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Exploration on Environmental Education Though Construction of Global Parks in Zibo City

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Abstract: In this paper, the development status of environmental education in representative urban parks in Zibo City is investigated, studied, analyzed, and summarized. Besides, the role of natural resource commentary systems, waste sorting center visitations, and specialty gardens are expounded. In order to provide a reference for the integration of environmental education in the construction and renovation of parks in Zibo City, the problems in several practices like specialty gardens and WeChat public account is discussed.

Keywords: Urban environmental education

Online publication: June 21, 2023

1. State of urban construction of a world park in Zibo City

As a typical megalopolis, Zibo City consists of urban and rural areas, with mountains in the south and rivers in the north, a stretched layout and a long history. It has the natural endowment and social foundation to build a global park city. It has been planned for Zibo to be turned into a global park city in the next 5-15 years, with green mountains and rivers, beautiful people and fertile fields, strong city and rich industry, clear layout, harmonious integration of the city and gardens, and become a pioneer in the construction of national park cities.

2. Urban park landscape as an important carrier of environmental education

Environmental education is the process of integrating environmental ideas, concepts, principles, and methods into modern universal education in order to achieve sustainable development and create a civilized society [1].

As the main green space in the city, urban parks contain information such as environmental knowledge, environmental ethics, and environmental balance, which are ideal for environmental education. The design vocabulary conveys the importance of nature. At the same time, it also provides a window for more people to understand nature [2,3].

3. Development status of environmental education through parks in Zibo City

There are currently four forms of environmental education through parks in Zibo City: natural resources commentaries, waste sorting center visitations, gardens, and WeChat public accounts (reading corners), as shown in **Table 1**.

Table 1. Forms of environmental education in representative urban parks in Zibo City

Park name	Environmental resources	Form of education
Zibo People's Park	Lakes, plants, animals	Natural resource commentary system, waste sorting center visitations
Qisheng Lake Park	Lake district landscape, plant landscape, animal landscape	Natural resources commentary system, waste sorting center visitations, and science popularization activities
Lianchi Park	Lake district landscape, plant landscape	Natural resource commentary system, botanical garden (rose garden)
Zibo Botanical Garden	Plant landscape, lake landscape	Reading room of Zibo Botanical Garden (picture book borrowing, natural science popularization, paintings, landscape drawing, and aesthetic education), specialty gardens, natural resource commentary system
Jiudingshan Forest Park	Geological landscape (slope, mountain, mine pit), plant landscape	Natural resource commentary system
Huashan Ecological Wetland Park	Spring water, lake landscape, plant landscape	Natural resource commentary system, specialty garden

3.1. Natural resource commentary system

There are usually lakes and plants in the urban parks in Zibo City. Environmental education is then done through listing the type of plants in the park, displaying basic information such as plant families, genus, Latin names, and natural habitats, so that the public can have some understanding of the plants in the garden. However, the content that can be presented through these methods are limited, and it is difficult provide further explanation or education. Besides, there are still problems such as incorrect names of the plants or inappropriate location and size of the displays. In addition, although bulletin boards or signs are set up at the corner of the event venue or at the roadside, but the content and form are relatively simple.

3.2. Waste sorting center visitation

In the process of park renovation and upgrading the global parks, the Zibo City Waste Sorting Center was built in the People's Park, creating a public space that integrates green life design, experience, display and sharing. This waste sorting center allows the general public to gain knowledge about garbage classification and participate in urban management. Similar practices include the waste sorting publicization and science popularization activities in Qisheng Lake Park.

3.3. Botanical gardens

A specialty garden is a garden where the same type of ornamental plants is planted within a certain range for sightseeing, science popularization, or scientific research. This design is commonly used in botanical gardens and sometimes in urban parks. For example, there is a rose garden in Lianchi Park. In recent years, more than 10 types of groundcover, miniature, modeling, old, and climbing roses have been introduced into the park. In order to improve the landscape quality, urban parks such as Huashan Wetland Park and Torch Park also have different types of specialty gardens such as cherry gardens and peony gardens. Specialty gardens allow the public to appreciate the variety and beauty of a certain plant. However, due to the lack of more in-depth science education in the park, viewers cannot deeply understand the relationship and differences between the varieties and other in-depth knowledge.

3.4. WeChat public account

Zibo Botanical Garden has launched a WeChat public account for the reading room, which provides services such as picture book borrowing, natural science popularization, outdoor sketching, and aesthetic education.

In short, the environmental education in urban parks in Zibo City is still in its infancy, and there are many problems. There is no mandatory regulation of relevant policies for the natural resource system, thus the explanations are not done well; the explanation system is outdated, and the equipment is too simple with limited functions; explanations related to environmental values are insufficient, and there is a lack of publicity and education on knowledge related to geological landforms, animal resources, and water resources, and a mature science education system has not yet been formed.

4. Direction of development and suggestions for environment education in Zibo City

4.1. Optimizing the natural resource commentary system of urban parks

4.1.1. Establishing a comprehensive natural resource commentary system

With the concept of civilization through environmental education and the process being improving environmental literacy of the people, while considering the close relationship between the urban parks of Zibo City and the construction of global parks, the commentary systems should include explanations on the natural environment, resources, the ecosystem of the park, and the symbiotic relationship between man and nature (**Table 2**).

Table 2. Interpretation content system of urban park ecosystem

Natural environment	Natural resources	Ecosystem	Symbiotic relationship between man and nature
(i) The characteristics, types, quantity scale, landscape distribution, and rare species in the park. (ii) The geographical location, climate, and development history of the park. (iii) The role of parks in urban economic and social development.	(i) Geographical landscape (ii) Waters (iii) Biological landscape (iv) Weather	(i) Trees, shrubs, vines, flowers, and other plants (ii) Birds, beasts, insects, and amphibians.	Explaining the symbiotic relationship between man and nature using videos, pictures, case analysis, etc.

4.1.2. Building a quality assurance system for the commentaries

A professional commentary team should be created, and the commentaries should be given in a scientific, suitable, and easy-to-understand way so that the content can be accepted and understood easily.

Compared to the guides and explanations displayed in general natural scenic spots, urban parks should present richer environmental knowledge, use more diverse explanation methods to grab the attention of tourists, and enhance the information dissemination of the explanations. A tourist center should be set up at larger parks to display information of the park in a concentrated manner. Visitors can then pay more attention to various types of ecology through specimens, pictures, videos and materials from television programs, seminars and discussions, case analysis, and lectures. These methods can help disseminate information of the park more efficiently. Information of the park can also be disseminated through websites or self-built apps that is equipped with professional environmental commentators. Trees, flowers, insects,

birds, and amphibians in the park can be introduced using explanatory boards with pictures and texts; commentary kiosks can be built in areas such as river streams, wetlands, and plant communities, and relevant knowledge can be popularized with the help of touch screen videos and audio guides [4].

4.2. Practicing environmental concepts in the construction of urban parks and landscape improvement

Based on the concepts of "ecological construction first, educational significance second," "overall coordination and harmonious coexistence," and the related theories about environmental landscape, educational psychology, landscape aesthetics, etc. are used to construct and upgrade urban parks that are humanized, characteristic, leading, interactive, interesting, and sustainable. For example, the construction of urban parks, advanced ecological design technologies such as artificial wetland treatment systems, rainwater collection systems, intelligent irrigation systems, nature-themed corridor designs, and underground bins are used; the buildings in the park are built with green and environmentally friendly materials; the flora of the park is dominated by a variety of native plants to provide a good habitat for various animals and increase biodiversity. The historical and cultural memory of ancient buildings, old streets, ancient temples, screen walls, ancient trees, and famous trees in the city are preserved in the renovation and upgrading process, so that people can be immersed in the history of the site and the residents will feel a sense of nostalgia [3].

4.3. Creating a "garden within a garden" that popularizes science and encourages public participation

Thematic and specialty gardens should be created with the goal of popularizing science and "immersive" experience in the park. A "garden in the garden" can also be created by sectioning new functional areas on the basis of the original urban parks. These parks can somewhat make up for the separation of humans and nature brought about by urban life and enable people to connect with nature. Environmental education can be provided through these urban green spaces in a scientific way, and it allows the participation of the public.

In plant-specific and animal-specific parks, the introduction of animal and plant knowledge can be done through broadcasting, LCD screen displays, 4D science and education halls, QR code scanning, and other ways instead of graphics and texts alone to enhance public. The agricultural industry is an industry that human beings depend on for survival and reproduction. Therefore, farmlands are an important part of the ecosystem. In urban parks, an "agricultural garden" can be added to provide farming experience. Farmland can be simulated by displaying the farming activities, tools, crops, and common creatures in the farmland to popularize agriculture and related knowledge to tourists. Tourists can also be allowed to experience the farming activities and learn more about farming. In this way, urban residents can then grow closer to nature and land [4].

The construction of a global park city has brought new development opportunities and challenges to Zibo City. Integrating environmental education into all levels of urban park construction is conducive to civilization and sustainable development, and effectively promoting the natural environment of Zibo City. It will comprehensively enhance the city's competitiveness and influence and satisfy the people's yearning for a better life.

Disclosure statement

The authors declare no conflict of interest.

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Research Progress of Epoxy Asphalt Material for Roads

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Abstract: Asphalt is a semi-solid or solid mixture formed by hydrocarbons and non-metallic elements. It is widely applied in the fields of building waterproofing and road paving. Asphalt is a low noise, durable, and renewable pavement material. However, asphalt materials have some shortcomings such as liquefying at high temperatures and brittleness at low temperatures, which are less adaptable to different environments. Therefore, people have gradually shifted their focus to asphalt modification. This paper presents an in-depth analysis and research on the composition, structure, and performance of epoxy asphalt materials for roads, so that this material can be widely used.

