proportion at 22%, suggesting a strong foundation in drawing skills acquired through school learning and practice. Collaborative designers in construction drawing projects followed at 18%, with 13% being professionals overseeing these projects, and 10.07% as construction drawing draftsmen. Graduates play a substantial role in the construction drawing design phase of architectural projects.

Regarding employment positions in interior design, as shown in **Figure 5**, 18.64% of graduates assumed project leader roles, while 16.95% served as chief designers. Additionally, there were graduates in roles like construction drawing draftsmen and scheme design draftsmen. Some graduates diversified into other interior design positions, including client liaison, market research, and construction supervision.

Regarding job positions in BIM design, as shown in **Figure 6**, the majority, at 43%, worked as BIM draftsmen across disciplines. In architectural design, 29% served as BIM draftsmen, while 29% assumed project leader roles. This progression from architectural-focused BIM roles to broader professional capacities in BIM design reflects alignment with market demands.

In **Figure 7**, one-third of graduates excelled in comprehensive green building consulting and project management. This highlights the value of expanding and cultivating green building knowledge within the architectural design framework for enhanced employability.

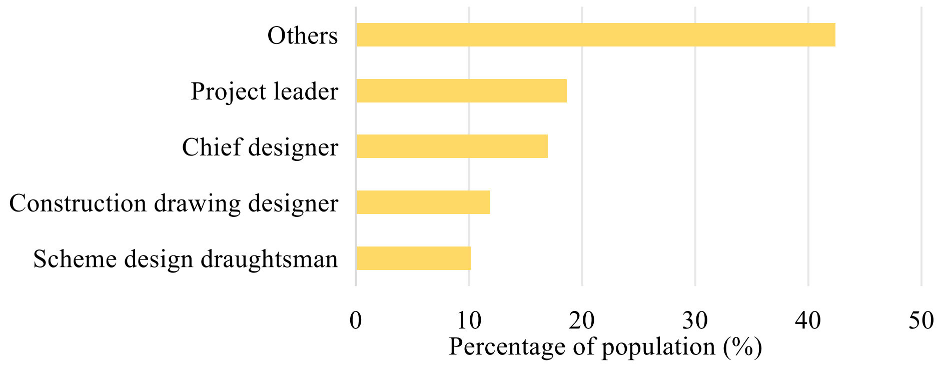

Figure5. Employment positions of graduates in interior design

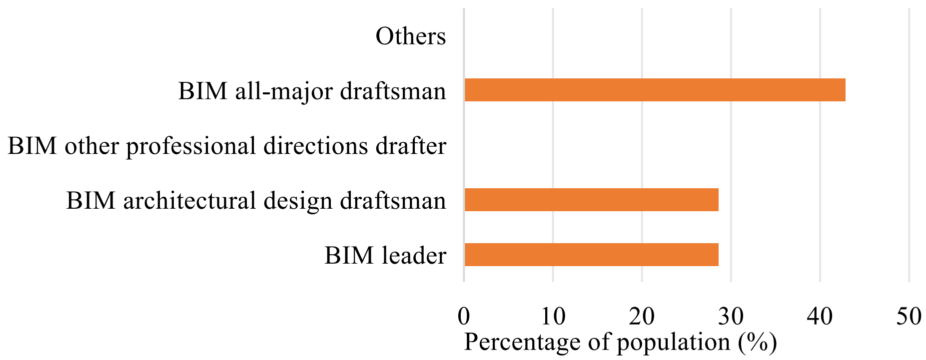

Figure 6. Employment positions of graduates in BIM design

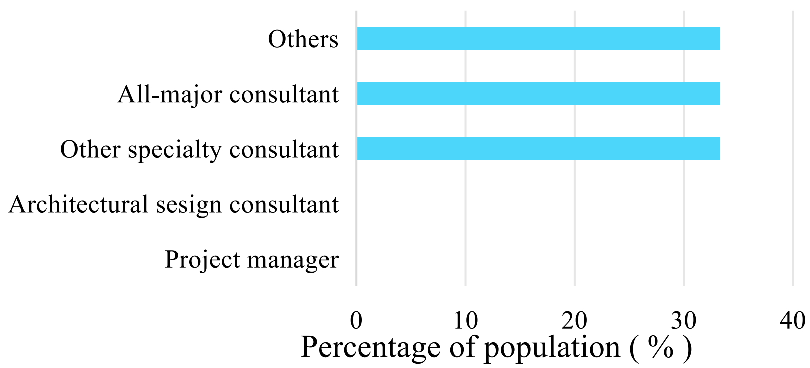

Figure 7. Employment positions of graduates in green design

3.3. Recommendations

Therefore, architectural design talent cultivation should focus on the following:

(1) Optimizing the curriculum

The curriculum structure should be adjusted according to market demands and industry development trends, and cutting-edge courses such as green building and BIM technology should be included to meet market demands. Besides, the practical lessons should be strengthened to improve students' practical skills and comprehensive qualities.

(2) Prioritizing fundamental scheme design

Fundamental scheme design should be emphasized in schools to nurture students' designing, innovation, and teamwork skills. A comprehensive curriculum that includes architectural technology and knowledge should be formed to effectively equip the students to be architectural scheme assistants.

(3) Enhancing construction drawing skills

The cultivation of construction drawing design and drafting skills should be strengthened. Schools should focus on developing proficiency in computer-aided design drawing, construction drawing techniques, and knowledge of architectural structures. Qualities like patience and precision to improve drawing accuracy and efficiency should be emphasized.

(4) Deepening school-enterprise cooperation

The practical lessons should be well-connected to the job positions to offer students diverse job experiences, aligning them more effectively with future career positions.

4. Conclusion

In this study the employment preferences of vocational architectural design talents were investigated, the effectiveness of the current development approach was assessed, proposes targeted reforms were proposed. Architectural design remains the top choice for graduates, constituting 63% of selections, indicating sustained demand for traditional design. To align with market needs, talent development should not only emphasize traditional design but also enhance cross-disciplinary skills, encourage exploration of new design directions, and foster diversification thinking. In conclusion, educational institutions should bolster foundational teaching, enhance professional and cross-disciplinary skills, and consider improvements in curriculum structure, practical teaching, faculty development, and school-enterprise collaboration to boost the employability of graduates.

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Discussion on the Application of Pipe Jacking Construction Technology in Municipal Road Drainage Projects

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Abstract: In the construction of municipal road drainage projects, pipe jacking construction is a relatively common construction method. This construction technology can avoid a large amount of excavation work, improve drainage construction efficiency, avoid large-scale damage to the road surface, and exert small traffic impact. Therefore, it is currently widely used in drainage construction, but judging from the current actual application situation, there are still many problems that require further improvement. This article mainly analyzes the advantages of and current technical problems in pipe jacking construction technology in detail, explores corresponding solutions, and lays a foundation for the optimization of municipal road drainage engineering construction.

Keywords: Municipal roads; Drainage projects; Pipe jacking construction; Advantages

Online publication: November 28, 2023

1. Introduction

Pipe jacking construction management in municipal road drainage projects is a key technical method to ensure the effective operation of urban drainage construction. In drainage projects, once there is a problem with the construction quality, or a relatively large impact area caused by the construction, it will affect the reputation of municipal enterprises and cause inconvenience in citizens' lives. Judging from the current pipe jacking construction technology model in municipal road drainage construction, the construction technology has been continuously improved and the construction field has been expanded, thus becoming an important technical method in trenchless construction of drainage projects. With the continuous development of pipe jacking construction technology, pipe jacking construction has entered a more advanced stage, and automatic deviation correction can be used to ensure the accuracy of pipe jacking construction and improve construction quality.

2. Advantages of pipe jacking construction in municipal road drainage projects

2.1. Unaffected by the weather

The main work of pipe jacking construction is completed underground, so it will not be affected by bad weather. Generally, if there is bad weather such as rain, snow, or ice during municipal construction, workers should stop their work and take a rest. Construction can only continue after the bad weather has passed. This construction method will inevitably affect the construction progress. Moreover, the extension of the construction period of municipal drainage construction will also have a serious impact on people's normal lives. Pipe jacking construction can effectively solve these problems. In addition to not causing large-scale road damage, it can also persist in construction in bad weather, avoid delaying the construction period, and reduce the impact on citizens' lives.

2.2. Less destructive underground facilities

During pipe jacking construction, the land disturbance at the construction location is relatively small without large-scale damage. Most urban drainage pipes are built under buildings and traffic roads. Conventional drainage construction will inevitably affect the underground pipelines and other facilities. However, pipe jacking construction can prevent these problems. Pipe jacking construction can avoid other pipelines and obstacles through curves, without affecting the original lines, and at the same time, it will not interfere with residents' lives [1].

2.3. Efficient and safe drainage pipeline construction

The construction of some municipal drainage pipelines needs to pass through densely populated streets in the city center. Excavation in large areas will inevitably lead to ground damage and affect the normal operation of the city. One of the features of pipe jacking construction is that it allows construction without ground excavation. It does not involve traffic restrictions or demolition work, and the construction is safe, efficient, and has little impact on the environment.

3. Common problems in pipe jacking construction of municipal road drainage projects

3.1. Significant deviation in the pipeline axis

During the pipe jacking process, if there is a large deviation between the axis design and the actual axis, it will easily cause the pipe to bend, thus causing damage to the pipe sections or leakage at the interface. The main reason for this situation is that the resistance force on the front of the bottom layer during pipe jacking construction is uneven, which leads to a deviation of the pipeline guidance, resulting in a large deviation. It may also be that the back of the jacking pipe is uneven and displaced, causing abnormal movement of the resultant line. In addition, the jack construction during pipe jacking construction is not synchronized, or the gap between jacking forces is relatively large, resulting in limited installation accuracy and easily causing deviation of the resultant force.

3.2. Uneven ground

During the construction of municipal road drainage projects, pipe jacking construction is prone to uneven ground around the construction axis, or uplift or settlement. In this case, the ground will be affected, and this will pose certain risks to the surrounding buildings and traffic, thus affecting normal life. The main reason for this situation is that the earth pressure of the tunnel boring machine is unbalanced during the pipeline jacking process, which causes the ground to bulge or settle. During the operation of the earth pressure balance tunnel boring machine, the soil in the forward position needs to be cut and mixed. In this case, a relatively large amount of fluid soil will be formed in the soil bin. If the front soil pressure control is between active and passive pressure, it will cause the ground to bulge or settle. The underground soil quality will undergo relatively large changes during excavation. From the perspective of theoretical calculation, this control mode is prone to severe differences and is difficult to grasp effectively, because the uneven pressure causes uneven ground problems [2]. In addition, the control effect of earth pressure will be affected and lead to earth pressure instability if there are problems such as the earth pressure balance tunnel boring machine having insufficient adaptability to the earth pressure, unscientific adjustment during the cutting process, small area, etc. In addition, the gaps around the pipes can also cause uneven ground problems. The curved form of excavation or the correction of deviations will create gaps around the pipe. If the cross-section formed by the curve advancement is larger than the cross-section of the pipe, a large amount of soil will enter the surrounding voids, causing ground subsidence. Moreover, grouting is currently used in pipe jacking construction, and delayed grouting will also cause settlement. The friction between the pipeline and the surrounding soil will also cause unevenness in the ground. During the jacking process, the pipeline will form a relatively large friction force with the soil. This friction will cause disturbance to the original soil structure and lead to ground subsidence. Uneven pipe shape interface also increases the impact of disturbance. Leakage at pipe joints will also cause ground settlement due to water and soil erosion at the leakage location.

3.3. Large jacking force during pipe jacking construction

A sudden increase in jacking force during pipe jacking construction will affect the construction quality. The main reason for excessive jacking force is that the soil collapses during the jacking process, or there are obstacles in the direction of jacking, etc., which increase the resistance to progress. Deviation of the management axis or curved route will also increase friction. In addition, the effect will also be affected if the ratio of the drag reduction medium during pipe jacking construction is improper, or if the mud is insufficient or not poured in time. If there is a long pause due to a problem during jacking construction, it will also affect the drag reduction ability.

4. Application of pipe jacking construction technology in municipal road drainage projects

4.1. Preparation before construction

Before starting the pipe jacking construction of municipal road drainage projects, relevant personnel must first go to the site to conduct construction surveys and understand the hydrology and geological environment of the construction site, as well as the distribution of surrounding buildings. After fully understanding the conditions of the construction site, corresponding construction plans should be formulated. Firstly, it is necessary to design construction drawings, strengthen construction inspection, and determine specific construction dimensions and burial depth. Then, improvements should be made based on the deficiencies in the drawings. At the same time, a large amount of construction equipment needs to be used in pipe jacking construction. In order to ensure the smooth progress of the construction, it is necessary to first ensure that all construction equipment meets the construction requirements, and that the equipment can operate safely by inspecting the working status of the construction equipment [3]. In addition, the inspection of construction materials should be strengthened and all construction materials entering the site must meet the standards. It is also necessary to stack them at designated locations, with proper classification to effectively prevent quality problems with the construction materials. Before construction, the construction site drawings should be checked again, the wiring work should be done based on the drawings, the workload should be reviewed, and the construction time should be adjusted based on the weather.

4.2. Pipe jacking construction technology

4.2.1. Muddy water propulsion method

The muddy water propulsion method requires a cutterhead boring machine as the main construction machine. The construction personnel gradually advance by controlling the frontal soil pressure. In the construction, it is necessary to ensure the stability and balance of pressure, and adjust the circulating water pressure according to the specific situation. This propulsion method is conducive to ensuring the stability of groundwater pressure. In addition, construction will be carried out step by step to avoid interruptions in the process.

4.2.2. Earth pressure propulsion method

The earth pressure propulsion method in pipe jacking construction is a relatively common construction method. It refers to a construction method that uses balanced pressure to advance after the mixture in the cutting chamber reaches a saturated state. In earth pressure propulsion construction, there is no need to use transportation equipment such as mud pumps, and propellers can be used directly. The low-cost equipment does not require mud treatment, which can improve the construction effect and economic benefits of the project. Generally, balanced tunnel boring machines are in single-blade or multi-blade mode, and are mainly used for pipe diameter advancement from 1,000 to 3,000 mm.

4.2.3. Mud-concentrated propulsion method

This method uses secondary grouting as the main construction method, which can reduce the friction on the ground and improve the efficiency of pipe jacking construction. This construction method can effectively separate the gravel above and below the ground and transport these materials from the underground to the outside. At present, the mud-concentrated propulsion method is widely used. During construction, the excavation position of the construction pit is first determined, then concrete pipes are made, and multiple concrete pipes are assembled into a whole. Subsequently, the oil pump is used to jack up the construction to achieve pipeline connectivity. After pipe jacking construction, there is no need to disassemble the pipeline. Construction workers can inspect all aspects of the pipeline and make sure there are no abnormalities before proceeding with construction.