Keywords: Epoxy asphalt material for roads; Asphaltene; Toughness modification

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1. Introduction

Due to its excellent performance and long durability, epoxy asphalt is widely used in steel bridge deck pavement. Bridge pavement is a relatively common bridge structure in bridge engineering. It will be affected in different ways when vehicles pass through it, and rutting will also occur; shrinkage cracks and fatigue cracks will appear at lower temperatures. Pavement materials can be detached from the road surface due to moisture, resulting in problems such as looseness and potholes. Therefore, it is of great significance to systematically analyze and study the high temperature and low temperature crack resistance, water stability, and other aspects of asphalt materials.

2. Research status of epoxy asphalt materials for road

At present, epoxy asphalt manufactured by Chem Co Systems, an American company and TAF, a Japanese company is the most used in the deck layer of steel bridges in our country, among which the products of Chem Co Systems dominate, and its consumption accounts for 80% of the steel bridge decks in our country. In terms of epoxy asphalt's compressive strength, flexural modulus, Marshall stability, dynamic stability, and solidification modulus, TAF is better than Chem Co Systems. However, at 15 ℃, 10Hz, and 600 microns, TAF's epoxy pitch has better four-point bending fatigue than Chem Co Systems. Besides, TAF's epoxy-based asphalt mixture also has many advantages, such as simple construction management, short maintenance period, little to no pavement foaming, etc. In addition, the epoxy asphalt cementitious material of TAF has a high modulus, which allows the cementitious material and the steel sheet to bond more strongly, which reduces the strain of the pavement material [1].

Professor Huang of Southeast University, an academician of the Chinese Academy of Engineering, has made great contributions to the development of our country's epoxy asphalt industry. The Second

Nanjing Yangtze River Bridge led by Huang used epoxy-based asphalt concrete for the first time in 2001 and achieved good results after 15 years. Therefore, they took the lead in the development of epoxy-based asphalt concrete in China.

3. Composition and structure of epoxy asphalt materials for roads

Epoxy asphalt is mainly made of asphalt, epoxy resin, and curing agent. During the blending process, due to the interaction between epoxy resin and curing agent, the asphalt forms a cross-linked three-dimensional network structure. Therefore, at high temperatures, the asphalt will not deform due to thermal expansion; and at low temperatures, its crack resistance is significantly enhanced, which is higher than that of ordinary asphalt. The results show that the microstructure and properties of epoxy asphalt not only depend on the ratio of epoxy resin and asphalt, but also the curing and composition of asphalt and epoxy resin [2].

3.1. Effect of asphalt composition on epoxy asphalt

The actual composition of epoxy asphalt is relatively complex. It can be divided into soft mineral tar and asphaltene according to the degree of solubility. Mineral tar can be separated into three components through chromatography – saturated, aromatic, and colloid. The different composition and polarity of asphalt molecules will produce different effects with epoxy resin, thus resulting in large differences in structure and properties. Asphaltene is the most easily separated component in asphalt, and it is also the main component in asphalt. It has a great influence on the viscosity and hardness of asphalt. Saturated and aromatic components in loose asphalt are easily absorbed by polymer chains, causing swelling of the asphalt, which also has a certain impact on the properties of epoxy resin [3].

There is a big difference in the interaction between mineral tar and asphaltenes with epoxy resins. Studies have been done on phase separation, viscosity, and mechanical properties of epoxy resin compositions with different oil contents. It was found that if the proportion of asphaltene decreased, the viscosity of epoxy asphalt increased, and the damping performance and mechanical properties will be improved [4]. In the composition of epoxy resin, the higher the content of asphaltene, the phase separation size of the asphalt microdomains in the epoxy asphalt gradually increases, and there will be uneven distribution. Some scholars separated asphaltene and mineral tar from asphalt and blended them with epoxy resin respectively and conducted in-depth research on the influence of asphaltene and mineral tar on the microstructure and properties of epoxy asphalt [5]. It was found that the viscosity of the epoxy resin increased as the asphaltene content increased. In a study done by Min *et al*., a small amount (1%) of asphaltene microdomains were distributed evenly. The asphaltene micro-domain gradually increased with the increase of asphaltene content and caused a non-uniform distribution state. Asphaltenes increased the storage modulus of epoxy resins while they are in the rubbery state. With the same amount of bitumen, the epoxy resin system had a lower viscosity. The glass transition degree of epoxy asphalt gradually increased when the tar content increased. When the tar content does not exceed 50%, the mechanical properties of epoxy mineral tar are significantly better than those of epoxy asphalt [6].

In engineering practice, in order to improve the performance of epoxy asphalt, it is usually necessary to modify the base asphalt. This practice is more common in thermoplastic elastomers and thermoplastic resins. Poly(styrene-butadiene-styrene) (SBS) is a styrenic thermoplastic elastomer, which belongs to the triblock copolymer of butadiene, styrene-styrene triblock, and is currently the most widely used modifier. Because polybutadiene is highly compatible with asphalt, the light components in SBS and asphalt are fully swollen, so that they are evenly dispersed in the base asphalt. SBS modified asphalt can be added to epoxy resin to produce epoxy asphalt. With epoxy resin as the main raw material, SBS is used to modify the asphalt to produce a new type of epoxy asphalt. Studies have shown that the mechanical properties of the SBS modified asphalt-epoxy resin composite is the best when the polystyrene content is 30%.

3.2. Effect of epoxy resin and its curing agent on epoxy asphalt

Epoxy resin, curing agent, and other toughening and compatibilizing additives together form an epoxy resin system. The curing process has been heavily studied due to its importance. Epoxy resin is a type of low molecular weight polymer, and its molecular structure is composed of two or more epoxy groups and aliphatic, alicyclic, or aromatic compounds. The presence of the epoxy group in the epoxy resin allows the formation of an insoluble and infusible cross-linked polymer with a variety of curing agents. There are a few types of epoxy resin: glycidyl ether, glycidyl amine, alicyclic epoxy, and vinyl epoxy, all with different structural characteristics. When applying these products, the proportion of the glycidyl ether is the largest while the cost performance of bisphenol A epoxy resin is relatively high. Therefore, bisphenol A epoxy matrix is also mainly used in the preparation of epoxy matrix at present.

There are a few types of curing agents, such as polythiols, organic acids, aliphatic or cycloaliphatic amines, etc. Epoxy resin glue can be roughly divided into four types according to the reaction temperature: (1) polythiol curing agent is a low-temperature curing agent; (2) aliphatic amine, alicyclic amine, low molecular weight polyamide etc. are all room temperature curing agents; (3) some of them are medium temperature curing agent systems such as alicyclic polyamines, imidazoles, and resins; (4) acid anhydrides, aromatic polyamines, phenolic resins, etc. are all high temperature resistant curing agent system.

After mixing the epoxy resin and the curing agent, the curing time of the initial mixture should be in line with the requirements of asphalt concrete mixing, transportation, paving, and rolling. In addition, the curing agent should not only work in high temperatures, but also at room temperature. The requirements of epoxy asphalt should also be considered when selecting the curing agent. In the 1960s, some scholars used diethylenetriamine and phthalic anhydride as epoxy resin curing agents, and tar as a solvent to synthesize a new type of epoxy resin asphalt material [7]. However, the compatibility of the curing agent and tar has great influence on the properties of the epoxy resin. Since then, other epoxy asphalt curing systems have been developed. Relevant scholars have proposed an epoxy asphalt material for road Bridges, which includes two parts: one is epoxy resin, and the other is modified asphalt and curing agent containing carboxyl and anhydride groups [8]. Aliphatic dibasic acid has also been used as a curing agent with maleic anhydride as the modifier to produce high-performance epoxy asphalt [9]. On some occasions, in order improve the comprehensive performance of epoxy asphalt, it is necessary to add some composite curing agent. For example, an epoxy asphalt composite material can be prepared using sebacic acid, modified tung oil anhydride, and methyl tetrahydrophthalic anhydride as curing agents, an. This method shortens the induction period of the curing reaction and improves the tensile strength, surface hardness' and glass transition temperature of the epoxy bitumen.

3.3. Structure of modified epoxy asphalt

As a new type of modified material, epoxy resin has been applied on long-span bridge decks because of its excellent performance. However, since it is a multi-component composite material, it is difficult to achieve a synergistic effect only by simple doping. Besides, due to the difference in polarity and density, it is difficult to achieve uniform dispersion during the curing process, and long-term storage will cause peeling. In addition, because its main substance is rich in benzene rings, it has excellent mechanical properties such as compression resistance and wear resistance, but its plasticity is insufficient. Large deformation of the steel bridge deck damages the asphalt layer. Fatigue and other factors cause cracks that are difficult to repair. Therefore, a set of studies on improving the toughness and compatibility of epoxy asphalt has also been carried out, in hopes of developing epoxy asphalt materials that can meet the actual engineering needs.