4.3. Jacking construction process

4.3.1. Jacking construction inspection

Before starting the pipe jacking, the status of the jacking equipment should be checked and a trial run should be conducted. Then it is necessary to dig out the mouth of the wall protection pipe and push the tool pipe into the soil layer. During the jacking construction, every 30 cm of construction work should be measured. If there is any deviation from the design, the deviation should be corrected in time. After the pipe enters the soil layer, during normal jacking, the amount of jacking needs to be increased to 100 cm each time, and at the same time, regular measurements and corrections are still required [4]. The allowable deviation of the elevation needs to be controlled within 3 mm. If it exceeds the allowable range, the deviation must be corrected in time.

4.3.2. Device installation

For the design of the back wall, jacks are used as the main support structure. In order to ensure uniform stress on the back wall, steel plates can be laid on the wall panels [5]. Generally, the back wall needs to be kept perpendicular to the pipe jacking direction, and the vertical deviation range is controlled at about 0.1%. The horizontal torsion error cannot exceed 0.1%. Next is the installation of the working well guide rail. The jacking slope and center line can be properly set based on the design requirements, and the safety and stability of the structure can be ensured by installing guide rails. At the same time, the installation location needs to comply with the slope and elevation requirements.

4.3.3. Pipeline installation and construction

Before starting the pipe laying construction, the quality of the concrete pipe should be checked to avoid problems such as cracks and damage. At the same time, all pipes must have smooth walls [6]. The quality of the pipe mouth shall meet the construction standards, and the pipe shall be cleaned and lubricated. It is also necessary to check the lifting equipment of the pipe to make sure it meets the construction requirements before lowering the pipe. When lowering the pipe, after lowering the first section of the pipe, the bottom elevation and center of the pipe are measured to ensure that the position of the pipe pattern meets the construction requirements.

4.3.4. Measurement and correction

The measurement work during pipe jacking construction has relatively high requirements for refinement, and the test results are directly related to the quality and efficiency of pipe jacking construction. It is also the main basis for deviation correction. Therefore, during pipe jacking construction, construction workers must make full use of laser levels and total stations for measurement. After the measurement is completed, they should perform deviation correction based on the measurement results and the direction of the deviation [7]. Generally, the pipe jacking should be measured once every 20 to 50 cm. When the construction process is normalized, the frequency of measurements can be reduced. In the measurement of the center line, plumb bobs can be hung on both sides of the working well and the pile body can be extended to the bottom. By comparing the position of the laser level with the plumb weight, the scale value of the center ruler is read, and the corresponding value is judged according to the specific test results [8]. If the laser coincides with the center line, it means that there is no deviation from the direction and thus meets the requirements. Otherwise, the deviation needs to be corrected. During the elevation test, the laser level is set at the position of the top iron, and the elevation measurement results are obtained by measuring the front-end pipe body. The last process is correcting the deviation. Combined with the actual measurement results of pipe jacking construction design, the measurement and correction are done properly. The guide joint should be set on the tool and the guide jack should be set. If the deviation exceeds 5 mm, it is necessary to correct the deviation in time to ensure the accuracy of the jacking direction. An automated correction and guidance system (**Figure 1**) can also be used to complete more precise correction work.

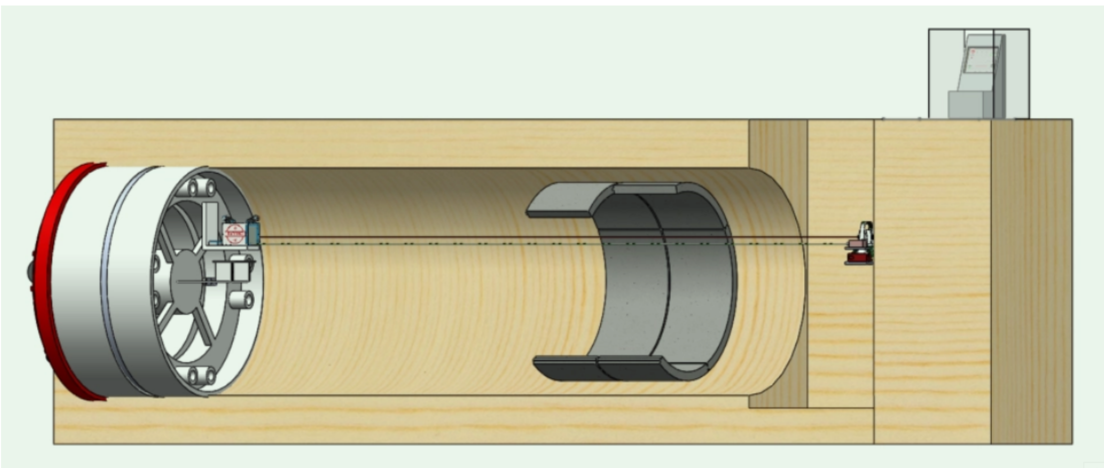

Figure 1. Automatic guidance system for catheter deviation correction

5. Pipe jacking construction technology and construction measures for municipal road drainage projects

5.1. Strengthening pipe jacking inspection and control

The distance measured by pipe jacking is generally no more than 150 m and is tested by a laser theodolite. Under the operation and guidance of professional personnel, the elevation and direction of pipe jacking are detected and controlled. During pipe jacking construction, it is easy to cause undesirable situations such as displacement of the starting point and the backsight point. In order to effectively prevent these problems, pipe jacking measurement and inspection must be strengthened. Routine inspections need to be carried out once a week. If the project is complex or the geological conditions are poor, the frequency of inspections needs to be increased appropriately [9]. If there is a large deviation between the inspection results and the design, the reasons for the deviation need to be analyzed and dealt with in a timely manner. After a section of pipe jacking construction is completed, the elevation and center of the pipe are inspected. The specific detection point settings should be determined based on the corresponding parts. Generally, one measurement point is set for one interface. If the position of the nozzle is misaligned, additional measurement points need to be appropriately added.

5.2. Strengthening road surface settlement detection

During the pipe jacking construction of municipal road drainage projects, it is necessary to determine whether the specification requirements are met by measuring the level of the working well and calculating the settlement movement value. During the construction of the receiving well, the slope displacement of the well should be detected, and corresponding improvement measures should be taken based on the detection results to ensure the safety of the construction. During construction, it is necessary to adopt corresponding monitoring network devices and set corresponding reference points to meet the road settlement requirements. During pipe jacking construction, observations should be made at least once a day, and observation information should be recorded in a timely manner. After the construction is completed, continuous testing is required to determine the specific settlement situation, and the allowable settlement deformation is controlled within 20 mm.

5.3. Taking scientific management measures

During the construction of municipal road drainage projects, before entering the hole for pipe jacking construction, the condition of the hole should be inspected first. A drainage system was also constructed to drain all water from the working well to facilitate subsequent construction work. At the same time, construction work is carried out strictly in accordance with the requirements of the construction drawings [10]. During excavation in the early stage of construction, it is necessary to ensure the suitability of the excavation and avoid over-excavation or under-excavation problems. In the event of an emergency, parameter adjustments need to be made in conjunction with approval requirements. During jacking, workers should work together to control the speed of jacking and the amount of slag produced, thereby creating a more stable and safe construction environment. At the same time, the control of jacking pressure and excavation surface pressure is strengthened to maintain a balanced development state.

6. Conclusion

In summary, the pipe jacking construction technology of municipal road drainage projects is an important construction method in current urban municipal projects. Through pipe jacking construction method, it can improve the excavation chaos of pipe network in traditional pipeline construction, improve the economic and social benefits of pipe jacking construction in drainage engineering, and avoid the impact on citizens' lives. However, it is necessary to consider common construction problems during construction, and perform prevention and control to prevent hidden construction hazards and ensure construction quality.

Disclosure statement

The author declares no conflict of interest.

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Study of Spatial Characteristics of Streets and Alleys in Traditional Villages: Taking Pingtan Comprehensive Experimental Area as an Example

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Abstract: Taking the traditional residential street space in Pingtan Comprehensive Experimental Area as an example, the factors influencing the formation and development of lane space and the distribution characteristics of lanes were analyzed in this paper. Subsequently, an analysis was conducted on the scale and proportion of street and lane space enclosed in the settlement, the experiential aspects of street and lane space, as well as the node space. Lastly, a systematic summary of the street space characteristics in the settlements of Pingtan Island and Dongxiang Island is presented.

Keywords: Traditional villages; Street spaces; Characteristics; Pingtan Comprehensive Experimental Area

Online publication: November 28, 2023

1. Research background

In recent years, China has been experiencing an increasing demand for urbanization and the integration of urban and rural areas. As a result, the country is confronted with the harsh reality of losing at least one hundred villages every day [1]. The development of villages plays a significant role in shaping the beliefs and culture of the majority of Chinese people. Traditional villages serve as the carriers of people's beliefs and culture, while traditional dwellings serve as the foundation for the formation and development of villages. Additionally, street and alley spaces serve as the primary venues for daily communication and production activities. These spaces are also vibrant hubs for cultural exchange in villages, characterized by a strong local flavor.

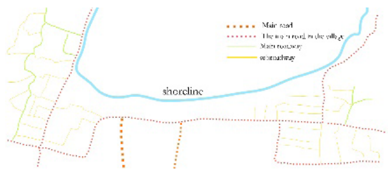
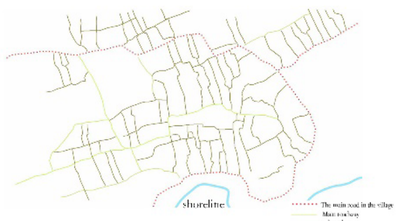
From the perspective of place and crowd organization, there are evident disparities between traditional streets and urban roads. Traditional streets not only fulfill daily transportation functions but also act as venues for interpersonal communication and socialization. On the other hand, urban roads primarily prioritize accessibility during transportation [2]. At the same time, many scholars have shifted their focus to street space. Duan proposed the concept of spatial genes. Although it has similar main axis arrangements domestically and internationally, it is influenced by regional culture in terms of layout levels, systems, and orientations [3]. Gao and Zhang have conducted research on street space in mountainous settlements. The former studied and summarized the spatial characteristics and perceptions of four Miao settlements in southeastern Guizhou, while the latter studied the relevance of street space in Guifeng Village, Fujian [4,5].

Pingtan County is situated in the eastern part of Fujian Province, facing Taiwan region across the Taiwan Region Strait, and is renowned as the “Thousand Reef Island County.” Its unique geographical location and natural environment have contributed to the development of a distinctive architectural culture and form. The Pingtan stone houses represent a prime example of traditional houses in Fujian Province. Numerous scholars in China have conducted comprehensive research on traditional villages within the Pingtan Comprehensive Experimental Area, focusing primarily on the transformation design of traditional houses, the identification of village landscape genes, and the protection planning of stone houses. However, there has been relatively limited research on the street and alley spaces within these traditional villages. To address this gap, our study aims to preserve the favorable current conditions and geographical location. We have selected Beigang Village, Junshan Village, Dacuoji Village, Yangmeikeng Village, Baisha Village, and Baisheng Village on the main island of Pingtan, as well as Hubian Village, Aodi Village, Aoxing Village, and Dongxia Village on the subsidiary island of Dongxiang as the research subjects.

2. Street and alley spatial structure characteristics

The distribution of village buildings is not only influenced by the cultural history and ancestral temples in the village, but also by the natural environment. For example, the influence of terrain elevation differences or coastal locations, these natural factors have certain impacts on the distribution of buildings and streets in the village (**Table 1**).

Table 1. Distribution types of streets and lanes

Types of distribution	Distribution characteristics	Representative villages
Free-style	This type of settlement is limited by the natural environment, and the settlement will change due to changes in terrain or coastline. The density of buildings and the size of streets and alleys will vary depending on the population of the area.	 Woxing Village, Wodi Village, Lakeside Village
Mesh-style	The main roads in the street and settlement intertwine with each other, forming a branching pattern. The main roads serve as the backbone of the entire street network, while the rest of the streets follow its overall direction.	 Baisha Village, Baisheng Village.
Radiating-style	There is a main artery, and the rest of the streets or roads radiate from the main artery. The distribution of alleys is flexible and changeable, and there can be multiple development centers.	 Yangmeikeng Village

2.1. Free-style street layout

The village is situated in a mountainous region with rugged terrain, and the difference in elevation exceeds thirty meters. Some villages are also near the coast, resulting in a development pattern of streets and lanes with a free-style layout. The free-style street and lane settlements in coastal areas are influenced by the natural terrain. Residential buildings are arranged based on changes in elevation, resulting in a flexible overall spatial layout, as well as diverse building orientations and volumes.

2.2. Mesh-like street and alley layout

This type of settlement is primarily found in hilly regions characterized by relatively flat or gentle slopes. The architectural structures within this area are concentrated to maximize land utilization, resulting in a high density of residential buildings. The streets and alleys exhibit a winding and branching pattern, with the main roads serving as the framework of the street network. Secondary streets extend and expand from the main roads, creating a branching street organization that connects the surrounding areas. The main street, which traverses the entire network, dominates the street layout. Additionally, various small paths are interspersed throughout the village, leading to different areas within.

2.3. Radial street layout

This particular type of village is primarily found in plain areas or regions that are relatively flat. The village's structure consists mainly of clusters of groups within the village, which are autonomous but also interconnected, thus collectively forming the overall village layout. The overall layout is characterized by one or more main roads, with additional roads extending outwards from the main roads. This layout shape resembles that of a "fishbone". The distribution of streets and lanes is relatively arbitrary and adaptable, yet it still maintains a certain level of order.

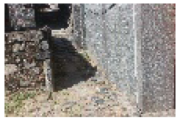
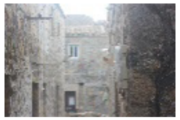
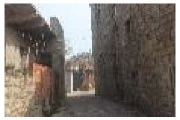
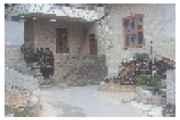
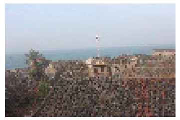
3. Street and lane interface analysis

Space is essentially formed through the interaction between the object itself and the individual perceiving it [6]. Street space consists of three interfaces, namely the ground, walls of buildings or structures, and covering structures on top of the space [7]. These interfaces, regardless of their size, material, combination method, or color, have the ability to create a diverse street experience (**Table 2**).

3.1. Street and alley spatial bottom interface

The bottom interface in the village primarily consists of roads, ramps, stairs, ditches, and platforms, which are delineated by continuous variations in paving materials or the enclosure of buildings [8]. Different types of street and lane layouts exhibit distinct characteristics, with free-style street and lane spaces exhibiting closer connections to the terrain and surrounding environment, resulting in extended and more developed bottom interface spaces. Conversely, grid-like and radial bottom interface spaces exhibit weaker connections with the terrain and environment, highlighting the evident traces of artificial planning. The bottom interface is significantly influenced by the terrain, which can be either winding or flat. Moreover, the bottom interface serves not only as a means to guide traffic but also possesses landscape functions. In terms of material composition, the main roads and street bottom interfaces in the village predominantly employ direct concrete hardening, while some alleyways are adorned with neatly laid cobblestones. A small number of roads remain unpaved or hardened and are directly exposed to bare earth. Additionally, certain road surfaces are composed of a combination of various materials, such as embedding pebbles between cobblestones to enhance the sense of layering and aesthetic appeal of the road surface.

Table 2. Interface composition of street and lane space

Bottom interface	**Type**	1	2	3		4	5		6	
	Material	Cobblestone	Cobblestone + cement	Pebbles + cement		Pebbles + cobble-stone	Cement		Loess	
	Texture	Smooth	Rough	Relatively smooth		Rough	Relatively rough	Rough	Smooth	Rough
	Detailed	Roughly laid out	Surface disorder-ly	Tightly laid out	Scattered laid out	Neatly laid out	Connected as a whole		Weeds on both sides	Covered with weeds
	Photo									
Side interface	**Type**	1		2	3	4	**Top interface**	**Type**	1	2
	Material	Cobblestone		Red brick	Hollow brick	Granite		**Material**	Tile	Cement
	Texture	Relatively rough	Rough	Rough	Rough	Rough		**Texture**	Rough	Relatively rough
	Detailed	Herringbone or irregular masonry		Regular masonry		Regular masonry		**Detailed**	Arc in cyan-black or red color.	Connect as a whole
	Photo							**Photo**		

3.2. Street and alley space side interface

The side interface primarily refers to the composition of the surrounding courtyard walls and the surrounding environmental elements. Due to the influence of the natural environment and geographical location, the utilization of traditional Chinese construction materials such as earth and wood is not suitable for large-scale application on the island. Therefore, island residents utilize locally abundant stone materials for construction and wall building. In free-style streets and lanes, the continuity of street and lane spaces is weaker due to the influence of terrain fluctuations and coastal environments. However, the complex terrain, diverse forms of building walls on both sides, and the rich jointing techniques of building walls provide a visually rich experience.

3.3. Street and alley spatial roof interface

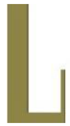
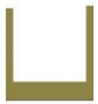
The top interface refers to the architectural elements that define the boundary between buildings and the sky, including roofs, eaves, gables, verandas, and structures on both sides of streets and alleys [9]. There are three main configurations of the top interface: the first configuration has no protruding structures obstructing the overhead space; the second configuration has a veranda or protrusion on one side, partially covering the top space of the street or alley; the third configuration has interconnected structures connecting the tops of structures on both sides, completely separating people from the sky, or each side of the structures has verandas that almost completely cover the entire top space. Among these three configurations, the third configuration creates the strongest sense of enclosure.

4. Street and lane spatial scale analysis

The formation of street and alley spaces is a deliberate and purposeful creation resulting from the adaptation and compromise of local residents with the natural environment. According to Japanese architect Yoshinobu Ashihara's discourse on street space and aesthetics, the ratio of width to height (D/H) in streets and alleys serves as the standard scale for spatial proportions, allowing for the study of the interaction between street and alley spaces and individuals [10]. This article focuses on communication-oriented lanes as illustrative examples, omitting major roads primarily designed for transportation purposes.

The combination forms observed in the streets and lanes can be categorized into five main types: "building + building," "subsidiary building + building," "building + wall," "subsidiary building + wall," and "wall + wall." The different forms of streets and lanes are influenced by various factors such as terrain, hydrology, and culture, which evoke distinct emotions in people. In the layout of streets and lanes with a free-style design, the D/H value of the "building + wall" form tends to be larger, ranging from 0.7 to 1.23. In network-style settlements with streets and lanes, the building density is higher, and the street width primarily falls between 0.8 and 2.5. As a result, the D/H values of different combinations of street and lane forms begin to exhibit varying degrees of decline. Notably, the D/H value of the "building + wall" combination form is 0.11, creating a sense of depression and discomfort among individuals. Similarly, the D/H values of the "building + building" combination form in streets and lanes are mostly distributed within the range of 0 to 0.4, evoking a more oppressive atmosphere. In radial streets and lanes, the street width is relatively wide, and the buildings are typically two-story structures. Consequently, the D/H value of the street space is higher compared to network-style and free-style layouts, resulting in a generally positive and open street experience (**Table 3**).

Table 3. Spatial scale of streets and alleys between different settlements

Settlement	Lakefront Village (free-style streets and alleys)				Dongxia Village (free-style streets and alleys)			
Composition	Building + Building	Wall + Building	Wall + Building	Wall + Building	Building + Building	Building + Building	Wall + Building	Building + Building
Profile								
Proportion	0.95	0.70	1.23	1.1	0.50	0.52	0.81	0.45
Feeling	Good	Good	Broaden	Broaden	Good	Good	Good	Good
Settlement	Baisha Village (network-style streets and lanes)							
Components	Subsidiary building + Subsidiary building	Building + Wall	Building + Building	Building + Building	Subsidiary building + Wall	Building + Wall	Building + Wall	Building + Building
Profile								
Proportion	0.5	0.11	0.26	0.16	0.64	0.53	0.5	0.32
Feeling	Good	Suppressed	Suppressed	Suppressed	Good	Good	Good	Suppressed
Settlement	Dacuoji Village (radiating street lanes)							
Components	Wall + Wall	Wall + Wall	Building + Wall	Building + Wall	Building + Wall	Building + Subsidiary building	Building + Subsidiary building	Building + Subsidiary building
Profile								
Proportion	1.18	0.98	0.58	0.45	0.58	0.48	0.39	0.4
Feeling	Broad-mindedness	Broad-mindedness	Good	Good	Good	Good	Suppressed	Suppressed

5. Conclusion

From a cultural perspective, there exists an inherent correlation between the architectural design of ancestral temples and the layout of streets and alleys in villages. This correlation primarily manifests in two forms: encircling and guiding. When it comes to street and alley distribution, this connection becomes more pronounced. From a natural environment standpoint, the distribution of streets and alleys can be categorized into three types: free-style, grid-style, and radial patterns.

Regarding interface composition, notable disparities can be observed between the granite used in lateral interfaces and the traditional civil structures found on the mainland. However, there are no significant distinctions between the bottom and top interfaces. In terms of scale, settlements with a free-style street and alley layout boast the largest width-to-height ratio (D/H), providing individuals with a more spacious and pleasant street experience.

Disclosure statement

The authors declare no conflict of interest.

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The Importance of Construction Project Archives Management and Ways to Strengthen it

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Abstract: China's economy has been developing rapidly in recent years, leading to an acceleration of urbanization, which in turn caused the number of construction projects in various regions to increase significantly. Archives are important information for construction projects. The quality of archives management can have a great impact on the quality and economic benefits of construction projects. For this reason, it is necessary to increase the emphasis on archives management of construction projects and take effective management measures. This article introduces the concept of construction project archives, highlights the significance of effective management in construction project archives, and examines prevalent issues along with practical measures to enhance construction project archives management, with the goal of offering valuable insights for archive managers.

Keywords: Construction projects; Archives management; Strengthening measures

Online publication: November 28, 2023

1. Introduction

China's construction enterprises are facing significantly increased competitive pressure, and it is imperative to actively promote the reform of the construction project management system. Archives management is a key part of construction project management and can have a great impact on the development of construction enterprises. Therefore, construction enterprise managers need to pay more attention to archives management, analyze existing problems, and formulate perfect construction projects based on actual conditions. An archives management system optimizes and adjusts the management model to achieve the best management results.

2. Main contents of construction project files

Construction project archives mainly refer to the audio and video, charts, drawings, and written materials formed during the planning, construction, and management of a project. They are the true original records of the entire construction process and are also valuable information resources for construction companies. The main contents of construction project files are as follows. (1) Comprehensive documents and information:

Comprehensive documents and information for construction projects mainly include government department approvals, construction plan tasks, project-related hydrogeological and meteorological data, land acquisition and demolition and resettlement documents, project plans and design information; planning, environmental protection, health, fire protection, and approval materials from other departments; documents and materials related to project construction supervision, project completion acceptance and quality appraisal documents, and project settlement and audit reports and project-related audio and video materials [1]. (2) As-built drawings: As-built drawings mainly include the general layout of the project, the indoor pipeline as-built drawings, the decoration engineering as-built drawings, the structural engineering as-built drawings, the water supply and drainage engineering as-built drawings, the strong and weak electricity completion drawings, the ventilation and air-conditioning engineering as-built drawings and other professional as-built drawings. (3) Other documents: In addition to the above file contents, construction project files also include commencement and completion reports, drawing review and design change data, technical disclosure and material substitution documents, construction organization design; establishment-related data, construction material related data; project quality appraisal documents, project construction, recording and processing documents, construction technology summary documents, etc [2].

3. The importance of construction engineering file management

At this stage, the overall number of construction projects in various regions of our country has increased significantly. During the execution of construction projects, a variety of archival materials can be generated, such as preliminary approval documents, construction records, completion acceptance documents, etc. Effective management of construction project archives is of great significance. First of all, archives can accurately and comprehensively reflect the details and also the management and maintenance of construction projects after completion. Through effective management of archives, construction companies can determine their shortcomings in daily management and formulate targeted improvement measures to promote the improvement of their market competitiveness. Secondly, construction project archives play a guiding role in the development of construction enterprises. With proper construction project archives management, enterprises can refer to the archive content when designing and constructing similar projects, thereby promoting the scientific development of construction projects [3]. Disputes may occur during the construction of a project, so good construction project file management can provide valuable reference materials for resolving various disputes. Finally, construction project files are an accumulation of urban construction experience and technology. They are also the main basis for urban building repairs, renovations, and expansions. Therefore, construction companies need to effectively strengthen construction project file management to contribute to the development of the city.

4. Problems in construction project file management

4.1. Incomplete and inaccurate information

Construction engineering archives are diverse, particular, and complex. They are difficult to collect and organize, and there is a high risk of errors, which in turn leads to frequent problems such as inaccurate archive data. Besides, some construction companies do not pay enough attention to the management of construction project files and have not formulated a complete management system. There are many problems in terms of file collection and data input, resulting in many false data in the files, and as-built drawings with major errors. As a result, there is a deviation from the facts, which leads to the inability of the architectural archives to play its due role [4].

4.2. Failure to hand over completion files on time

Some construction units fail to organize archives in time upon the completion of a project, resulting in delayed transfer of completion files. Some construction companies have problems such as arrears in project payments, resulting in extended construction periods and stagnant archiving of construction projects. Problems such as incomplete, scattered, and lost archival data are prominent, which in turn affects the progress of completion acceptance and handover of construction projects, and hinders the stability and the healthy growth of construction companies.

5. Measures to strengthen construction project file management

5.1. Developing standardized and unified construction project archival standards

The scale of a construction project is large, and the period of construction is long. Besides, a project involves a wide range of fields, so there is a large number of data involving different areas of the project. Therefore, it is necessary to formulate standardized and unified standards to ensure the authenticity, completeness, and effectiveness of the archive's content, and to ensure that archives play their due role in the construction of construction projects. First, the construction project organization design document must contain the signatures and approval information of the construction unit, supervision unit, preparer, technical supervisor, and other participating parties, and the content must be written clearly. Secondly, the joint review document of construction project drawings must contain information such as the project's name, the location of the construction site, the content and time of the joint review, and the construction personnel involved. The documents must be stamped by relevant departments with their official seal [5]. Thirdly, documents such as building and engineering construction material certificates and quality inspection reports must be complete and the contents must comply with relevant national regulations. Fourthly, the contents of contracts and agreements in construction projects must be detailed, comprehensive, and fair, and must not contain loopholes. Technical disclosure documents must meet the requirements of quality acceptance specifications. For example, relevant documents for pipeline installation must record in detail the pipeline support method, pipeline location, and size. and other information, and relevant information should be described in detail during the acceptance process. Fifthly, the archives of sub-projects must be reasonably divided, the content must be true and accurate, and there must be no missing items. The content of the construction diary must be comprehensive and true. Sixthly, electronic archive materials such as pictures, images, and texts in construction projects need to be classified and managed, and their standards must be determined based on database requirements [6].

5.2. Clarifying the rights and responsibilities of all parties involved in construction project archives management

In the process of carrying out construction project archives management, it is necessary to clarify the rights and responsibilities of all parties involved in construction project archives management, and formulate a reward and penalty system to improve the sense of responsibility of relevant personnel. The following solutions can be adopted in the process of determining rights and responsibilities. (1) Design unit: Construction engineering design units must submit construction drawings and technical plans within the specified time, and the relevant content should meet the requirements of national standards. (2) Contractor (employer side): The contractor is mainly responsible for completing the application for construction projects, which includes obtaining the land, planning, and construction approval documents and relevant licensing qualifications. The contractor will also be responsible for providing project feasibility reports, design plans, construction drawings, bidding documents, contracts, and other documents. The contractor plays a connecting role among construction units, design units, supervision units, and urban construction archives. (3) contractor (construction side): The main responsibility of this contractor is to ensure that the quality of the construction project meets the requirements of relevant national standards and is required to provide quality inspection reports related to accessories, mechanical equipment, and concealed projects [7]. (4) Construction control unit: The main responsibility of the construction control unit is to control the construction site, and it is required to submit documents such as construction progress and on-site visas. (5) Survey unit: The survey unit is mainly responsible for the survey of construction projects and is required to submit a construction project survey report.