3.4. Toughening modification

The crack resistance of epoxy asphalt is not ideal due to the high degree of cross-linking and brittleness of epoxy rubber. Therefore, it must be toughened to improve its performance. Among them, rubber elastomers, thermoplastic resins, nanoparticles, and polymers with low glass transition rates are commonly used toughening agents. For example: some scholars mixed terminal carboxylated nitrile rubber with epoxy asphalt to obtain a cold-mixed epoxy asphalt with high toughening properties [10]. Ethylene glycol-polyvinyl acid copolymer (EVA) can be used to toughen the epoxy resin. Studies showed that good comprehensive properties can be achieved when the mass content of EVA is 1.9%. The tensile elongation and tensile strength increased by about 7.8% and 30%, respectively with added EVA compared to regular asphalt epoxy. Some scholars chose natural nano-clay (attapulgite) as a toughening agent and it was found that nano-clay can greatly improve the tensile strength, various moduli, and viscosity, bonding strength, and the thermal stability of epoxy asphalt [11]. Polymethyl methacrylate have also been used as the core and polybutadiene as the shell to mix core-shell nanoparticles with epoxy resin and asphalt to obtain a new type of nanoparticle with high specific surface area of the new epoxy asphalt composite system. The purpose of the project was to achieve homogenization of asphalt micro-regions through adding nanoparticles; at the same time, the polybutadiene in the nanoparticles also has the effect of toughening and modifying. The experiment found that with nanoparticles, the tensile strength increased by 29%, the elongation at break increased by 60%, and the toughness increased by 200% after adding 1% nanoparticles. However, in reality, due to the addition of some toughening modifiers, the viscosity of this system will often increase, which will have a certain impact on the structure. Thus, some small molecule plasticizers can be added to meet the needs of the building. Small molecule plasticizers like phthalates have the effect of reducing viscosity and toughening, but it tends to leak, which will negatively affect the properties of materials and the environment. Compared to small-molecule plasticizers, polymers with flexible chains like polyethylene glycol can reduce the viscosity of the system and the degree of cross-linking of the epoxy resin, thereby achieving a toughening effect, but it does not transfer to the surface, leading to the instability of material properties [12].

4. Conclusion

Generally speaking, although the performance of epoxy asphalt for roads have been greatly improved through modifications and optimizations, there is no systematic research on the internal between its mesostructure and performance. In the construction of epoxy asphalt, due to factors such as construction temperature, system viscosity, and construction time, various requirements are put forward for the selection of curing agent, viscosity control, and optimization of curing time. Therefore, the development of a low viscosity epoxy asphalt with high operability and toughness is the main issue. In recent years, in order to improve the performance of the project, people a new type of water-based epoxy asphalt has also been developed. In addition, epoxy-based asphalt is a thermosetting substance and cannot be reused. Therefore, dynamic bonds are added to the epoxy resin matrix so that the matrix can be regenerated.

Disclosure statement

The authors declare no conflict of interest.

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Water Supply and Drainage Design for Prefabricated Buildings Under the Green Building Concept

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Abstract: With the continuous development of society and the market economy, people are putting forward higher and higher requirements for the construction, technology, and environmental friendliness of buildings. The prefabricated building not only has high installation efficiency, but is also safe and environmentally friendly, which is in line with the green building concept. The drainage design is a critical part of prefabricated buildings. In order to ensure the quality and construction efficiency of the building project, it is necessary to design the building water supply and drainage properly. Therefore, an in-depth investigation on prefabricated buildings was carried out in this paper, and water supply and drainage design for prefabricated buildings under the green building concept is proposed, in hopes of providing references for future water supply and drainage designs.

Keywords: Green building concept; Prefabricated building; Water supply and drainage

Online publication: June 26, 2023

1. Introduction

The construction industry in China has been developing very rapidly and the number of construction projects has increased. The quality of water supply and drainage is directly related to the stability and safety of prefabricated buildings. Besides, in the design of water supply and drainage systems for prefabricated buildings, it is also necessary to follow the pace of social development, fully implement the concept of green building and focus on improving the environmental protection through the design, so as to further promote the development of prefabricated buildings. The quality of the drainage design is directly related to the stability and safety of the prefabricated building.

2. Prefabricated buildings

Most of the prefabricated components used in the construction of a prefabricated building are assembled on site. Therefore, the prefabricated components play a very important role in the construction of a prefabricated building, not only to meet the construction needs of a prefabricated building, but also in assembling the prefabricated components together using various techniques to complete the building structure. The characteristics of prefabricated buildings are shown in **Table 1**.

Table 1. Characteristics of prefabricated buildings

Features of prefabricated buildings	Advantages
Pouring is rarely required at the construction site	Reduces pollution of the surrounding environment
Simpler construction process	Shortens the construction period of the building
Simultaneous renovations can be carried out	Contributes to the early commissioning of building works
High requirements for components	Helps to ensure the overall quality of construction work
In line with the green building concept	Helps to improve the greenness of construction projects

3. Water supply and drainage design for prefabricated buildings under the green building concept

3.1. Designing domestic water supply and hot water systems for prefabricated buildings under the green building concept

In the design of the water supply and hot water systems, the location of the riser pipe wells must be clearly defined, and the installation of the main riser pipe must be carried out strictly in accordance with the design requirements [1]. The design method of the domestic water supply and hot water system for prefabricated buildings under the green building concept is shown in **Table 2**.

Table 2. Design methods for domestic water supply and hot water systems in prefabricated buildings under the green building concept

Design of domestic water supply and hot water systems for prefabricated buildings	Content
Reserved design	The water supply and drainage pipes in the prefabricated buildings are generally constructed by means of open installation. This technique is not only simple, but also very convenient and does not need to be coordinated with other building construction processes.
Pre-embedded design	Slotted pipes are often required during the fabrication of PC components. This design method also has the disadvantage that the requirements for prefabricated pipe slots are very high.
Pipe-separated design	Most of the pipes' components need to be joined together before the construction of the building. Although this design method is very scientific, it places higher demands on the quality of the pipes.

3.2. Optimizing the water supply and drainage design for prefabricated buildings

There are some problems in the design of the water supply and drainage for prefabricated buildings, which are shown in **Table 3**.

Table 3. Problems in the design of water supply and drainage for prefabricated buildings

Problems in the design of water supply and drainage for prefabricated buildings	Impacts
Inadequate water and drainage pipes	Not in line with the green building concept and causes water wastage
Inadequate drainage pressurization	Low water pressure
Low water utilization in water supply and drainage	Poor water circulation, and the water is not clean

The focus of water supply and drainage designs should be on the core of the green building concept, that is energy saving and environmental protection. Therefore, the building water supply and drainage system design should be further optimized, so as to make better use of water resources and reduce wastage. To avoid unreasonable placement of water supply and drainage pipes, the pipes should be made of good quality plastic, which can replace metal pipes. The quality of the pipes directly affects the function of the pipes. Therefore, when designing the drainage system for a fabricated building, it is important to source from reputable piping suppliers. It is also necessary to pay attention to the water pressure. Under the concept of green building, when optimizing the design of water supply and drainage in prefabricated buildings, in order to prevent the uneven strength distribution of the pipes due to high pressure, glass fiber, thermosetting, and other materials can be used for pipe linings. Besides, it is also important to ensure that the parameters of the pipe linings are compatible with the drainage pipe, so that there is no large gap when the two are connected, which can not only reduce water wastage, but also ensure the quality of the drainage pipe [2].

3.3. Design of built-in bathrooms for prefabricated buildings

Sanitary ware is a very important part of the drainage design, and it is not just an installation of components [3]. In fact, the whole bathroom is formed by a combination of various sanitary ware and matching accessories, including water and sewage pipes, valves, and many other accessories. The green building concept can be applied in the design of bathrooms can be installed in the base of the molded chassis, so that there is no need to use cement and sand, etc., only adhesives and screws. It is a dry construction method, which not only saves labor costs, but also greatly reduces the construction period of the water supply and drainage of the prefabricated building. This method is suitable for prefabricated houses, hospitals, hotels, and other buildings with a large number of standard toilets. For example: 4 to 10-storey staff dormitories, because the dormitory buildings have many bathrooms of the same size and the bathrooms are relatively small, so it is more suitable for the installation of the whole bathroom.

3.4. Application of BIM technology in the design of water supply and drainage for prefabricated buildings

In the case of water supply and drainage of prefabricated buildings, the holes required for the installation of water supply and drainage pipelines are created when the prefabricated components are produced, and they cannot be adjusted again in the subsequent construction process. Therefore, if it is not possible to ensure the accuracy of the position and size of the pre-drilled pipeline holes at the preliminary stage. as a result, the pipelines cannot be installed properly, and its consequences will be unimaginable [4]. The application of BIM technology in the design of water supply and drainage in prefabricated buildings is very crucial to improve the fitting of the pipes in prefabricated buildings. In this way, the situation of inaccurate holes can be prevented, which avoids delays in the construction of the building and reduces wastage of construction materials. For example, BIM technology can be applied at the initial stage of the construction of a prefabricated building, where a three-dimensional model can be used to detect whether the water supply and drainage pipelines would collide in advance, so as that the water supply and drainage pipelines could be installed smoothly in accordance with the relevant requirements. The integration of BIM technology into the design of water supply and drainage for prefabricated buildings will definitely improve the construction efficiency of prefabricated buildings to a certain extent.

4. Conclusion

In short, with the continuous development of the market economy and the growing problem of environmental pollution, people are becoming more aware of the importance of environmental protection. Therefore, the construction industry must follow the development of society and strengthen the

implementation of the green building concept. In this paper, the design of water supply and drainage for assembly-type buildings is optimized based on the green building concept. The design of water supply and drainage is directly related to the safety, stability, and environmental friendliness of the water supply and drainage system. In order to improve the level of drainage design and reduce water wastage, it is necessary to strengthen the understanding of prefabricated buildings, accurately grasp the characteristics of prefabricated buildings, and discover the problems in the drainage design of previous prefabricated buildings and the impact of these problems. It is important to optimize every detail of the design, so as to meet people's needs for water supply and drainage while ensuring that it is green and environmentally friendly, thus further promoting the development of prefabricated buildings.