5.3. Create a good atmosphere for construction project file management

In order to improve the management construction project archives, construction enterprises need to pay more attention to archives management, actively participate in the collection, arrangement, and utilization of archives, and create a good construction project archives management atmosphere. To achieve that, construction companies need to set up a construction project archives management department. The department personnel will need to implement the archives management system, improve archives management awareness, publicize the relevant content of archives management within the enterprise, and guide all personnel to cooperate in the archiving process. Secondly, construction companies need to consider the characteristics of construction projects, reasonably determine the goals of archives management, formulate a complete management system, promote cooperation and exchanges between archives creators and departments, and constantly improve their archives' categories, quantities, and standards. Moreover, it is also important to ensure that the files are standardized, authentic, and accurate. Lastly, construction enterprise archives management personnel need to master the archives management system proficiently, and integrate an information-based archives management system to gather and structure construction project archives. They should also be able to mine valuable information in the archives to promote the advancement of their construction projects [8].

5.4. Establishing a construction project archives management system based on project management

It is necessary to implement dynamic management of archives that aligns with real-time circumstances. This involves establishing a management system based on project management, collecting archival information generated in each link in a timely manner based on the construction plan and project progress, reviewing the archive content, and carrying out archiving and classification, and mining effective information. Firstly, construction companies need to actively implement the whole-process construction project file management. This involves setting precise collection times in line with the construction plan, focusing on key and weak-link file information, and categorizing documents pertaining to project approval, bidding, planning and design, demolition and resettlement records, construction, completion acceptance, and other relevant aspects. [9]. Secondly, construction companies need to focus on strengthening the quality management of construction project archives, strictly formulate archiving standards and specification requirements, dynamically analyze and research relevant information in archives, and collect feedback to continuously increase the value of their archives.

5.5. Establishing a construction project archives management model that combines before, during, and after the event

To achieve excellent archive management, construction enterprises create a construction project archives management model that integrates pre-event, in-event, and post-event considerations, taking into account their specific circumstances. Pre-event management mainly refers to the management in the early stages of construction data formation, and the focus of management is to control the source of archival data. In pre-event management, construction companies need to accurately distinguish the codes of construction projects, compile a coding system, and determine the codes for the unit projects. Construction companies need to establish standardized and unified records and acceptance forms that include relevant information about the project. In addition, construction companies need to strengthen supervision and guidance in the process of collecting and organizing archival materials, so as to ease archive management. Before the construction of a construction project, construction companies need to collect archival information such as project approval, construction organization design, construction drawings, geological survey reports, etc. During the construction process, they need to dynamically collect and organize archival information from each link, organize construction logs, conduct technical briefings and other tasks, and take effective measures to ensure that the quality of the archives meets relevant standards. After the project is completed, the construction company needs to organize various information in detail and complete the archiving and transfer of files in a timely manner.

6. Conclusion

The implementation of construction projects involves a large amount of data, so it is imperative to strengthen archival management. At this stage, there are many problems in the management of construction project archives. To this end, it is necessary to formulate standardized and unified construction project archives standards, clarify the rights and responsibilities of all parties involved in the construction project archives management, create a good construction project archives management atmosphere, and project management, establish a construction project archives management system as a basis, and build a construction project archives management model that starts from the initiation to the completion of the project.

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The author declares no conflict of interest.

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Application Strategies of Transparent Design in Architectural Design

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Abstract: Transparent design is a reverse space processing method in architectural design that involves partially or completely removing the original division of space, thereby making the entire space more diverse. The application of transparent design methods mainly includes the processing of two-dimensional and three-dimensional spaces, and it involves aspects like building entities, design spaces, design materials, and building structures. Transparent design is a popular form of modern architectural design. It transforms the space and reflects the beauty of the space, allowing light, sight, and air to freely blend throughout the space. At the same time, architectural design is also consistent with the idea of "form follows function" advocated by contemporary architecture, so it has been gradually growing in popularity in architectural design. This article presents a detailed analysis of transparent design, including the types of transparent design, structural model design in transparent design, and the application strategies of transparent design in architecture.

Keywords: Architectural design; Transparent design; Glass

Online publication: November 28, 2023

1. Introduction

Aesthetics and comfort are crucial aspects of contemporary architectural design, with a focus on the external aspect of form. Because modern people prefer being unrestrained, most living environments are mainly designed with the idea of spatial transparency, showing obvious spatial hierarchy through different structures and materials. The indoor colors and light are also considered as part of the design, so as to achieve better results. This design method helps promote the development of the construction industry and allows more diversified architectural forms.

2. Overview of transparent design

Transparent design is currently one of the most common and efficient methods for processing two-dimensional and three-dimensional spaces. It mainly includes physical processing, space processing, material construction, and many other aspects. The application of transparent design in architectural design can effectively manage two or more spaces. The spaces can be segmented and divided through different construction methods and materials, which enhances spatial openness and minimizes obstructions. As a result, natural light is better able to illuminate the environment within the space [1].

The first application of transparent design in China was in the construction of Jiangnan classical gardens. The transparent design method was used to plan and reorganize transparent structural spaces such as doors and windows, so that visitors can have a variety of experiences in various spatial situations. It also enhances the correlation between various landscapes, thereby efficiently connecting various spatial scenes. Besides, it also highlights the unique beauty of classical gardens and makes visitors feel relaxed and happy. At the same time, the transparent design overcomes the limitations of previous architectural spaces and strengthens the layering of the landscape, which makes the garden more appealing to the public.

3. Transparent design type

(1) Visual transparency

Transparent or translucent decorative materials and building materials can be used to achieve visual transparency. Visual transparency can be divided into three categories. (i) Absolute transparency: Transparent design not only maximizes visual effects but also fosters a sense of openness. Transparent glass is mainly used to achieve this effect because it can create exquisite, translucent, open, and clear visual effects. (ii) Translucency: Translucent glass and valances are mainly used in a translucent design. Through the appropriate combination of various materials, a layered and hazy aesthetic can be created. The division of space should not be the sole emphasis in a design, but the style, materials, and colors should also be considered. Spaces cannot be completely separated scientifically and reasonably. Instead, it should be adaptable to local conditions and circumstances to ensure the continuity and fluidity of the building. (iii) Enhancing visual perspectives through virtual modification methods. The design's transparency can be elevated by incorporating features such as wall openings, intricate patterns, or grilles in specific areas. This design technique is widely used in some classical gardens in southern China. However, in the architectural design process, it is crucial to focus on the harmonious coordination of materials, colors, and styles to cultivate a subtle, profound, and refined artistic concept [2].

(2) Ventilation design

It is important to have good ventilation in a building. Today, as the living standards of society continue to improve, the demand for ecologically friendly and healthy housing has gradually increased. The indoor ventilation effect can be effectively improved by allowing air circulation in the indoor space. In actual design, In practical design, it is essential to consider the primary structural orientation and openings of the building. Proactive efforts should be made to improve the ventilation of buildings to fulfill the demand for healthy and environmentally friendly structures. In addition, when designing openings, the outside air should be fully utilized to create airflow, thereby improving the quality of the indoor environment. In addition, proper placement of air ducts and consideration of wind direction are crucial in the design process, and the positioning of air inlets and outlets should be optimized. This allows the odor and moisture as well as the heat and harmful gases from the room to be dissipated quickly, [3].

(3) Space transparency design

Space transparency design is a holistic design concept and processing method. When designing transparency in and around a building, it is important to ensure a harmonious blend, interaction, and connection between the building's interior and exterior. his can be achieved by selectively creating openings and openings in partitions, in line with the design objectives. In the case of a multi-layer transparent design, emphasis should be placed on enhancing the visual flow effect, with a focus on improving continuity, openness, and the seamless connection between layers to achieve a multi-dimensional aesthetic purpose. In building design, it is necessary to understand the rhythm and dynamics of the space and conduct in-depth research and analysis of spatial flow to infuse the entire area with a sense of vitality.

4. Structural model design in transparent design

4.1. Types of glass

(1) Tempered glass

Tempered glass is produced by heating, softening, cutting, and rapid cooling of ordinary glass. Tempered glass is strong, and when it breaks, it will turn into small shards instead of large pieces of glass. Besides, it is safe, low-cost, and abundant [4].

(2) Laminated glass

Laminated glass is made by combining ordinary glass and tempered glass. Its safety factor is even higher than that of tempered glass. Besides, laminated glass will only crack but not break into pieces. In addition, it has a better soundproofing effect and also the color of the film can be changed to achieve the desired aesthetic.

(3) Insulated glass

Insulated glass is a unique type of glass that combines regular and tempered glass using an aluminum hollow frame, creating a space between them. This design provides excellent sound insulation, thermal insulation, and frost protection. Therefore, when designing the transparent structure of a building, it is crucial to tailor the approach according to the specific usage needs.

4.2. Glass construction method

(1) Glass fin

The vertical glass structures on glass components are called glass fins. Glass fins utilize the bending, self-weight, and compression capabilities of the glass itself to improve the overall design efficiency of the building and meet the requirements of a transparent design. When installing and setting glass fins, a suitable adhesive should be selected based on the type of glass used to enhance the bond between the glass wall and the glass fins. The main advantages of using glass fins are that it eliminates the need for metal frames, and all connecting parts are completely transparent and open, enhancing the openness of the space. Glass fins have been widely used in buildings such as lobbies and halls [5].

(2) Structural silicone glazing

Structural silicone glazing involves the use of stainless steel, aluminum alloy, and other structural elements. The interior of the structure consists of glass, and rubber strips are employed for bonding. This approach creates a frame structure that seamlessly blends with the surrounding architecture and offers relatively high safety levels. The glass within the frame can improve internal transparency, strengthen the connection and integration with the external environment, and create a good visual space. However, in this type of structure, it is also necessary to control the concealment of the frame to improve the overall appearance.

(3) Dot Point Glazing (DPG)

As a new type of building structure, DPG is widely used in modern architecture. DPG is a method that involves drilling holes at the four corners of tempered glass and using freely rotatable metal bracket claws for connection. This technique enhances the overall stability of the building. There are two types of DPG buildings, namely single column type and truss type. the single-column type and the truss type. The truss type can further be categorized into three subtypes: parallel truss, triangular truss, and fish truss. The primary advantage of these structures is their ability to fully utilize the support and transparency of glass and steel materials. This enhances the aesthetics and safety of the building. Single-column structure also consists of three subtypes: I-frames, square columns, and single steel pipes. Single-column structures are simple, have small footprint, and are suitable for inter-layer structures. Besides, they are highly safe, aesthetically pleasing, and easy to maintain, so it has been widely promoted and applied.

5. Application strategies of transparent design in architectural design

5.1. Transparent design by the openwork method

The use of openwork techniques to achieve architectural transparency design is illustrated by using the design of a coffee shop.

(1) Front desk design

The coffee shop's design features a blend of various colors, creating a diverse and culturally enriched atmosphere. Instead of traditional openwork techniques, the coffee shop features a glass openwork design at the front desk. The transparency of the glass enhances the visual hierarchy and allows for a clear view of the products displayed on the counter. In terms of materials and object arrangement, the frame structure incorporates a hollow design by blending metal frames with wooden cabinets, enhancing the interior décor's aesthetic appeal [6].

(2) Cafe leisure area design

The leisure area of the coffee shop adopts the traditional openwork method, using square openwork and circular openwork structures to form partitions. This method can not only improve indoor openness, but also prevent physical partitions from dividing the interior as a whole [7]. Furthermore, partitioning with openwork design can significantly enhance the efficiency of indoor light transmission and reduce the need for artificial lighting, aligning with building energy conservation goals. Some seating areas also feature hollow design elements that complement the overall partitioning, creating a harmonious and unified space. A square three-dimensional hollow frame can be mounted on the coffee shop's wall, creating an illusion of extending the space outward. When illuminated, the three-dimensional frame's shadow effect enhances the sense of depth and dimension within the interior, achieving improved visual transparency. In addition, the shadows caused by the hollow partition wall can also serve as a "picture within a picture," not only extending the space but also enhancing the aesthetics of the architecture [8].

(3) The hollow design and dark contrast effect of the coffee shop

In traditional carving, the building or decoration will be damaged to some extent [9]. Traditional openwork technology can no longer meet the current architectural design ideas and needs, and is gradually being replaced by other technologies. The coffee shop uses openwork techniques in the designs of the seats and glass bar counters, and some vibrant paintings are also hung on the black walls to make the colors of the room more diverse. The oil painting creates a strong contrast with the dim wall, which helps to enhance the visual impact.

5.2. Building transparency design based on DPG structure

(1) Glass fins

Metal support claws are installed on the glass fins to make it a glass support structure. It has good permeability and is easy to construct, making it suitable for lobbies, shared spaces, and other places. However, there are certain limitations to glass fins when used in high-rise buildings. When the distance between the ground and the glass is close, people's senses and vision will be amplified, resulting in a serious sense of oppression [10].

(2) Truss

There are three types of trusses: parallel truss, triangular truss, and fish truss. A truss combines the beauty of steel structure and transparent glass, which not only increases the transparency of the building, but also adds to the modern artistic sense of the building. In addition, trusses can be coated with fire-retardant coatings, fluorocarbon coatings, or paints according to the building's usage requirements. However, the design of this structure is complex and difficult, and it may create a sense of bulkiness.

6. Conclusion

Generally speaking, the application of transparent design in architectural design can not only meet the viewing needs of the spatial structure, but also organically combine the architectural structure and the external structure to create a good visual effect, thus improving the architectural quality and the overall aesthetics of the building. Therefore, it is necessary to strengthen the research on transparent design methods. The selection of materials and structural types should also be considered when applying a transparent design. Both transparency and safety should also be fully considered to ensure the best design quality.

Disclosure statement

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Simulation Evaluation of Outdoor Noise Environment in Buildings

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Abstract: Green campus design has become an essential strategy to enhance campus life and learning. However, noise pollution remains a troubling aspect that impacts teaching and learning processes, even causing harm to the health of students and teachers. Therefore, acoustic environment quality design is crucial. This article focuses on the expansion project of a school campus in Shenzhen. We simulated and analyzed the outdoor noise environment separately for the proposed teaching building, as well as the existing buildings like the dining hall, teaching building, and laboratory building. The results showed that the proposed teaching building was mainly affected by surrounding noise, with the worst outdoor noise being in classrooms adjacent to the teaching building in the south and the basketball court at the west of the classroom, with maximum noise values reaching 73 dB and 66 dB, respectively. In the future, these rooms should be renovated to achieve an excellent indoor soundproof environment.

Keywords: Green campus; Outdoor noise; Simulation analysis; Acoustic environment

Online publication: November 28, 2023

1. Introduction

Green buildings are characterized by their minimal resource consumption, eco-friendliness, and their ability to contribute to a harmonious natural environment throughout their entire life cycle. With the shift from basic three-dimensional space to a comprehensive perception of architectural space, architects began to prioritize the architectural acoustic environment. The acoustic environment is a crucial aspect of the architectural setting, and satisfaction with the acoustic environment has been shown to have significant weight in the overall evaluation of indoor environments [1]. Mourshed and Zhao discovered that the acoustic environment was the third most important design factor in healthcare spaces ahead of factors such as lighting, space, color, and landscaping [2]. Additionally, numerous studies have revealed that the acoustic environment has a significant impact on users' emotions [3,4], behavior [5,6], perception [7], recovery, and health [8-10]. In campus buildings, noise can somewhat affect campus life and teaching activities, it might even impact the health of teachers and students. Therefore, it is crucial to design an acoustic environment for a comfortable indoor environment. In this article, under the background of green campus construction and taking an expansion project of a high school campus in Shenzhen as an example, this article simulates and analyzes the outdoor acoustic environment using simulation software to improve campus acoustic environment design. The results showed that the acoustic environment can be through such measures as improving the soundproofing of building envelope structures, using soundproof windows and doors, and taking soundproofing measures for windowsills and ceilings. The purpose of this article is to promote campus acoustic environment transformation, emphasizing the importance of integrating campus acoustic environment design into the planning and design of new or expanded buildings in their construction phase. Besides, this article also aims to promote green campus design.

2. Research method

2.1. Research objective

The project is located on a school campus in Shenzhen city. The existing buildings include a laboratory building, a teaching building, and a comprehensive building. The building to be added is a teaching building. The proposed teaching building is located on the east side of the basketball court. Building 1 is the proposed teaching building. Buildings 2–5 are existing buildings, with Building 2 being the comprehensive building, Building 3 being the dining hall, Building 4 being the teaching building, and Building 5 being the laboratory building. The project site plan is shown in **Figure 1**.

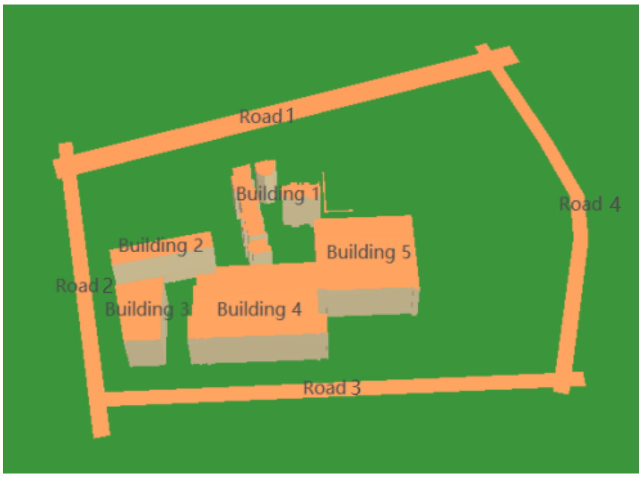

Figure 1. The project site plan

As this project involves teaching buildings, considering that the reading and singing sounds from the classrooms may cause noise interference between the buildings, simulated analyses have been conducted on the outdoor noise environment of the existing cafeteria, teaching building, and laboratory building, the proposed teaching building, and the proposed comprehensive building, with the proposed teaching building being the main focus and the research subject. Considering the influence of the reading and singing sounds (surface sound source) in the classrooms of the existing cafeteria, teaching building, laboratory building, and proposed comprehensive building, as well as the basketball court and surrounding traffic noise (linear sound source), this study investigates whether the proposed teaching building will be subject to noise interference from the existing and proposed buildings during its subsequent use.

2.2. Simulation software

the Sound Environment Design for Urbanism (SEDU) software was developed by the research team of Tsinghua. It was used for noise calculation, evaluation, and prediction in this paper. SEDU is a software program that adheres to international standards such as ISO9613-2:1996 specified by the International Standardization Organization (ISO), as well as Chinese standards like GB/T17247.2-1998 and HJ2.4-2009, outlined in China's Environmental Impact Assessment Technology Guidelines (HJ), and JTG B03-2006, which is part of China's Highway Construction Project Environmental Impact Assessment Standard (JTG). The software strictly follows national standards and can sequentially calculate both indoor and outdoor acoustic environments. The outdoor calculation results can serve as boundary conditions for subsequent indoor sound insulation performance calculations.

Considering the complexity of the surrounding noise environment after the completion of the project, a software was used to simulate and calculate the noise values during the day and night, including the noise distribution on the project site, the noise distribution on the noise-sensitive building at a height of 1.5 meters along the building study plane, and the noise distribution on the facade of the noise-sensitive building.

2.3. Analysis model

An outdoor acoustic environmental simulation analysis model was established based on relevant data such as architectural design drawings. The model mainly included objects such as evaluation target buildings, surrounding buildings, sound barriers, roads (including rail transit), and green belts.

The main source of outdoor noise in construction sites was traffic noise, and industrial noise sources might also be one of them based on the surroundings of the project. The noise sources for this project are shown in **Table 1**. It should be noted that the speed and traffic volume of the vehicles in the table were set based on the actual situation of the project. The roads around the campus are bituminous concrete roads.

Table 1. Traffic noise sources

Road	Time period	Design speed (km/h)	Small vehicles		Medium vehicles		Large vehicles	
			Hourly traffic flow	Noise grade 1 at 7.5 m dB(A)	Hourly traffic flow	Noise grade 1 at 7.5m dB(A)	Hourly traffic flow	Noise grade 1 at 7.5m dB(A)
Road 1	Day	60	400	72	50	72	0	79
	Night	60	100	72	20	71	0	78
Road 2	Day	60	200	72	20	72	0	79
	Night	60	80	72	20	71	0	78
Road 3	Day	60	200	72	20	72	0	79
	Night	60	80	72	20	71	0	78
Road 4	Day	60	200	72	20	72	0	79
	Night	60	80	72	20	71	0	78

According to the Code for Design of Primary and Secondary School Buildings (GB50099-2011), Article 4.3.7, the noise level of reading and singing in classrooms transmitted to 1 m outside is about 80dB, and the noise level of sports facility surroundings during physical education classes is about 70 dB–75 dB. Therefore, during the simulation, the noise level at the edge of the basketball court was set to a line source of 75 dB. A vertical sound source was set at a distance of 1m from the new teaching building 1 exterior, with a noise level set to 80 dB.

3. Results and discussions

Through software simulation calculations, the site noise distribution was predicted under two working conditions – daytime and nighttime. Color maps of the site noise distribution and noise distribution along the research plane at a height of 1.5 meters above the ground were formed, and color analysis and data analysis of the noise level distribution on the facade of the participating buildings were performed. The legend is detailed in **Figure 2**. The site noise distribution is shown in **Figure 3**.

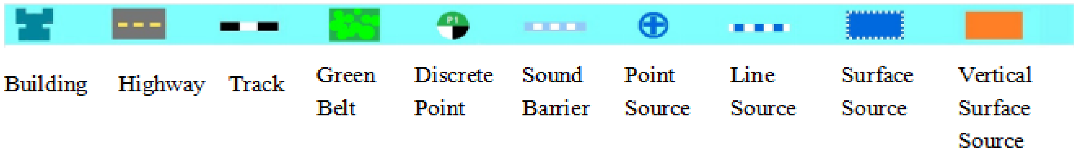

Figure2. Legend

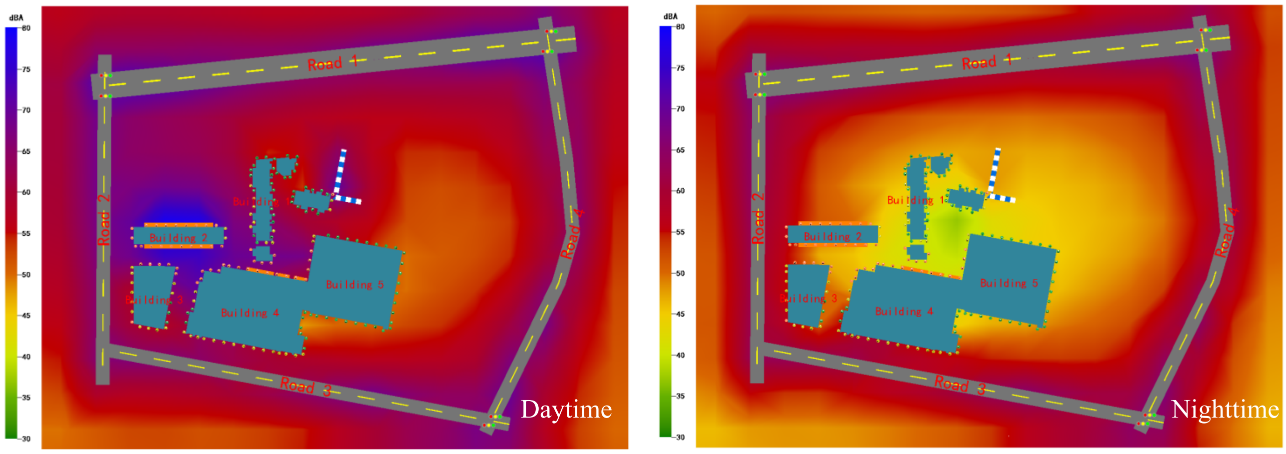

Figure 3. Sound pressure level distribution at a height of 1.5 m above the ground during the daytime and nighttime

The distribution of noise along the research plane at a height of 1.5 meters above the ground in daytime and nighttime for each participating building was analyzed, and the upper and lower numbers inside the circles in each building's top view indicate the maximum noise values during daytime and nighttime, respectively. The outdoor daytime and nighttime noise analysis for this project is shown in **Figure 4**.

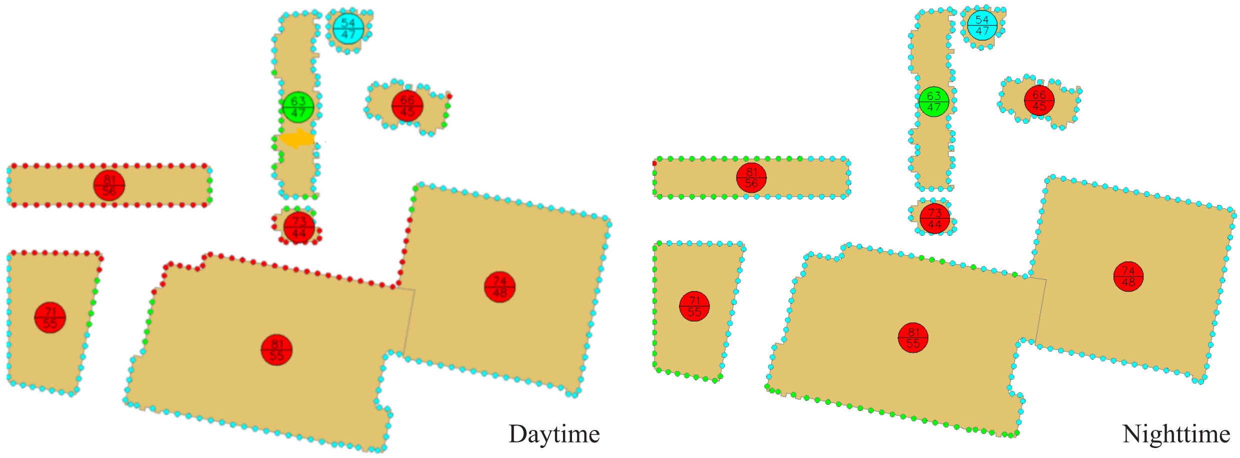

Figure 4. Sound pressure level distribution at a height of 1.5 m above the ground during the daytime and nighttime

Based on the above analysis, the proposed teaching building would be affected by noise from the surrounding area, and the maximum outdoor noise at the facade was 73 dB. The most unfavorable main function room was the classroom adjacent to the southern teaching building and the classroom on the western side of the basketball court, with maximum outdoor noise values of 73 dB and 66 dB, respectively. These two rooms with the most unfavorable outdoor noise should undergo indoor noise evaluation.

4. Conclusion

The outdoor noise environment of buildings on campus was studied in this paper. Through software simulation and result analysis, the outdoor noise situation of the buildings can be summarized as follows.

The proposed teaching building was affected by noise from the surrounding area, with the maximum outdoor noise at the facade being 73 dB. The most unfavorable main function rooms were the classroom adjacent to the southern teaching building and the classroom west of the basketball court, with maximum outdoor noise values of 73 dB and 66 dB, respectively. When calculating indoor background noise, these two rooms were the most unfavorable in terms of noise levels.

The building expansion plan can be designed based on the above outdoor noise simulation results to avoid potential indoor sound environment problems and create a comfortable indoor environment. This will also promote green and ecological design and transformation of campus environments.

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(2) 2022 Green Building Design Golden Course Construction Project of Shenzhen Polytechnic University, China

(3) 2023 Guangdong Provincial Education and Teaching Reform Research and Practice Project, China

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The authors declare no conflict of interest.

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Reliability Design for Longitudinal Slope Length of Expressway

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Abstract: The significance and the strategies of applying the reliability design method of longitudinal slope length in expressway engineering were explored in this study. The objective is to offer insights that can be beneficial for designing longitudinal slope lengths in contemporary expressway projects, with a focus on enhancing their reliability and safety.

Keywords: Expressway; Longitudinal slope design; Longitudinal slope length; Reliability

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1. Introduction

With the continuous development of the modern highway transport industry, the safety and reliability of longitudinal slopes have begun to attract much attention. To address the challenge of vehicles struggling on highway inclines and to prevent unnecessary traffic safety incidents, reasonable strategies should be implemented to ensure the reliability of the slope length.

2. The significance of highway longitudinal slope length reliability design

From a highway engineering point of view, the significance of the longitudinal slope length reliability design includes the following aspects: (1) Reducing the slope resistance that heavy vehicles need to overcome when going downhill, so as to reduce the downhill speed and ensure the safety of heavy vehicles. (2) Solving the difficulties of large vehicles in ascending slopes and avoiding the safety accidents caused by large vehicles skidding on the uphill slope. (3) Reducing the speed difference between different types of vehicles when going, so that the capacity and safety of highways can be significantly improved [1]. It is clear that in modern highway engineering, the reliability of the length of the longitudinal slope has a significant impact on the traveling experience and road safety. Therefore, this issue should be prioritized by designers, and effective strategies should be taken to improve the reliability of the design of the length of the longitudinal slope of the motorway.