Disclosure statement

The authors declare no conflict of interest.

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Application Strategy of BIM Technology in Municipal Road Design

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Abstract: The development of information technology provides certain convenient conditions in the design of municipal roads, and allow the achievements of high standards and requirements of current road design and construction. Among many information technologies, building information modeling (BIM) technology is more widely used in road design and has achieved good results. BIM technology can realize information sharing, allow the design of virtual models, discover design problems in time, and reduce the rate of design changes later or in late stage. At the same time, through the coordination and standardization of the design of road traffic and underground pipelines, it provides new design ideas for the development of municipal roads. This paper mainly analyzes the application advantages and status of BIM technology in municipal road design, and puts forward the application strategy of municipal road design.

Keywords: BIM technology; Municipal road design; Status quo; Application strategy

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1. Introduction

Construction of municipal roads are important projects in urbanization construction, and the quality of municipal road design is directly related to the effect of urban planning and travel safety. The current municipal road design and construction work is more complicated and difficult, especially in the case of large-scale reduction of urban land and complex building structures. It is necessary to consider comprehensive factors such as both sides of the municipal road and underground pipelines before designing the construction of the municipal road. Once a design error occurs, it will not only affect the progress of the project, but may also cause damage to the pipelines under the road, resulting in huge losses. The application of building information modeling (BIM) technology can form an intelligent virtual model. By inputting various design parameters, the life cycle of building products can be dynamically observed to avoid design problems.

2. Application advantages of BIM technology in municipal road design

BIM technology is a three-dimensional design mode, and compared with two-dimensional design mode, it can comprehensively display the content of architectural product design. The current municipal road engineering is facing more complex environment with more influencing factors. The design using BIM technology can realize visualization, comprehensively present the life cycle of road construction, and discover non-compliant design content in time through simulation, improving road construction efficiency

and effectively control construction costs. In addition, the requirements of different construction stages in municipal road are varied, and it is difficult to collect design information in some complex environments. Some use drones, laser radar, and other technical means to collect information [1]. According to the geographical environment survey information, BIM technology is used to verify the road route selection to determine the scientificity of the road route selection. At the same time, through the pipeline collision analysis method, damage to the underground pipeline can be avoided during the construction. In addition, the application of BIM model is conducive to the accuracy of engineering quantity calculation. Using BIM technology to make section and axonometric drawings, construct road models, and realize visual design product display can accurately convey design intentions.

3. Application status of BIM technology in municipal road design

3.1. Late application time

In China, the application of BIM technology in the design of municipal road engineering projects is relatively late. The rail transit road construction was the first to use BIM technology, which provides a certain basis for municipal road construction. Although the usage of the BIM application in municipal road construction started late, the development speed is relatively fast. With the ever-expanding scale of municipal road construction, new requirements are put forward for the construction quality and construction's effect of the project to ensure the safety of construction and improve the construction design standards. However, delay in using BIM application in municipal road construction will also lead to limited experience in the application of BIM technology, and there are still certain technical drawbacks in specific applications. For example, the lack of awareness of information sharing leads to the incomplete information collection, and the need to change design data repeatedly, further affects design efficiency.

3.2. Strong application expertise

In the construction of municipal road engineering projects, the construction system is complex and huge. It is necessary to do a good job in the connection of various construction stages and promote the collaborative design and development of various disciplines. In China, currently the design work of municipal road engineering projects, most of them are still accustomed to the two-dimensional graphic design method. In the early stage, technical disclosure meetings are held to effectively communicate municipal road engineering information and drawings, rationally allocate resources, and control construction quality. At present, the scale of municipal road projects in China is relatively large, and the construction requirements are high. It is necessary to shorten the design cycle as much as possible, and frequently exchange and share information [2]. However, due to the insufficient application of BIM technology, it affects information interaction and engineering design.

4. Application strategy of BIM technology in municipal road design

BIM technology can be applied to many aspects in market road design, including the design of sites, pipelines, special routes, and engineering quantity calculations. Through the construction of 3D models and the simulation of engineering quantities, it provides designers with more intuitive and three-dimensional design basis, reduces the probability of later design changes, and promotes the smooth development of construction projects.

4.1. Application in site planning

Municipal road site planning is the premise of design and construction, and it is also an important design basis, which directly affects the quality of subsequent construction. However, since the traditional municipal road design is mainly based on manual survey, the accuracy of the design needs to be further

improved. The application of BIM technology in road planning is conducive to the optimization of the design site. Specifically, it can be analyzed from the following aspects: Firstly conduct a three-dimensional analysis of the site elements. The application of BIM technology in site planning can combine the elements of the site to build a three-dimensional model, which is beneficial for designers to arrange and manage the site reasonably at each stage. Comprehensively consider the site transformation in different construction stages, and strengthen the optimization of the road site according to the site layout requirements, and avoid repeating operations, which can influence the design effect and quality. For the construction of the site model using BIM technology, it is necessary to strictly follow the elevation grid design, import the construction site data parameters into the BIM software, and plan the road elevation and drainage in advance. Earthwork excavation and filling can be avoided as much as possible by means of earthwork balance. Secondly, BIM technology can be combined with Geographic Information System (GIS) to optimize the overall layout structure of the road. Effectively solve the problem of inaccurate data collection and analysis, caused by large amounts of data and the influence of subjective thinking in municipal road planning. In addition, the application of BIM technology can also realize the simulation of urban road space, which is conducive to more accurate assessment of road traffic flow and crowd flow, reasonable planning of the number and structure of lanes, and scientific road planning [3].

4.2. Application in intersection design

In the design of municipal roads, it is inevitable that there will be intersection problems. The traffic flow and pedestrian flow at intersections are relatively large, and there are different road structures such as motor vehicles, sidewalks, and non-motorized lanes. If the allocation is unreasonable, it is very easy to cause accidents or cause traffic congestion, further affecting the normal traffic order. Therefore, BIM technology can be used to simulate the intersection before designing. To build a 3D model, firstly input terrain parameters, then perform horizontal and vertical design, channelization design, traffic facility design, and finally analyze and adjust as shown in **Figure 1**. After the construction of the 3D model is completed, the traffic flow at the intersection is observed, and subsequently traffic design is optimized accordingly [4]. For example, if it is found that there is a lot of left-turning traffic, it is necessary to increase left-turning lines and set up turning waiting areas to improve vehicle operating efficiency.

Figure 1. Application of BIM technology in intersection design.

4.3. Application in underground pipeline design

Underground pipelines are important factors to consider in municipal road construction, and professional elevation and plane coordination are required to avoid touching pipelines and causing construction accidents. In the design of road engineering, the radius, nature, and buried direction of the pipeline are first analyzed through geophysical prospecting to ensure the rationality of the pipeline. The application of BIM technology can carry out 3D simulation on the design of underground pipelines to form a virtual pipeline layout, as shown in **Figure 2**. For example, CAD software can be used to model the laying of underground pipelines, and combine different equipment to scientifically divide the pipelines in the construction drawings. In the modeling and design of pipelines, they should be arranged in order from large to small and from top to bottom, to avoid the difficulty of adjustment after a pipeline collision in the later stage [5]. After the modeling is completed, collision detection is conducted on the pipeline, and automatically a collision detection report is generated to determine whether the layout of the pipeline is reasonable, and make adjustments for unreasonable problems. A large number of reserved and pre-buried holes are involved in municipal road engineering, which is also a common problem in construction, where leakage or misplacement often occurs in these regions [6]. The application of BIM technology is conducive in ensuring the accuracy of pipeline hole reservation management, and subsequently reducing the difficulty of later management. The pipeline design method of design, analysis, and simulation is adopted to dynamically observe the engineering pipeline design situation. Different departments can be combined to analyze the pipeline design work from different angles, make decisions based on the model, and shorten the pipeline laying period as much as possible [7].

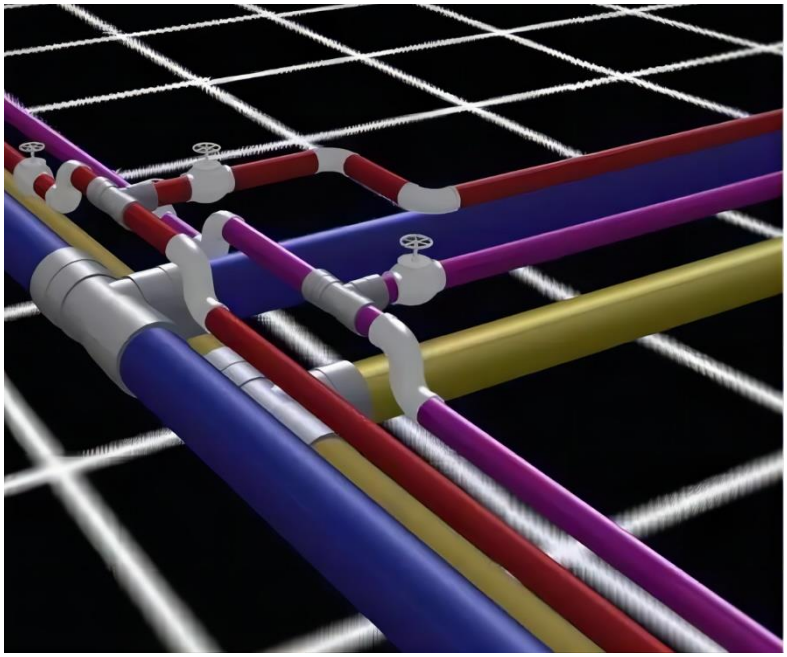

Figure 2. 3D simulation of underground pipelines based on BIM technology.