3. The strategies of reliability design for longitudinal slope length of expressways

3.1. Selection of representative models

When designing the length of longitudinal slopes in highways, in order to ensure its reliability, the designer first needs to reasonably select a representative model (i.e., the vehicle that is most likely to have a major safety accident) [2]. In China, large vehicles and minibusses are the most common types of vehicles involved in accidents, and the number of accidents for these two vehicle types is quite similar. However, in terms of the number of casualties, the number of casualties in traffic accidents involving large vehicles is higher. Most vehicles involved in such accidents have violations such as speeding or overload [3]. FAW is the most popular brand of heavy-duty vehicles in China [4]. Therefore, designers can choose FAW load vehicles as representative models of modern highway longitudinal slope length reliability design. **Table 1** shows the parameters of an FAW tractor-trailer representative model.

Table 1. Representative model parameters of a FAW tractor

No.	Program	Gear				
		Gear VII	Gear IX	Gear X	Gear XI	Gear XII
1	Shift speed, V_b	41.68 km/h	53.53 km/h	68.15 km/h	88.12 km/h	112.54 km/h
2	Dynamic parameter, W	2.23E-02	1.73E-02	1.36E-02	1.05E-02	8.25E-03
3	Dynamic parameter, Q	1.93E-03	1.17E-03	7.23E-04	4.32E-04	2.65E-04
4	Dynamic parameter, P	-3.03E-05	-1.47E-05	-7.49E-06	-3.86E-06	-2.23E-06
5	Inertia coefficient δ	1.209	1.138	1.097	1.070	1.055

3.2. Calculation of longitudinal slope length

After determining the representative model, the vehicle will be used as the basis for determining the length of the longitudinal slope in the expressway. When the vehicle is traveling on the slope section, its transmission will usually change between different gears, and in the process of changing gears, the engine will also provide different traction for the vehicle, which results in the acceleration and deceleration of the vehicle [5]. The vehicle decelerates until it reaches a uniform speed, and equation (1) can be used to calculate the slope length:

$$\lambda L = \frac{\delta}{12.96g}\int_{v_1}^{v_2} \frac{v}{Pv^2 + Qv + [W - \frac{(f+i)}{\lambda}]} dv \tag{1}$$

where λ represents the correction coefficient, where the value is 1, L represents the length of the longitudinal slope, g represents the acceleration of gravity, where the value is 9.8 m/s^2, v_1 represents the vehicle travelling speed before shifting gears, v_2 represents the vehicle traveling speed after shifting gears, v represents the vehicle's running speed on the horizontal road surface, f represents the drag coefficient of the rolling tires, where the value is 0.01, i represents the longitudinal slope, d represents the width of the longitudinal slope.

3.3. Scientific analysis of reliability function

Reliability refers to the probability of the structure performing its function within a specific period and conditions [6]. The structure is said to be reliable if it can perform its expected functions; otherwise, it would be deemed unreliable. The critical point between the reliable and unreliable state is called the limit state. By creating a functional expression linked to an engineering structure reaching this limit state, allows for a systematic evaluation of the structure's reliability [7]. With this approach, expressway designers can incorporate the aforementioned reliability theory into their designs. They can utilize the failure rate to depict the design value of the longitudinal slope that falls outside the safety range and indicates potential safety risks [8]. During this process, if the length and design of the slope allow the vehicle to ascend without slowing down to the minimum allowable speed, the designer can conclude that the vehicle can safely navigate the longitudinal slope section. The slope length required to ensure the safety of the vehicle while navigating the slope is called the safety value, and the slope length that is determined during the design process is called the design value. In the reliability design of longitudinal slope length, if the design value of slope length is smaller than the safety value, it indicates that the longitudinal slope length design of the expressway project is reliable [9]. If the design value is greater than the safety value, it indicates that the longitudinal slope length design of the expressway project is not reliable, and the longitudinal slope length design poses safety risks. Based on this theory, the reliability function of its longitudinal slope length can be expressed through equation (2):

$$Z = L - S \qquad (2)$$

where Z represents the reliability function of the expressway longitudinal slope length, L represents the safe value, which can be calculated using formula (1); and S represents the design value. Equations (1) and (2) involve many functional variables. So for the convenience of research, the designer can use the vehicle speed and slope at the entrance of the ramp as random variables, and use other parameters as deterministic variables. In the subsequent study, the slope change can be standardized, while the movement speed needs to be obtained by using field measurements. In order to obtain the vehicle movement speed parameters of China's highway longitudinal slope entrances under different speed design conditions, the designer can use the MetroCount 5600, a specialized vehicle typing statistical system, to classify the models and measure the vehicle speeds. According to the current design speed of China's highways, in this study, three types of longitudinal slope inlet design speed of highways were selected for investigation, which were 80 km/h, 100 km/h, and 120 km/h, respectively. After obtaining the corresponding vehicle travel parameters, SPSS software was used to carry out the K-S one-sample test of the data. **Table 2** shows the K-S one-sample test data of the survey results of vehicle traveling speed at the entrance of the longitudinal slope of the motorway.

Table 2. K-S single sample test data of the vehicle speed survey results at the longitudinal entrance of the expressway

No.	Program	Design speed		
		80km/h	100km/h	120km/h
1	Sample size	239	248	313
2	Mean value of normal parameters	74.779	78.597	80.894
3	Normal parameter standard deviation	6.575	7.147	7.072
4	Maximum positive difference	0.04622	0.00369	0.02455
5	Maximum negative difference	-0.4143	-0.02563	-0.3412
6	Absolute value of the maximum difference	0.04622	0.00369	0.03412
7	Test statistics	0.04622	0.03369	0.03412
8	Progressive significance	0.2	0.2	0.2
9	Exact significance	0.669	0.932	0.847

Through the above data analysis, it was found that under the three design speed conditions, the accurate significance of the statistical value of the vehicle traveling speed at the longitudinal slope entrance exceeded the significant level value (0.05), so its distribution was considered to be normal.

3.4. Verification of the reliability of the longitudinal slope length

According to China's Highway Route Design Code JTG D20-2017, for expressways with design speed of 80 km/h, 100 km/h, and 120km/h, the maximum slope design index should be controlled at 5%, 4%, and 3% respectively, and under certain circumstances, the slope can be reduced by 1%. In practice, since the strict criteria for the maximum longitudinal slope do not often directly impact the design, there is usually no need to further examine the probability of it failing in specific designs [10]. Under these three conditions, the minimum value of the longitudinal slope length of the motorway was 200 m, 250 m, and 300 m respectively; the maximum permissible speed when ascending the slope was 50km/h, 55km/h, and 60km/h, respectively. Using MATLAB software, designers can perform sampling simulation calculations to verify the reliability of the design value for downhill slope length across different design speeds, slopes, and slope lengths.

After calculation, it was found that when the design speed was 80km/h, the maximum slope length was 700 m, with a slope length reliability is 74.874%; when the design speed was 100km/h, the maximum slope length was 800 m, with a reliability of 86.555%; when the design speed was 120km/h, the maximum slope length was 900 m, with a reliability of 95.581%. However, according to the Unified Standard for Reliability Design of Highway Engineering Structures (JTG 2120-2020), when the design speed of the longitudinal slope opening is 80 km/h, 100 km/h, and 120km/h, the corresponding target reliability should reach 85%, 90%, and 95%, respectively. Therefore, it is clear that when the design speed of the longitudinal slope was 80 km/h and 100 km/h, the maximum length of the longitudinal slope calculated did not meet the actual safety requirements of the vehicle.

3.5. Determination of the safety value of longitudinal slopes

The calculation of the maximum value for the longitudinal slope length is based on typical conditions for maximum slope values. However, to determine the safety length of the longitudinal slope under specific circumstances, designers can consider reducing the maximum slope value by 1%. They can then gradually increase the maximum slope value and perform sampling simulation calculations to obtain the safety value for the slope length [11]. **Table 3** shows the results of the sampling simulation calculation of slope length safety value under the condition of different maximum slope values.

Table 3. Sampling simulation results of slope length safety values under different maximum slope values

No.	Design speed	Maximum gradient	Maximum slope length
1	80km/h	4%	850 m
2	80km/h	4.2%	800 m
3	80km/h	4.4%	700 m
4	80km/h	4.6%	600 m
5	80km/h	4.8%	550 m
6	80km/h	5%	500 m
7	100km/h	3%	1100 m
8	100km/h	3.2%	1000 m
9	100km/h	3.4%	800 m
10	100km/h	3.6%	800 m
11	100km/h	.3.8%	700 m
12	100km/h	4%	700 m
13	120km/h	2%	Unlimited

Table 3. (Continued)

No.	Design speed	Maximum gradient	Maximum slope length
14	120km/h	2.2%	Unlimited
15	120km/h	2.4%	1700 m
16	120km/h	2.6%	1400 m
17	120km/h	2.8%	1300 m
18	120km/h	3%	900 m

Based on the data analysis, it is clear that when the maximum longitudinal slope of the expressway is reduced appropriately, the safety value of the longitudinal slope length will change accordingly, and there may even be no limit to the safe length. Based on this, the maximum gradient of the longitudinal slope can be designed according to the actual operation of the expressway, and the design value of the slope length can be determined scientifically. In this way, the length of the longitudinal slope of the highway can be designed with sufficient reliability, and the safety of vehicles navigating the slope can be ensured [12].

4. Conclusion

In summary, the longitudinal slope length design is crucial in the design of highways. In order to ensure the reliability of the longitudinal slope length design, the design strategy should be outlined clearly. Besides, suitable representative models should be selected so that the longitudinal slope length can be determined reasonably. Besides, the scientific analysis of the reliability function, the effective validation of the reliability of the longitudinal slope length, and the reasonable determination of the longitudinal slope safety length value are also crucial aspects in determining a reliable slope length. In this way, the reliability of the design value of the longitudinal slope length of the motorway can be effectively guaranteed, and traffic accidents caused by the unreasonable design of the longitudinal slope length can be avoided.

Disclosure statement

The authors declare no conflict of interest.

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A Study on Informatization Teaching Efficacy in Higher Vocational Education in Guangzhou, China

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Abstract: China has been vigorously promoting the construction and development of Informatization teaching efficacy education. Informatization teaching efficacy was used as an indicator of the psychological state of teachers. This article analyzes relevant literature at home and abroad and determines the five dimensions that affect teachers' informatization teaching efficacy in informatization teaching.

Keywords: Informatization Teaching Efficacy; Teaching efficacy; Higher vocational institution teachers

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1. Introduction

Educational development has always been a priority in China, and the country has proposed a series of educational reform policies to support the multimedia teaching environment. Multimedia information-based teaching environment is an inevitable trend in future education. Information-based teaching has become a necessary skill for teachers, and multimedia information-based teaching has also been highlighted. The national education curriculum reform has not only changed teaching methods but also affected the teachers' psychology. In this paper, Informatization teaching efficacy was used as an indicator of the teachers' psychological state. Informatization teaching efficacy was evaluated based on subjective evaluation, confidence in their abilities, and teaching effect under the background of informatization teaching efficacy. Relevant literature at home and abroad was analyzed to determine the five dimensions that affect informatization teaching efficacy. The five dimensions were teaching attitude, course design, teaching strategies, self-improvement, and classroom management.

2. Problem statement

Informatization teaching efficacy refers to a teacher's self-evaluation in the teaching process: how well he/she can complete the teaching tasks. Informatization teaching efficacy plays an essential role in the professional development of higher vocational teachers [1]. It is affected by two factors: The self-confidence and the psychological state of teachers; the second factor is the impact of the teachers' psychology on students.

Through questionnaire research, it was found that informatization teaching efficacy in middle schools in terms of political and ideological education is affected by the teaching attitude. The more positive their attitudes are, the more effective informatization teaching efficacy will be. It was also found that the teacher's gender and personality, work efficiency, the teaching attitude, the course design, the teaching environment, the students' quality, the school's management and curriculum standards, etc., also affect classroom teaching behaviors.

Some teachers lack experience and understanding of their students, so they are not confident. However, as they try out different teaching methods, get feedback from the students, and continue to improve their work, they will gradually establish a set of effective teaching modes [2].

A higher teaching efficacy score indicates more diversified teaching strategies used in class in dealing with students' learning problem behaviors [3].

Studies have shown that promoting the independent development of teachers will help improve informatization teaching efficacy. The higher the degree of autonomy of teachers is, the stronger their sense of responsibility will be [4].

According to a survey conducted in the University of Arizona on the basic qualities required of 111 international Chinese teachers and volunteers in the United States, 97.3% of them said that classroom management ability was the most important quality. This shows that classroom management is one of the most crucial abilities a teacher must have [5].

A large number of studies at home and abroad have shown that informatization teaching efficacy not only has a positive impact on teaching behaviors, teaching strategies, teaching effects, student achievements, and student development, but also has an important impact on teachers' mental health, career development, and personal development [6].

The construction of multimedia informatization teaching efficacy environments has become the only way for China to develop Smart education. In China, colleges and universities across the country provide various training programs to improve their teachers' abilities in informatization teaching efficacy. As the country undertakes educational reform, teachers are facing more pressure and challenges. Informatization teaching efficacy being one of the psychological indicators is closely related to teaching activities and the teachers' personal development. As of now, there have been few studies on informatization teaching efficacy in vocational school teachers in China. Therefore, there is a need to study informatization teaching efficacy in a multimedia teaching environment.

The purpose of this study was to explore the effect of teaching attitude, course design, teaching strategies, self-improvement, and classroom management on informatization teaching efficacy in higher vocational institutions in Guangzhou, China.

2.1. Informatization Teaching Efficacy

Information technology is ever-evolving, introducing new tools, platforms, and applications all the time. Therefore, keeping up with these new technologies and assessing their impact on teaching efficacy presents a new challenge.

Informatization teaching efficacy is the intrinsic motivation of teachers' ability development. It can not only reflect the confidence and qualities of the teachers, but also predict students' learning outcomes. Hence, informatization teaching efficacy has become an important indicator of a teacher's competency.

Teachers with strong efficacy exhibit an increased enthusiasm for teaching, a strong commitment to their profession, a positive influence on student achievement, and an increased level of persistence. They consider new situations as challenges and do not give up [7].

Armor and Berman were among the early researchers who studied instructional efficacy as part of the "Teacher Effectiveness Evaluation Research" project, which later attracted the attention of many scholars [8]. As a result, the theory of teaching efficacy has been well-established. Teaching efficacy is theoretically derived from Rotter's control point theory and Bandura's self-efficacy theory.

Teaching efficacy can affect a teacher's emotional regulation; thus, it will also affect their work quality, ultimately affecting students' learning efficacy [9].

A study was done on the relationship between informatization teaching efficacy and the attitudes of teachers using computer-aided design as an example. The results showed that teaching efficacy was positively correlated with the teachers' attitudes [10].