4.4. Temporary construction road design application

In the construction of municipal roads, there are a large number of construction equipment, materials, and personnel on the construction site. The temporary placement and stacking of a large number of equipment and materials is likely to cause traffic congestion, leading to certain safety hazards at the construction site [8]. The application of BIM technology in the temporary construction of construction roads can make the planning of temporary roads and stacking locations through layout planning and collision experiments to

ensure the scientific nature of the scheme. For example, during the construction of a municipal road project, the construction site is narrow, with many buildings on both sides and a large flow of people. As a result, it is difficult to pile up construction materials and road construction. Before the construction starts, BIM technology is used to simulate the construction plan, identified the existing problems in the construction planning, and combine the construction progress and road characteristics to reasonably plan the temporary road construction [9].

4.5. Application in engineering quantity statistics

In the design of municipal roads, in addition to the design of the shape of engineering products, it is also necessary to pay attention to the cost of materials, construction progress, and quality and safety control of road design. It is also important to comprehensively plan the cost, analyze the feasibility of road construction, and strengthen the statistics of various components of the road to ensure the scientificity and accuracy of the quantitative statistics of the road design [10]. Additionally, rationally applying engineering calculation software to automatically analyze the physical engineering quantities to form a complete bill of quantities, which is conducive to the effective application of cost control work such as project pre-settlement and other later work. For example, the calculation function in the BIM software platform can be used to quickly calculate the road engineering project through one-click identification to ensure the accuracy of the material purchase data, which is conducive to shortening the project cost estimation cycle, and reducing the late budget change rate [11].

5. Conclusion

To summarize, urban municipal road construction is related to the overall planning effect of the city and people's travel safety. Therefore, road design must be done well before municipal road construction begins. The traditional two-dimensional design mode has been unable to meet the complex environment of current road construction and the accuracy requirements of road construction design. It is necessary to use BIM technology software to form a three-dimensional model, simulate the building body of the road construction, and simulate different construction scenarios and product structures in combination with different construction stages, to identify unreasonable design in time. Through pipeline collision test and traffic flow test, etc., the accuracy of road design and construction of various components is guaranteed. At the same time, through the application of data statistics and calculation functions, it can ensure the efficiency of project list and budget control, subsequently provide more accurate basis for the development of municipal engineering construction, and promote the healthy development of municipal construction projects.

Disclosure statement

The authors declare no conflicts of interest.

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Research on Infrared Image Fusion Technology Based on Road Crack Detection

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Abstract: This study aimed to propose road crack detection method based on infrared image fusion technology. By analyzing the characteristics of road crack images, this method uses a variety of infrared image fusion methods to process different types of images. The use of this method allows the detection of road cracks, which not only reduces the professional requirements for inspectors, but also improves the accuracy of road crack detection. Based on infrared image processing technology, on the basis of in-depth analysis of infrared image features, a road crack detection method is proposed, which can accurately identify the road crack location, direction, length, and other characteristic information. Experiments showed that this method has a good effect, and can meet the requirement of road crack detection.

Keywords: Road crack detection; Infrared image fusion technology; Detection quality

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1. Introduction

Roads play a vital role in people's daily activities and are the basic public facilities of cities, but their construction and maintenance costs are very high, therefore the road structure and transportation should be carefully planned. There is a lot of investment in road infrastructure around the world. The US Land Transportation Act allocated around 30.5 billion US dollars in the fiscal year 2016-2021, for roads, automobile safety, public transportation, automobile transportation safety, dangerous goods safety, railways, research, technology development, and statistics. The infrastructure and jobs legislation, is the long-term investment in infrastructure and the country, will add $5.5 trillion in new federal funding for roads, bridges, buses, water conservancy facilities, and communications between 2022 and 2026 financial years. According to the statistics of highway infrastructure and traffic in China, the number of highway engineering and traffic has developed rapidly. Past ten years, China's passenger throughput has decreased from 2.5 billion to 570 million, while national cargo throughput has increased from 2.5 billion tons to 3.7 billion. Cargo throughput has been maintained at a high level; Although the passenger flow has decreased, the effect of passenger traffic on road load is much smaller than that of freight, and the effect of the overall traffic on road load is very significant. From April 2018 to May 2019, there were 244 urban roads collapsed across the country. The stress on the pavement exceeds the load-bearing capacity of the pavement is an important factor causing collapsing of the pavement. Under the long-term load on the pavement, the pavement structure will be deformed, cracked, and even collapsed. With the extension of the service life of the road, long-term exposure to harsh environments, as well as the load and overload of vehicles and pedestrians, will cause long-term losses. Therefore, there is an increasing demand for road safety and sustainable development. It is also important for continues repairing and construction. Highway cracks are

the most common ones that affect the bearing capacity of the pavement, accelerate the destruction of pavement to pieces, and reduce the service life of the road. Cracks are an important symbol used to measure the damage state of the road, and development direction directly affect the damage of the road. Infrared imaging technology has the advantages of mature technology, high sensitivity, non-contact method, and not required to touch the bridge itself to detect the bridge cracks. The road crack detection method based on infrared imaging technology can quickly and accurately detect road cracks. However, due to the characteristics of large noise and serious blur in infrared images, the detection results of road cracks are seriously affected.

2. Infrared image fusion technology based on road crack detection

At present, the routine inspection of road cracks is mainly performed manually, which is time-consuming, laborious, and dangerous. Many scholars are studying the service life of roads, but to accurately estimate the service life of road surfaces many factors have to be considered such as time, load, environment, etc. Therefore, non-destructive detection technology, as shock echo, ultrasonic, ground penetrating radar, infrared imaging, etc. should be used for detecting road cracks [1-5].

As a non-destructive technology with wide application value, infrared imaging technology is of great significance in the detection of cracks in concrete pavement. It plays a pivotal role in many modern remote sensing technologies such as drone navigation, pedestrian monitoring, space warning, and oil spill detection. However, due to shortcomings of infrared image itself, such as blurred edges, low background contrast, and local unevenness, it is difficult to ensure its accuracy and robustness. However, there are some imaging technologies that use infrared imaging technology to detect surface defects of objects. It is still difficult to perform accurate positioning and detection in thermal imaging. Therefore, it is essential to combine the advantages of infrared and visual images to identify better fusion and robust, and accurate infrared image segmentation technology.

2.1. Infrared image preprocessing

Due to the influence of environmental conditions and other factors, the collected road images often have different degrees of noise, which will directly affect the accuracy of the road crack detection algorithm, therefore infrared images should be preprocessed before use. Since the infrared image is greatly affected by the external environment and is easily disturbed, it needs to be denoised. In addition, due to the large amount of noise on the road crack surface, when the traditional image processing method is used for denoising, the extracted crack feature information becomes distorted. Below are the examples of denoising techniques.

(i) Median filter denoising is an image denoising algorithm based on statistical characteristics. This algorithm gathers pixels of different scales and different gray levels to form an average value containing all pixel information as the target image [6]. The median filtering algorithm has the advantages of fast operation speed and simple parameter setting. However, although the median filter can effectively suppress the influence of noise, it cannot eliminate all the noises. In addition, this method can affect the detailed information of the image to a certain extent when extracting road crack features [7].

(ii) Histogram equalization is an image denoising algorithm based on grayscale transformation, which achieves image enhancement through histogram transformation [8]. It does not require additional gray scale transformation operations [9], and can effectively process both noise and noise-free images [10].

(iii) Median filtering combined with histogram equalization. When the median filter is used to preprocess the image, it usually causes a certain degree of noise interference. In order to better extract the characteristic information of road cracks, a combination of median filtering and histogram equalization should be used for processing.

(iv) The infrared image will be disturbed by various noises during the acquisition process, including the environmental noise of the camera and the noise of the image itself. When detecting road cracks, these noises will seriously affect the crack detection results. In order to eliminate the interference of these noises on the detection of road cracks, the image processing paper uses wavelet transform and image pyramid technology for image preprocessing, and analyzes and compares them through experiments. Wavelet transform is a time-frequency analysis method with multi-resolution decomposition characteristics, and it is widely used in the field of signal processing. In infrared image preprocessing, wavelet transform can realize multi-resolution decomposition. Under different decomposition scales, image information with different resolutions can be obtained. In this paper, 4×4 resolution wavelet packet decomposition and pixel-level fusion method are used for multi-scale fusion of infrared images.

2.2. Image fusion algorithm design

The overall flow of the infrared image fusion algorithm is shown in **Figure 1**. Firstly, the pixel-level information is obtained through the pixel gray mean and variance of the infrared image, then, according to the pixel-level information, the correlation between adjacent pixels is calculated, and finally, the images are fused according to the correlation coefficient to obtain the final fusion results.

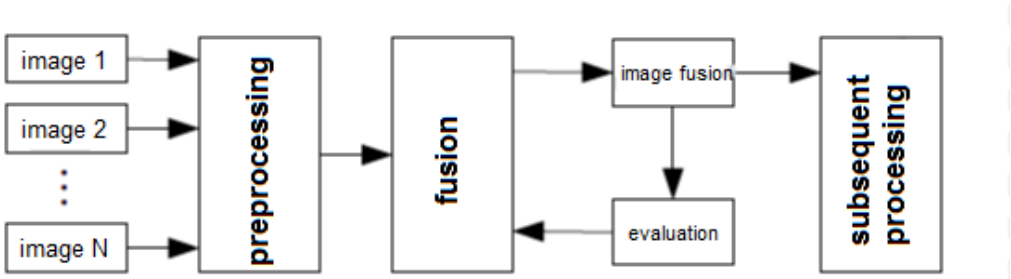

Figure 1. Overall process.

Below are the types of image fusion algorithms.

(i) Principal Component Analysis (PCA) is a linear algebra method for dimensionality reduction, which maps image data to a high-dimensional space through linear transformation, and then analyzes the original data in a new dimension. PCA transform image features into a high-dimensional space through projection for feature extraction.

(ii) Wavelet transform (WT) methods is an information processing technique based on multi-resolution analysis and multi-scale decomposition. WT has strong spatial resolution and good localization characteristics, and under different scales it can complete the extraction of different scale information in the image respectively and obtain the final result through comprehensive analysis and weighted summation.

(iii) Image fusion method based on regional features (IHB-AF) is an image fusion method based on regional features. This method uses regional features to describe the image and uses the geometric shape and gray information of the region to iteratively calculate the fusion coefficient in multi-scale space. Because IHB-AF organically combines pixel-level information and feature-level information, the fusion image not only preserve the gray level difference between the target and the background in the original image, but also reflect the difference between different feature points, and has strong anti-noise ability and anti-aliasing ability.

(iv) Based on the combination of maximum likelihood classification (MLC) and Laplacian pyramid decomposition method (LP). The MLC algorithm can perform maximum likelihood estimation on the

source image, and the calculation process is simple, but it needs to store a large amount of data for calculation and processing, while LP algorithm is simple in calculation and can compress a large amount of data into a smaller space, but it is difficult to achieve real-time processing and quick analysis. This method uses the combination of MLC and LP algorithm to form a fusion algorithm, it not only effectively reduces the computational complexity, but also ensure the fusion effect.

3. Road crack detection algorithm

The detection of road cracks is a complex task, not only the type, shape, location and length of road cracks should be considered, but also the influence of the surrounding environment and other factors on the detection results have to be considered as well. Therefore, when performing road crack detection, it is necessary not only to select the appropriate fusion algorithm, but also to select the appropriate fusion method according to the actual situation. The road crack detection algorithm based on the deep learning can identify the target, but it requires a large number of training samples and high computational complexity. The road crack detection algorithm based on the fully connected neural network can effectively solve this problem.

Convolutional neural network (CNN) is a convolutional neural network model, which mainly composed of input, output, and hidden layer. In the network, the input layer is a series of image samples, while the output layer is image information (**Figure 2**). CNN consists of three parts; 1: input layer; 2: hidden layer; and 3: output layer. The input image samples are processed through image preprocessing, convolution operation, and fully connected network, and the output information includes two parts, which are road crack information and image features. Road crack information mainly includes crack position, length, and width. Image features include light direction and gradient information. After the input image sample is preprocessed, the preprocessed image is used as the input layer of the network, and the CNN network is used for road crack detection. Since the relationship between road cracks and the surrounding environment needs to be used to judge the direction and length of road cracks in actual detection, this paper uses a fully connected neural network as the network model. The neural network is a deep convolutional neural network model with supervised learning capabilities. When detecting road cracks, the convolution method is firstly used to extract the edge information of road cracks, and then the full connection method is used to complete the identification of road crack position, direction, length, and other characteristic information.

In this paper, a method based on CNN is used to detect road cracks. Firstly, the region of interest in the multi-resolution infrared image is extracted, and the multi-resolution infrared image is decomposed by using multi-scale wavelet packet transform to obtain the high-frequency coefficients of the high, medium, and low sub-bands; Secondly, the low-frequency coefficients are extracted for fracture area information, while K-means clustering method is used to cluster the high-frequency coefficients; and finally, the multi-scale fusion technology is used to process the low-frequency coefficients to obtain the final fusion image. Among them, the low-frequency coefficients are calculated from the low-frequency sub-band information after wavelet packet decomposition, and the high-frequency coefficients are calculated from the high-frequency sub-band information after wavelet packet decomposition. Since there are a large number of background noises and roads in the infrared image, median filtering and Otsu threshold segmentation methods are also used to process the fused image.

Therefore, this paper combines the fully connected neural network (CNN), which not only realize the extraction of image features, but also realize the recognition of crack features.

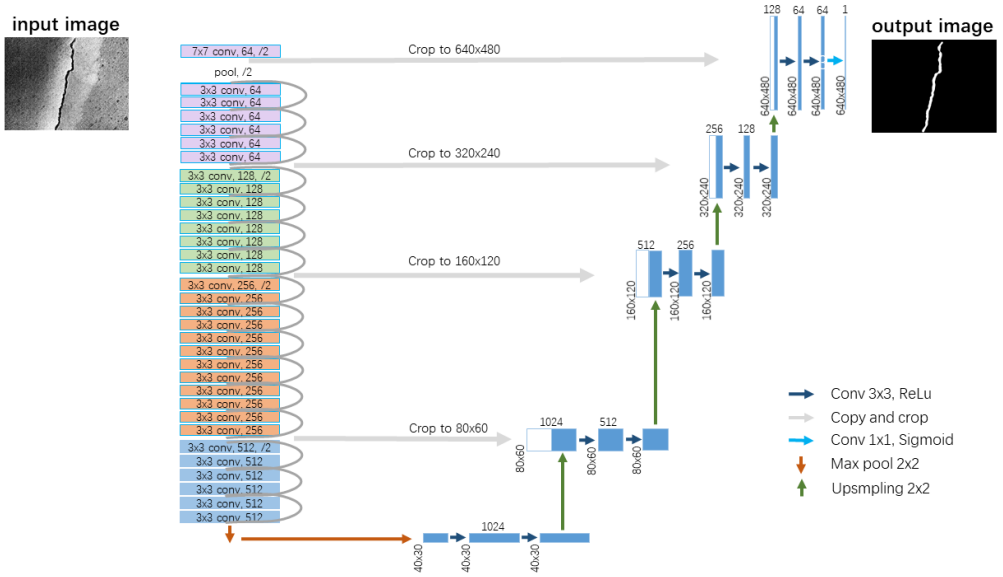

Figure 2. Model structure.

4. Conclusion

In the course of the experiment, considering that the threshold selection in image fusion has a great influence on the fusion effect, the infrared image fusion technology used in this paper has a better effect after fusing different types of road cracks, and can detect road cracks in low-light environments. Characteristic information such as the position, direction and length of the crack, and in a high-illumination environment, local feature information of road cracks can be detected.

Disclosure statement

The authors declare no conflict of interest.

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Analysis of Grouting Technology in Building Construction

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Abstract: The application of grouting technology in housing construction is to inject liquid grout into the cavities and cracks of housing construction. After it solidifies, the stability of housing construction can be improved. Grouting technology is not only very convenient but is also environmental-friendly, and it is relatively low-cost. Therefore, it is widely used in housing construction. In this paper, the types of grouting technology and its application advantages in housing construction are analyzed, and specific application strategies are put forward, in hopes of improving the quality of housing construction.

Keywords: Housing construction; Engineering construction; Grouting technology

Online publication: June 26, 2023

1. Introduction

In grouting technology, the grout is first prepared according to a certain proportion in advance, it is then injected into the cavities and cracks through pressure feeding. After some time, the grout will form a whole with the surrounding rock and soil layers, thus making the building more stable. Grouting technology is widely used in housing construction projects because it can not only ensure the quality of housing construction projects, but also improve the environmental protection and energy saving aspects of construction.

2. Types of grouting techniques

2.1. Jet grouting

High-pressure jet grouting technology is a grouting technology that combines chemical grouting and high-pressure waterjet cutting. After a hole is drilled with a drilling rig to the preset depth, high-pressure grouting fluid equipment and special nozzles are used to inject the grout into the desired area, which will cause certain damage to the surrounding soil. After curing, a grouting body will be formed in the area. The application of high-pressure grouting technology in housing construction can make the construction more stable and significantly improve the reinforcement effect of the project. Grouting technology is not only easy to operate and control, but also does not affect the structure of the upper building construction.

2.2. Static pressure grouting

In static pressure grouting, grout is injected into the cavity or crack using a grouting pipe through pressure difference or electrochemistry. After some time, air and water will be squeezed out from cracks or between particles, thereby forming a solidified substance and reducing pores. When the slurry solidifies, it will fill the entire crack or pore, making the previously loose granular soil stronger, thus improving the overall anti-

seepage performance of the soil structure.

2.3. Combined grouting technology

Combined grouting technology, as its name suggests, is a combination of jet grouting and static pressure grouting technology, which belongs to a grouting technology that is comprehensively applied sequentially. In housing construction, jet grouting can be used for the grouting of the pile body, and then static pressure grouting can be used to improve the grouting effect. Combined grouting is a new type of grouting technology, which not only has a wide range of applications, but also has a good reinforcement effect. This grouting technology can be applied to clay layers, silt layers, and gravel layers.

3. The main advantages of grouting technology in the construction of housing construction

In recent years, with the continuous development of science and technology, more research have been done on grouting technology. In order to adapt to the development of the overall housing construction industry, grouting technology has been able to progress and develop by leaps and bounds. As a result, grouting has been increasingly applied in housing construction, making the advantages of grouting technology more prominent. Firstly, grouting technology is easy to operate, because the equipment used is relatively simple, so it is easy for construction workers to complete the process correctly. Secondly, the effect of grouting is relatively ideal, because cracks or cavities can be filled through grouting, thus the building becomes firmer and more stable. Thirdly, grouting technology is comprehensive it can be applied in various housing construction projects. The grout can be used to fill the entire cavity or crack, and the grout will bond with the surrounding buildings. Lastly, grouting technology is environmentally friendly and energy-saving, because the materials used in grouting are usually synthesized from industrial waste that can be recycled, and this part of the material can also be recycled twice.