Besides the influence of information technology on informatization teaching efficacy has also been studied. In the study, it was pointed out that modern education not only changed teaching methods but also had a subtle influence on the teachers' psychology [11]. Information technology plays a role in informatization teaching efficacy. Information technology affects informatization teaching efficacy in four ways: performance/achievement, use experience, verbal persuasion, and emotional stimulation. Meanwhile, the application of information technology also affects informatization teaching efficacy. Thus, there is a relationship between teaching attitude, course design, teaching strategies, self-improvement, classroom management, and informatization teaching efficacy.

Only a few studies examined the five factors (teaching attitude, course design, teaching strategies, self-improvement, and classroom management) altogether. Therefore, the purpose of this study was to study the impact of five different influencing factors on the teachers of higher vocational institutions in Guangzhou. The teaching efficacy will be evaluated based on the aforementioned indicators.

2.2. Teaching attitude

Teaching attitude is an important factor that affects informatization teaching efficacy. Teaching attitude directly reflects the informatization teaching efficacy of teachers. If teachers are professional and positive, the teaching effects would be better. If a teacher is irresponsible, the relationship between the teacher and his/her students will be affected, leading to low teaching efficacy. Therefore, it is important to study how teaching attitude affects informatization teaching efficacy.

Mark Bray came to a frightening conclusion: "Teachers" are the decisive factor in the success or failure of education [12]. Teachers have tremendous power to make children's lives happy or miserable. They can be instruments of pain or a medium of inspiration. They can embarrass or delight, hurt or save. He said that when the teacher walks into the classroom with a smiley face, the students will be very comfortable and relaxed; if the teacher approaches them with an angry face, the students will keep quiet as they are afraid of agitating the teacher. When students in the classroom are affirmed and encouraged, they become very excited; when the teacher is sarcastic and cynical, the students will be disheartened. It can be seen that the teacher's attitude plays a very important role in students' learning.

Certain teaching methods are favored by teachers because of their stability and clarity [13]. The online attitude that teachers should adopt in a virtual classroom has been studied. It has been pointed out that online education will not only the teaching methods but also the teachers' understanding of the meaning of teaching [14].

There are two categories of teaching attitudes. The first one can be divided into positive teaching attitude and negative teaching attitude [15]. A positive teaching attitude is a correct understanding of students' ideological cognition, ability, and personality. A teacher with a positive attitude can stimulate students' interest in learning.

However, a negative teaching attitude will hinder the improvement of teaching quality and the overall development of students' body and mind.

Teaching attitude can also be divided into three elements: the teachers themselves, the attitude towards their students, and the teaching content. As the goal of education shifts from being exam-oriented to focusing on the quality of education, teachers should strive to improve themselves and emphasize cultivating their students' creativity [16]. Besides, the teachers should also be patient when teaching their students. Strictly speaking, the elements of teaching attitudes should be far more than these three, it should also include teaching methods. On the other hand, building upon the understanding of teaching elements as teachers, students, and teaching activities (or educational influences), teaching attitudes can be described as a teacher's attitudes towards their career, students, and teaching activities. Incidentally, a teacher's attitude towards their teaching activities (or educational influences) directly affects their work quality. Therefore, it can be clearly said that there are omissions in the classification of teaching attitudes that are just based on three elements.

2.3. Course design

Course design refers to the organization of the curriculum, including the foundation of the curriculum, the organizational methods and skills of its elements, and the evaluation of the curriculum plan. The concepts related to course design include curriculum organization, curriculum development, curriculum preparation, curriculum construction, and so on.

The purpose of course design is to transform the requirements of social development, the trend of knowledge growth, and students' needs into a course, with suitable standards, content, and structure. The most common form of course design is to arrange the components or elements of a course. The components or elements in a course usually include the objectives, the content, the learning activities, and the methods of evaluation. Therefore, the combination of these elements into a unified course organization constitutes course design. Therefore, this study also intended to find out how course design affects informatization teaching efficacy.

Course design also refers to the organizational form or structure of the curriculum, that is, the arrangement of various factors of the curriculum [17]. Course design can be based on two aspects: theoretical basis and method and technology. The so-called theoretical basis mainly refers to the three foundations of course design: discipline, students, and society. The so-called method and technology refers to the arrangement of curriculum factors according to the theoretical basis. Curriculum factors are often referred to as objectives, content, activities, and evaluation.

Course design is the key to the curriculum reform of vocational education, which will make the education system more systematic [18]. The formation of a "functional structure" can be viewed as a systematic learning resource formed by learners in various "pre-education materials" rather than strengthening the development of professional skills [19].

Wang asserts that the Design model course is a representation of how course design operates in reality or as an illustration of the ideal operation [20]. Its purpose is to introduce, communicate, or demonstrate the blueprint of course design to guide forthcoming course design actions. Course design is the process of transforming social development requirements, knowledge, and students' needs into course contents that meet students' level of physical and mental development and logical order of knowledge.

Shi made a detailed distinction between course design and course development [21]. In his opinion, the connotation of course development is greater than that of course design. Course design only includes the establishment of course objectives and the selection and organization of course content.

According to Jiang, course design refers to the formulation of the structure of a course, which depends on the decision-making at two different levels [22]. The broad level includes determining the fundamental values of the course, and the specific level includes the utilization of different technologies and the execution of the curriculum elements.

Cong suggests that course design involves designing each aspect, categorized into macro, medium, and micro levels [23]. These three levels of course design are both independent and intrinsically interconnected.

2.4. Teaching strategies

Teachers ought to adapt their teaching methods based on their students' responses, create personalized teaching strategies, critically review each teaching phase, maintain reflective diaries, and analyze and summarize their teaching experiences regularly. This iterative process aims to continually enhance teachers' effectiveness in utilizing information technology for teaching. During classroom sessions, a pivotal responsibility for teachers is to sustain the flow of the teaching process. When encountering a situation where the teaching process stalls, teachers should draw upon routine practices, recall past experiences to address the issue, and dynamically make interactive decisions based on evolving circumstances. Creatively implementing effective solutions is essential to re-energize the classroom and ensure seamless continuation of the teaching activities [24]. Therefore, it is important to find out how teaching strategies affect informatization teaching efficacy.

Teacher needs to consider two factors when making planning decisions: the resources they have and the constraints they are subjected to. The abundance of resources will affect the decision-making process of the teachers. This includes the teaching experience and the external resources available such as books, materials, and teaching equipment. The more resources teachers have, the more choices they have when making decisions, which allows more possibilities. On the contrary, fewer resources allow fewer choices. The restrictive factors come from the environment, the situation of students, the teachers; beliefs, and other aspects. For example, students' level of English will affect the teachers' decisions on activity organization, task selection, evaluation methods, and other aspects.

Teaching strategies could be divided into three dimensions [25]: pre-class strategy, in-class strategy, and after-class strategy. Teaching strategies can also be understood as a series of problem-solving behaviors adopted by teachers to achieve teaching objectives [26]. Shi defines instructional strategies are relatively systematic actions taken in the teaching process to the teaching objectives [27]. Another scholar defines teaching strategies are a series of processes in which teaching activities are adjusted in order to achieve the teaching goals [28].

Zhou stated that teaching strategies are systematic decision-making activities carried out by teachers in order to achieve teaching objectives [29]. Che pointed out that teaching strategies are a new field and hot spot in instructional psychology research [30]. In a broader scope, instructional strategies encompass both teaching strategies and learning strategies. However, in a narrower context, instructional strategies specifically pertain to teaching strategies, constituting an integral part of instructional design. They are tailored to particular teaching scenarios to achieve teaching objectives and accommodate students' cognitive needs. This involves the development of teaching procedures and measures for teaching implementation.

2.5. Self-improvement

High teaching efficacy promotes teachers' self-improvement. Teaching efficacy is manifested in teachers' belief that they can influence their students. In this way, the teachers will have a mindset of wanting to improve themselves instead of just being forced by external circumstances. A strong sense of informatization teaching efficacy efficacy boosts teachers' confidence and validates their professional worth. It also enables them to assess their personality values objectively and receive precise guidance, stimulating their teaching motivation and fostering ongoing reflection, adjustment, enrichment, and personal development for continuous improvement [31]. Self-improvement refers to the awareness that a teacher has of improving his/her competency, professional identity, achievements, and work efficiency.

Self-improvement has been repeatedly shown to be a relevant factor for the effectiveness of teaching activities, as it is a powerful driving force influencing classroom behavior and teaching efforts. Therefore, self-improvement is crucial in terms of ensuring teachers' mental health and job satisfaction and students' academic performance [32].

Hoy and Woolfolk believe that teacher self-improvement is a development process in which teachers improve their professional knowledge and skills at every stage of their career [33].

Fives *et al.* proposed the connotation of teacher self-improvement from another perspective [34]. He believed that teacher self-improvement is not about the individual learning and development process of teachers throughout their careers. At the same time, it is also the result of teachers' experience in dealing with spatial and temporal situations.

Another researcher believed that teacher self-improvement means that teachers carry out tasks and activities according to their wisdom in their field without external intervention from non-professional sources [35].

Yao emphasized that teachers should have strong awareness and motivation to improve themselves [36]. Self-development can be achieved through independent reflection, self-renewal, design and plan formulation, implementation and regulation of professional development direction, etc. He also pointed out that independent development is the inner core factor of teacher professional development, and autonomy is the inner driving force of teacher professional development.

Yang *et al.* believed that the key to teachers' self-improvement lies in improving the awareness of professional development [37]. It lies in teachers' independent and active pursuit of self-development and professional development.

Sui found that college teachers have the lowest "perceived ease of use" of informatization teaching efficacy [38]. Therefore, colleges and universities can improve teachers' perception of informatization teaching efficacy by enriching their experience in using it. Various types of school-level teaching development projects can be organized to increase teachers' practical experience in informatization teaching efficacy. In this way, teachers would get to understand the usefulness of technology in improving teaching efficiency and effectiveness, which would improve their willingness to use informatization teaching efficacy, which in turn improves the teachers' proficiency in informatization teaching efficacy. There are various forms of teacher development projects in colleges and universities, such as informatization teaching efficacy training, teaching competitions, teaching supervision, educational technology competitions, micro-class competitions, etc. These activities are all ways to improve teachers' informatization teaching efficacy capabilities.

2.6. Classroom management

A researcher adopted a teaching potency scale with six dimensions, including course design, teaching strategies, technology use, classroom management, interpersonal relationships, and learning assessment [39]. A survey has been conducted on the teaching efficacy of 678 primary and secondary school teachers working in Tokat in terms of gender, curriculum matching, in-service training, work experience, etc. The results showed that the teachers were most competent in terms of classroom management. The followed by course design, interpersonal skills, learning assessment and technology use, and teaching strategies. The survey revealed that in higher vocational classes, misuse of multimedia equipment, improper use of self-help slogans, neglect of warning signs and safety gear, as well as neglect of the physical and psychological classroom environments, contribute to issues such as classroom restriction and rigidity, indifference in teaching methods, and a lack of attention to improving the classroom's psychological environment. Furthermore, there are observed problems related to the mismatch between students' life experiences and institutional environments [40]. Therefore, it is crucial to study how classroom management affects informatization teaching efficacy.

Friedman and Farber found that teachers who thought they were poor in classroom discipline and management reported higher levels of job burnout than those who thought they were better [41].

Lu mentioned in their discussion on the influence of teacher factors on classroom management that good discipline is the fundamental guarantee for the establishment of an orderly learning environment, in which teachers, as the organizers and managers of classroom teaching, play a key role [42].

Jones *et al.* pointed out that classroom management should go beyond "student discipline," and all things that teachers do to promote students to participate in classroom activities with concerted efforts and create a vibrant and fruitful teaching environment belong to classroom management [43].

In a cross-sectional study of Dutch teachers, Brouwers and Tomic found that a high level of student sabotage leads to a low level of self-efficacy in classroom management, and a low level of self-efficacy in classroom management leads to a higher level of teacher burnout. Conversely, a higher level of teacher burnout will lead to a higher level of students' destructive behavior, which will further reduce teachers' self-efficacy [44].

Jalili *et al.* conducted a study from the perspective of teachers' personalities and believed that extroverted teachers could control the classroom better than introverted teachers in adult foreign language learning [45].

Zhou *et al.* believe that classroom management includes classroom discipline management, information management, operation regulation, and time management [46].

Yan *et al.* believe that classroom management includes three aspects: establishing classroom routines, dealing with classroom problematic behaviors, and creating a good classroom teaching situation [47].

3. Conclusion

In this study, literature regarding informatization teaching efficacy, teaching attitude, course design, teaching strategies, self-improvement, and classroom management were analyzed.

In summary, this study aims to contribute to the research on the effectiveness of information-based teaching of higher vocational teachers in Guangzhou. It is of practical significance for higher vocational teachers to adapt to the information-based teaching environment, improve the efficiency of information-based teaching, make full use of information technology to improve teaching quality, and promote teachers' personal development.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Application of Construction Robots in the Context of Construction Industrialization

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Abstract: Based on the original construction technology, construction robots are realized by integrating industrial information technology, and construction robots are used to replace manual labor in completing construction projects. China's research on construction robots is still in its early stages. Research efforts need to be increased in order to promote better applications of construction robots. To this end, by analyzing the application of modern construction robots, we conduct a comprehensive study on the development of construction robots to ensure that construction robots can be widely used in the future.

Keywords: Construction engineering; Robot; Intelligence; Construction technology

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1. Introduction

Upgrading the intelligent construction industry is one of the effective ways to solve many problems in the construction industry. In the broad sense, construction robots include all robotic equipment related to the entire life cycle of a building. In the narrow sense, construction robots specifically refer to robotic equipment closely related to the construction operations, usually one that performs specific construction tasks such as masonry, cutting, welding, etc., in building prefabrication or construction processes. The output value of China's construction industry continues to expand, which also provides sufficient space for development for the construction robot industry. It is estimated that by 2023, the application scale of China's construction robot industry will reach 22.4 billion yuan [1]. Although China's patented construction robots are currently growing rapidly, most of them are still in the research and development stage, and have not entered the commercial field or achieved large-scale mass production, and the penetration rate of downstream application is less than 1%. By implementing and using construction robots, the construction industry has saved some labor costs, improved construction efficiency and construction quality, and effectively solved problems existing in construction projects. Since modern construction robots are still in the early stages of research and application, large-scale production and utilization have not yet been achieved. Construction robots have only been applied to actual construction with the reform and development of the construction industry in recent years [2]. The professional content and construction scope involved in the research of construction robots are relatively wide, including construction survey, maintenance, demolition, etc. However, in order to ensure the quality of construction, the development of construction robots needs to be further clarified to achieve intelligent and high-precision standards [3].