4. Effective strategies for applying grouting technology in building construction

4.1. Application of grouting technology in building wall structure

During the construction of housing projects, wall cracks often appear. In this case, grouting technology can be used to repair the cracks, and a suitable grouting method should be selected according to the specific conditions of the wall cracks. For example, when repairing cracks in the floor slab, it is necessary to select and use grouting materials with higher adhesion and shear strength according to the location of the cracks. If there is leakage in the wall, it is necessary to first determine the location of the leakage and then use cement slurry to repair the leakage by using the hole distribution method. When preparing the cement slurry, it is necessary to ensure that it has a certain fluidity and adhesiveness. If there are cracks in the door frame or window frame, a mixture of grouting materials should be used. The grout should be first injected around and on the top of the door or window frame, followed by the bottom position. In the process of grouting, it is necessary to prevent the loss of grout and minimize the possible adverse effects on the construction quality of the project due cement shrinkage.

4.2. Application of grouting technology in kitchen and bathroom construction of housing projects

The advantages of grouting technology in the kitchen and bathroom construction of housing projects are mainly reflected in the anti-seepage and waterproof properties. There are a lot of drainage pipes in the kitchen and bathroom of a building, so the chance of leakage is relatively high, which can easily cause the wall to be wet. Water seepage in the kitchen and bathroom is mainly due to the damage of the waterproof layer. Therefore, in the construction of kitchens and bathrooms, it is necessary to strengthen the anti-seepage treatment in advance. The anti-seepage effect can be achieved through the application of grouting technology. The construction personnel can first close the water pipe valve, and then dig the drainage

channel from the position adjacent to the ground and the bottom of the wall. The grouting material is mainly cement, and epoxy mortar is used to treat the drainage tank, and targeted grouting treatment can then be performed on the gaps to solve the problem of kitchen and bathroom leakage.

4.3. Application of grouting technology in the construction of foundations housing projects

Nowadays, the application of grouting technology is very extensive, and it can be applied in many construction projects, and its application effect in the construction of foundations in housing projects is very ideal. Grouting technology can not only be applied to soft soil foundations, but also other foundation structures, which can make the overall construction effect of more standardized and reduce construction quality problems of foundations in house construction. It is first necessary to use a drilling rig to drill a hole, and then tightly seal the hole to avoid mud outflow, and finally control the moisture of the grouting material to achieve the ideal effect.

4.4. Application of grouting technology in concrete structure of housing construction projects

When grouting technology is applied to the concrete structure of housing construction projects, the hole position needs to be designed according to the location of the defect, and the hole distance should be controlled within 300–400 mm, and the hole diameter needs to be between 0.6 and 1.2 mm [1]. If the crack is in a wet state, you can use the grooving method for grouting; if it is a dry joint, holes are first created at about 25–45 mm from both ends of the crack, and then epoxy glue are applied to the seal to prevent the slurry from flowing out. Strong cement is required for pipe burying and groove sealing. If it is a wet joint, some water can be added to the material to increase the affinity of the material, avoid bonding during grouting, and ensure reinforcement at the same time. If it is a dry joint, material of lower viscosity can be used, and it is important to control the curing time, which is usually about 14 hours, so that not only can the cracks be fully filled, but also the bonding effect can be improved.

4.5. Application of grouting technology in basement construction of housing construction projects

For the construction of basements, the environment is generally relatively humid, and the ventilation is often relatively poor, so there is usually water seepage. In addition, the basement is a hollow structure, which will weaken the load capacity of the foundation [2]. For this reason, during the construction of basements, the mechanical properties of the basement can be enhanced through the application of grouting technology. In the process of basement construction, it is necessary to strictly control the drilling depth to ensure that the drilling depth is within the thickness of the basement concrete structure, and the drilling angle must be controlled between 30° and 40°, and all exposed cracks should be cut simultaneously. It is important to control the pressure while grouting. A relatively low pressure is used for grouting in the initial construction stage, and the grouting pressure is gradually increased until the grouting process is completed. The environment in the basement is quite different from the above-ground environment, so the grout solidifies at a slower rate in basements. If there is still water seepage at 4 to 5 days after grouting is completed, then a second grouting process is required. Grouting is repeated until the water seepage problem is resolved.

5. Measures to control the quality of grouting in housing construction

5.1. Reasonable selection of grouting materials

The grouting materials that are often used in the grouting construction of housing construction are the chemical-type and granular-type grouting materials. In recent years, chemical grouting materials have been widely used, including epoxy resin slurry, polyurethane, and water glass [3]. Chemical grouting materials are not only easily injected, but it also has a low viscosity. Granular grouting materials are mainly composed

of water, cement paste, and admixtures. Among them, the properties of cement materials are relatively stable. After sufficient mixing, a stable cemented body can be formed, so cement is widely used.

When choosing grouting materials for housing construction projects, it is also necessary to consider whether the materials will pose a threat to the health and personal safety of the occupants. At the same time, it is also necessary to ensure that the selected materials will not cause adverse effects on the nearby environment, so the materials selected need to be non-toxic [4]. In order to ensure the quality of grouting, the selected grouting materials must meet the following conditions: first, the material must have be highly adhesive, fallibility, and comprehensive mechanical properties [5]; secondly, the affinity and permeability of the grouting material must be good, so that the gaps and holes can be filled properly; thirdly, the material must be easy to use; finally, the material must have cost-efficient. In addition, it should also be noted that if the quality of the grouting materials used is not up to standard, it will be difficult to improve the reinforcement effect of the project, so it is necessary to strictly control the quality of grouting materials [6].

The conditions of the construction site are often different for different housing construction projects, and the grouting materials selected are also different [7]. For example, different grouting materials should be used for different types of cracks. Ordinary cracks can be filled with grouting materials with better permeability and affinity. For the cracks that are very humid, it is necessary to choose grouting materials with good hydrophilicity, so as to improve the stability of the building structure [8].

5.2. Key points of applying grouting technology in building construction

In order to effectively control the quality of grouting construction, it is not only necessary to pay attention to the selection of grouting materials and technical methods, but also to ensure the functionality of the equipment needed, that is, before construction, it is necessary to carefully check the equipment and piping systems used in the entire grouting process, and the grouting parameters should be set reasonably according to the construction requirements [9]. Besides, it is also important to strengthen the management of the construction site, allocate sufficient human resources depending on the specific conditions of the construction site, and do a good job in the inspection and supervision of the grouting process. Furthermore, it is also necessary to pay attention to the real-time monitoring of the construction site to find out problems in the construction in time and resolve them in time [10]. In addition, it is necessary to strictly check the quality of grouting construction and employ special quality inspectors and technicians to check and verify the quality of grouting construction, so as to effectively guarantee the quality of grouting.

6. Conclusion

In conclusion, it is necessary to strengthen the application of grouting construction technology in housing construction, so as to ensure the stability and quality of the overall project and maximize the value of grouting construction technology.

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Application Strategy of CBR Test in Highway Engineering

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Abstract: California Bearing Ratio (CBR) test is highly professional and requires a high level of skills. In order to improve the accuracy of the test results, the relevant staff will not only need to understand the rules and procedures involved in the test, they would also need to be meticulous in their work to avoid human errors, provide good data support for highway engineering, and improve the overall quality of the project. Therefore, this paper presents an analysis of the application of CBR test in highway engineering, which can provide reference for engineering and promote the development of the highway industry.

Keywords: Highway engineering; CBR test detection technology; Soil quality

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1. Introduction

At present, the highway covers all regions of our country. Due to the vast land area of our country and the complex geological conditions in various regions, the overall quality of highways can directly impact the people's travel safety. Therefore, it is important to improve the overall quality of highways. The California Bearing Ratio (CBR) test is used to carry out detailed inspections on the quality of highway projects to understand the problems and deficiencies in them and implement relevant optimization measures. In this way, the quality of the project can be improved, and this lays a good foundation for the development of the highway industry.

2. Project overview

Taking a highway project as an example, the highway consists of slow lanes and main lines. The total length of the road is 13km, and it is designed according to the two-way four-lane marking. The width of the subgrade and the soil shoulder are 6.5 meters and 0.25 meters, respectively, and the subgrade of some road sections can be up to 8 meters.

3. Overview of CBR test

The CBR test is used to evaluate the bearing capacity of materials, and it is usually applied to road pavement testing. CBR test was first introduced in California, USA. In this test, the load-strength ratio of a standard crushed stone is compared with a sample that is filled to a height of 2.5 mm or 5 mm, usually expressed as percentages [1]. While performing this test, it is necessary to determine the best water content and dry density for specimen preparation. In order to simulate the most unfavorable state of the material, it is necessary to immerse the specimen in water before the test, and this is when a penetration test is carried out, and a load

plate is placed on the top surface of the specimen to effectively simulate the additional stress on the soil foundation and the pavement structure. During the penetration test, the larger the bearing capacity of the material, the greater the load pressure that needs to be applied.

4. CBR test

4.1. Principle

CBR test simulates the most unfavorable environment in the actual development and application of the material. Therefore, the material should be immersed in water for 4 days before the test. A penetration test is carried out after the material is immersed in water. In order to simulate the additional stress generated by the subgrade on the soil foundation, a load plate is applied at the top position. As a result, the higher the strength of the material, the higher the value of the CBR in the case of penetrations of 50 mm and 25 mm loads [2].