2. Characteristics of industrial robots

2.1. Programming

The development of production automation lies in flexible startup. Industrial robots can change based on changes in the working environment. Therefore, it plays an important role in flexible production with batch consumption, variety, and high efficiency, which is the key to flexible manufacturing.

2.2. Personification

Industrial robots have legs, arms, claws, and other parts similar to humans in terms of mechanized structure, and are controlled by computers [4]. Therefore, intelligent industrial robots have biosensors related to humans. For example, skin type, power type, vision, speaker, language, and other sensors. Sensor applications improve the ability of industrial robots to adapt to the surrounding environment.

2.3. Universality

General industrial robots also have versatility when performing different tasks. Different operating tasks can be performed by replacing the hand-operated end operator.

2.4. Industrial machine technology involves a wide range of disciplines

The combination of machinery and microelectronics creates mechatronics technology. With the emergence of the third generation of intelligent robots, it can acquire sensors for external environment information, as well as the memory function, language understanding ability, image recognition ability, and reasoning and judgment ability of normal artificial intelligence (AI). These are all part of the application of microelectronic technology, especially the application of the closely related computer technology. Therefore, the development of robotics can promote the development of other related technologies, and the development and application level of robotics can also verify a country's scientific and technological level as well as industrialization level.

3. Applications of construction robots

Labor shortages in the construction industry are growing, with increasingly fewer young people planning to join the construction industry. At the same time, construction is also accompanied by serious safety issues. According to rough statistics, about 30% of occupational accidents occur in the construction industry, and the risk of fatal accidents in the construction industry is four times that of other industries [5]. At the same time, labor productivity and cost-effectiveness issues are also key issues in construction.

Robots can solve health and safety issues on construction sites, complete the handling of large and heavy loads, and replace workers in working in polluted areas. In addition, robots can complete complex and repetitive processing tasks and perform dangerous tasks. Through automated construction methods, the shortage of labor and skilled workers in the industry can be solved, and young people can also be attracted to join the construction field. From a cost-benefit perspective, taking the use of concrete materials as an example, compared with traditional construction methods, three-dimensional (3D) concrete printing can save 30–60% construction materials and 50–80% labor costs, and shorten the construction period by 50–70%, thereby significantly reducing the production costs in construction.

3.1. Ground construction robot

In 2014, members of the Singapore Future City Experiment collaborated with personnel from ETH Zurich and developed a floor-tiling robot, as shown in **Figure 1**. The structure of the floor-tiling robot mainly consists of two parts.

(1) Manipulator: The end of the manipulator is equipped with concrete sprayers and suction cups. Sensors are installed at both ends of the equipment to identify and locate the space of the floor tiles, and effectively identify the boundary of the floor tiles. With the application of computer programs, calculations are used to ensure the accuracy of floor tile paving.

(2) Autonomous mobile robot navigation platform: The platform mainly controls the moving speed and range of the robot. It has navigation and control functions, which can promote the flexible movement of the floor-tiling robot, and can be used in the floor tile laying construction of large and small buildings.

The core component of the floor-tiling robot is the robot positioning system, and laser sensors are installed inside the robot. Generally, there are about four laser sensors. If too many laser sensors are installed, it will have a certain impact on the operating accuracy of the positioning system, and even cause errors in positioning data information. In the manufacturing of robots, it is necessary to accurately control the number of laser sensors to ensure the positioning accuracy of the robot. However, there are still many shortcomings in the actual application of floor-tiling robots, which need to be improved and optimized.

Figure 1. Floor-tiling robot

3.2. Demolition/removal robot

Construction projects involve earth excavation, waste disassembly and renovation, earth removal, and other construction contents, which increase the difficulty and danger of construction. Moreover, the process of earthwork will produce a large amount of dust, causing air pollution to the surrounding environment. Building demolition relies heavily on manual control of machines, and the risk of demolition is relatively high. It is easy to make disassembly errors, which poses a life safety threat to on-site construction technicians, consumes a large amount of human and physical resources, and contradicts China's green, environmentally friendly, and energy-saving construction concept [6]. In order to effectively solve this construction problem, relevant departments have developed a demolition robot through the effective use of modern information technology, thereby changing the traditional mode of manually driving the demolition equipment and realizing an operation mode of impact crushing using robot. When the robot is carrying out impact crushing operations, it mainly uses a rocker to automatically and effectively control the robot, thus keeping construction workers away from the demolition site, and ensuring construction safety at the demolition site. In addition, the demolition robot is small and flexible, and can be used indoors or in demolition work of small building. However, demolition robots are widely used in rescue work.

3.3. 3D printing construction robot

There are relatively many control systems involved in 3D printing construction robots, including three-dimensional computer-aided design systems, robot control systems, engineering material management systems, etc. 3D printing construction robots can build solid models of three-dimensional building by using 3D printer based on existing three-dimensional model. With the effective use of 3D printing construction robots, the construction process can be simplified, thereby saving construction time and improving construction efficiency. For example, the AIBuild startup company in London, UK, has realized a 3D printed AI robot with modern information technology. The robot has 3D printing functions, AI algorithm functions, and industrial robot control functions. In actual use, the robot is visually controlled through AI algorithms. Technology can avoid blindly executing computer instructions, and with the effective use of this technology, an information feedback loop can be realized, and problems existing in the robot's self-test printing process can be promptly adjusted, which will play a role in improving the efficiency of architectural 3D printing.

3.4. Floor grinding robot

In cement floor grinding, although the use of ground grinders can reduce labor consumption and improve grinding efficiency, the dust treatment effect is relatively low. It is inconvenient to adjust the tie rod during the operation of the grinder, and this situation often occurs during transportation. The bottom of the device collides with the ground, causing damage to the ground [7]. To this end, by utilizing industrial information technology, a floor grinding robot is realized. The robot changes the rotation angle of the tie rod by activating the device knob and then pushing the knob to move in the first chute. In addition, during the operation of the floor grinding robot, the brush at the bottom of the casing will automatically clean the polished dust, and a vacuum will be used to collect the dust in the channel. The dust generated after polishing will cause harm to the human respiratory system.

3.5. Spraying robot

Spraying robots are also called spray painting robots. They can complete automatic painting or automatic spraying during operation. This technology is mainly based on a robot, which combines computer information technology and control systems, including mailboxes and electrodes. Driven by hydraulic equipment, it can automatically complete the painting work in construction projects. Spraying robots are environmentally friendly and efficient. They meet the current painting needs and can also replace manual spraying work.

3.6. Vision-guided robot

With the continuous development of science and technology, intelligent technology and automation technology have been widely used in industrial production, which include robot vision. However, there are still problems in the application of robot vision. When there is loud noise in the industrial production workshop, the machine vision system will be affected, thus reducing the equipment sensitivity and damaging the performance of the equipment.

In the industrial production process, the application of machine vision systems has also attracted much attention. Some industrial production sites have relatively high temperatures, while some have low temperatures. At this time, the machine equipment must have anti-interference capabilities and strong stability. When collecting images, it is affected by the intensity of light. When the light is relatively low, it will affect the extraction, recognition, and analysis of the target image, causing the increase in the rate of defective products and affecting its production efficiency and accuracy. The current focus lies in how to solve these problems, improve machine performance, recognize images, and efficiently apply machine vision technology in industrial production. Firstly, efficient image processing software and hardware should be developed. The speed of image acquisition is partly affected by the speed of the hardware. High-quality hardware can reduce the burden on the host and has a direct impact on its system resolution, acquisition efficiency, image processing speed, and processing and analysis efficiency. High-quality software is also critical, which can significantly increase the speed of machine command execution [8]. Secondly, intelligent algorithms with strong adaptability, good stability, and high efficiency should be developed. Intelligent, stable, and efficient intelligent algorithms can increase system analysis and processing speed, improve the system's anti-interference ability in complex environments, and make the system more stable.

4. Key technologies for the development of construction robots

4.1. Structural design

At this stage, the structural volume of China's construction robots is relatively large, and the robot's own gravity is relatively high, which has a certain impact on the movement of the robot. For this reason, in the future development of construction robots, it is necessary to simplify the robot structure and adopt lightweight materials, mainly micron-level micro-motion materials, which can improve the motion resolution of the robot. By using composite materials instead of aluminum alloy materials for robots, it can not only reduce the manufacturing cost of the robot, but also reduce the gravity of the robot, and ensure the structural strength and hardness of the robot.

4.2. Sensor technology

In the future development of construction robots, sensor technology will be fully applied to meet the robot's functional requirements in information transmission [9]. Voice-activated sensors or visual sensors can be installed in the robot structure to accurately control the operation of the robot. This enables construction robots to operate effectively in positional work environments. For example, applying a pressure sensor based on process, voltage, and temperature (PVT) phase characteristics to the structure of a construction robot can effectively improve the pressure of the construction robot. The maximum pressure can exceed 100 MPa. Alternatively, image restoration technology can be used to realize a visual sensor. In construction robots, they can be used as the robot's "eyes" to effectively detect the surrounding environment. Humans can also be used to speak to the machine control system to implement voice-activated sensors, which can be used in construction robots to recognize language and make correct operational judgments.

4.3. Navigation and positioning technology

In the future development of construction robots, genetic algorithms or ant algorithms should be implemented based on the movement of construction robots to effectively assist robot sensors, control safe movement positions, avoid surrounding obstacles in a timely manner, and achieve accurate positioning. For example, the ultrasonic indoor navigation and positioning system can be used to calculate the ultrasonic reception time difference after emitting ultrasonic waves, so as to grasp the mobile position of the robot. During the test, the positioning accuracy of the robot was controlled. The laser navigation system of the construction robot can also be optimized and modified, a fusion encoder or an unscented Kalman filter (UKF) sensor can be added to the robot structure to comprehensively improve the navigation and positioning accuracy of the construction robot [10].

5. Conclusion

In summary, the realization of construction robots has laid a good foundation for further development in the construction field, and it is also an important new topic currently being studied in the construction field. There are relatively many types of construction robots. To effectively leverage the advantages of construction robots, comprehensive research on construction robots needs to be conducted to achieve high-precision, lightweight, and intelligent construction robots.

Disclosure statement

The author declares no conflict of interest.

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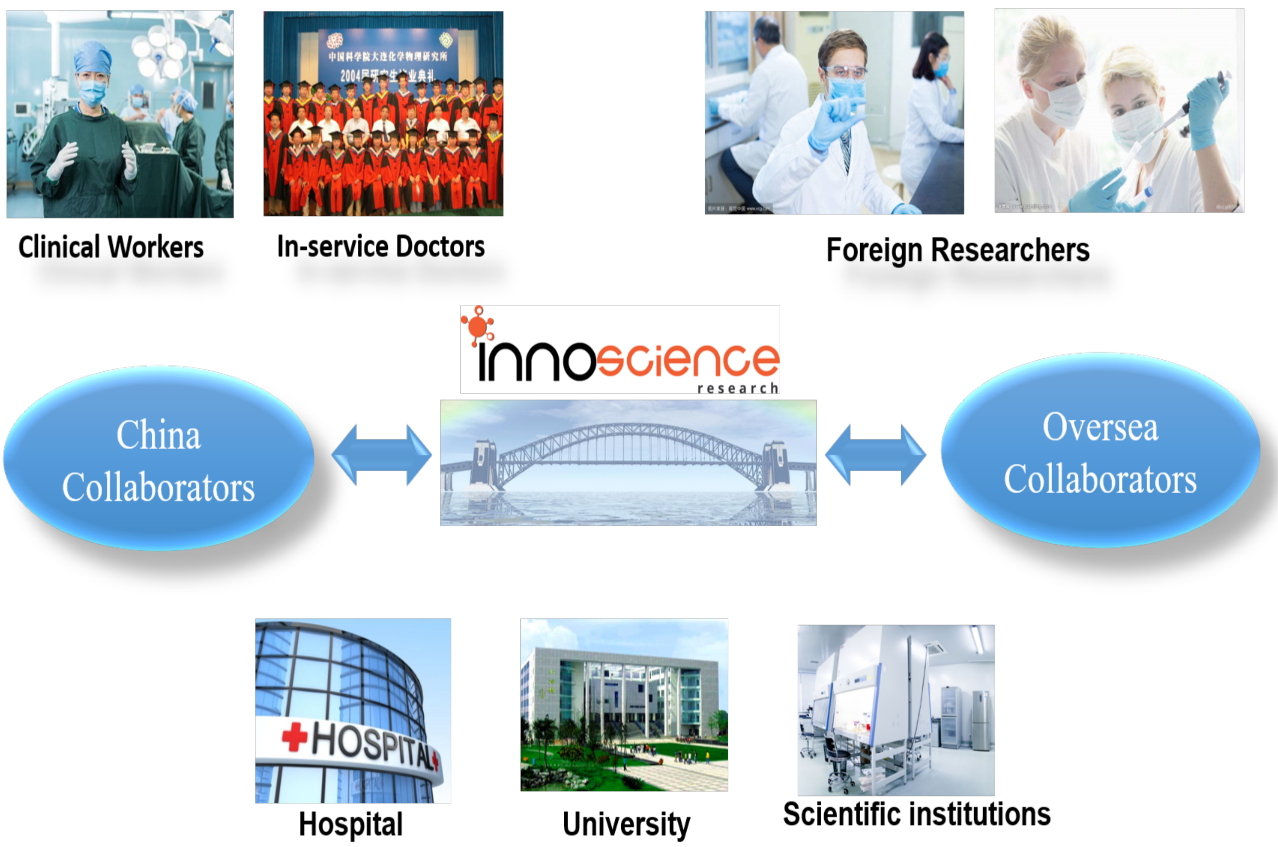

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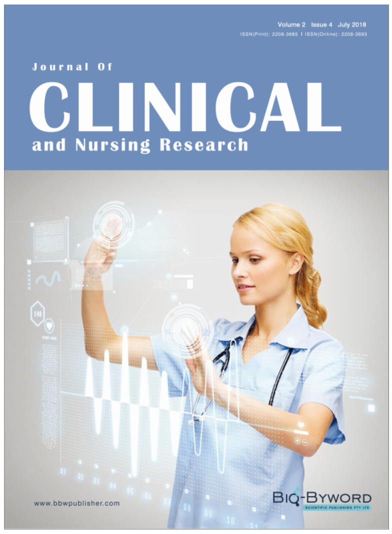

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