4.2. Specimen preparation

Proper specimen preparation is crucial in CBR test. First, when sampling, the uniformity and actual position of the specimen will have a certain impact on the test results, so the sampling work must be in strict accordance with relevant standards and specifications. While sampling, the topsoil on the surface should be removed, and the same amount of soil should be taken from the upper, middle and lower layers, or a complete specimen can be taken from a section of equal thickness or width [3]. Second, according to the relevant regulations and standards of our country, the specimens obtained can only be used after passing through a 5 mm sieve. However, this is not possible for samples collected at construction sites, so the samples need to be dried and crushed; if the specimen is clay, in order to crush it, it is necessary to increase time of stuffing to ensure that the soil block can pass through the 5 mm sieve. Third, a 40 mm sieve should be used to remove particles larger than 40 mm, and the proportion of particles larger than 40 mm should be recorded. Fourth, if the same soil has different water content, the strength value obtained will also be different. Therefore, the water content in the material needs to be measured the day before the experiment. The weight of the specimen should be more than 100 grams for fine-grained soil, more than 1000 grams for medium-grained soil, and more than 2000 grams for coarse-grained soil.

4.3. Specimen preparation

The preparation of the specimen mainly includes the following aspects: First, the condition of the particles needs to be fully considered during the selection of the test tube. After the quality is measured by test specimen tube, place it on the bottom plate, and arrange the collar, spacer, and filter paper accordingly. Second, in order to achieve the maximum dry density of the specimen, the specimen can be tamped. The samples are prepared in three ways, and three specimens are prepared in each way. Each specimen needs to be divided into three layers during the tamping process, and each layer is rammed for different numbers of times. The first layer is rammed 30 times, the second layer is rammed 50 times, and the third layer is rammed 98 times [4]. Third, the four-point method is mainly used in the screening process of the specimen. After the screening is completed, the specimen is spread on the metal plate, and the water content is calculated under optimal conditions to ensure that moisture content of the material is within the specified range. Fourth, the soil is stabilized with cement. After the soil is infiltrated, cement can be added into the soil. If fine-grained soil is used, the water content in the fine-grained soil should be reasonably controlled. After the cement is mixed with the soil, a wet cloth can be spread on the surface of the specimen in order to reduce the evaporation of concentrated water. If the whole process takes more than one hour, the specimen should be discarded. Fifth, after leveling the compaction mold, the specimen is poured into it. Then, after leveling the surface, the first layer is compacted. The hammer is dropped vertically, usually

from a height of 45 cm. After the compaction of the first layer is completed, the height of this layer must be checked, so that the remaining two layers can be adjusted in time. After compaction is completed, the surface needs to be roughened. This process is then repeated for the remaining two layers. Sixth, the collar is removed, the soil on the surface of the compaction mold is smoothened, the pads are taken out, and the total weight of the test tube containing the specimen is weighed. Other types of specimens are also prepared using the aforementioned procedures, with different times of ramming.

4.4. Soaking in water to measure expansion

(i) If plain soil is used as the specimen, the filter paper on the top surface should be replaced after the preparation is completed. Perforated plates should be used to ensure that the pressure on the structural layer of the specimen is consistent with the pressure on the top surface of the specimen. (ii) If the perforated plate and the test tube are placed in the water tank, the mold is tightened, the dial indicator is properly placed, and the readings in the dial indicator are read at the same time [5]. (iii) When filling up the water tank, it is important to make sure that water can enter the bottom and top parts of the specimen. (iv) After the immersion work is finished, read the reading of the dial indicator again, and calculate the expansion at the same time [6]. (v) Take the specimen out of the water tank, wipe the surface water, and remove the bottom plate, filter paper and porous plate after standing for 15 minutes, then weigh the mass of the specimen, and calculate the humidity change and density change of the specimen [7].

4.5. Test and detection instruments

The instruments used in CBR test mainly include penetration rods, test devices, bearing plates, loading devices, and penetration measuring devices. Among them, the loading device mainly includes a car with aggregates. The weight of the rear axle of the car must exceed 60kN, and the beam must be properly set. The test device mainly includes a pressure gauge and a jack. The capacity of the pressure gauge needs to be greater than the strength of the soil foundation, and the measurement accuracy needs to exceed 1% of the total range. The penetration rod is a metal cylinder, usually about 200 mm long, with a diameter of about 50 mm. There are 4 load plates, each of which has the same weight and a diameter of about 150 mm. There are two penetration measuring devices, which are fixed on the penetration rod in a symmetrical way. In addition, instruments such as rulers and balances are also used in CBR test.

5. Results of CBR test

5.1. The effect of immersion time

After compaction was carried out 70 times, the test soil blocks mixed with lime were immersed in water for one day, two days, three days, and four days, respectively before the CBR test was carried out. The results are shown in **Table 1**.

Table 1. CBR value (%) under different immersion time and ash content

Ash content (%) / Soaking time (d)	0	1%	2%	3%	4%
0	48.7	43.6	43.1	43.4	38.5
1 d	25.6	332.7	36.4	33.2	27.4
2 d	21.6	28.8	37.6	33.4	25.3
3 d	21.5	33.8	36.4	42.5	33.6
4 d	20.6	36.8	39.7	48.5	37.1

According to **Table 1**, the soil test block was less stable when no lime is added, and the longer the test soil block was immersed in water, the smaller the CBR value. After the soil was soaked in water for one hour, the decline of CBR value gradually decreased. However, as the soaking time gradually increased, the CBR value also continued to increase. The main reason for this phenomenon is the bonding reaction between soil and lime.

5.2. Effect of ash content on degree of compaction

In order to strengthen and understand the impact of ash content on highway engineering, the degree of compaction can be tested according to the requirements of the CBR test. The specific test results are shown in **Table 2**.

Table 2. Test of influence of ash content on compaction degree (unit: g/cm^3)

Ash content (%) / Compaction (%)	0	1	2	3	4
30 times	90.0	88.2	86.3	85.9	84.7
50 times	94.0	92.4	92.3	91.4	90.5
70 times	98.0	96.7	94.5	94.3	93.5
98 times	99.0	96.9	95.3	94.7	94.1

As shown in **Table 2**, in the case of the same number of compaction, the compaction degree of the test soil block will gradually decrease when the amount of lime added increases. This is because the cohesion of the soil is reduced after the lime is added, and the plasticity of lime soil also reduces [8]. When soil block reacts with the water and lime, the friction between the soil block particles increases, which seriously affects the compaction effect. As the number of compactions increases, the compaction strength of the loess test block is also increases, thereby reducing the compressible space.

5.3. Effect of ash content on CBR

The CBR value of the soil test blocks that were immersed in water for 4 days with different ash content were tested respectively. The specific test results are shown in **Table 3**.

Table 3. Results of the effect of ash content on CBR

Ash content (%) / Compaction (%)	0	1	2	3	4
30 times	5.8	18.5	19.4	22.7	20.6
50 times	8.7	32.6	30.9	36.9	25.7
70 times	24.4	38.4	40.5	47.2	31.0
98 times	22.7	36.7	28.6	29.6	21.8

According to **Table 3**, the increase of ash content resulted in an increase the CBR value. The CBR value was the largest when the ash content was 3%, the CBR value decreased as the ash content increased. This is because the ash content itself has a certain expansion rate and plasticity, so it has a certain stabilizing effect when it is integrated into the soil [9]. However, increasing the amount of lime mixed will reduce the

The CBR test is used to evaluate the bearing capacity of materials, and it is usually applied to road pavement testing. CBR test was first introduced in California, USA. In this test, the load-strength ratio of a the standard crushed stone is compared with a sample that is filled to a height of 2.5 mm or 5 mm, usually expressed as percentages [1]. While performing this test, it is necessary to determine the best water content and dry density for specimen preparation. In order to simulate the most unfavorable state of the material, it is necessary to immerse the specimen in water before the test, and this is when a penetration test is carried

ill reduce the controlled at

6. Influencing factors

6.1. Effect of soil quality on CBR

Regolith is the main component of mountain soil. All kinds of crushed stones are aggregated into regolith, so there is no strong cohesive force, and shear strength can only be borne by the internal friction, which mainly includes rolling, sliding, and other resistances. These properties are not directly related to water content, but to factors such as the shape, size, and strength of soil particles. Therefore, the shear strength of mountain soil is mainly determined by the roughness and size of the soil, and will not be affected by water content [10]. The viscosity of the silt is between the hillside soil and the topsoil. Therefore, in general, the greater the viscosity of the soil, the smaller the CBR value, and there is an inverse relationship between the CBR value and the soil viscosity (**Table 4**).

Table 4. Test results of the influence of soil quality on CBR

Soil	Maximum particle size/mm	Liquid limit W_1 (%)	Plastic limit W_p (%)	Best moisture content (%)	Maximum dry density ($g \cdot cm^{-3}$)	Expansion (%)	CBR value (%)
Topsoil	< 4	47.8	22.3	17.3	1.86	25.4	5.6
Silt	7	28.4	19.7	12.8	1.97	1.7	42.9
Mountain soil	12	30.4	18.4	7.5	2.36	0.28	53.5

6.2. Effect of particle size on CBR

See **Table 5** for the changes in CBR values of silt, topsoil, and mountain bark soil with different particle sizes.

Table 5. Changes in CBR values of silt, topsoil, and mountain bark soil

Soil	Maximum particle size/mm	CBR value (%)
Topsoil	4	4.0
	7	4.6
Silt	6	36.8
	8	45.7
Mountain soil	8	46.9
	12	52.7

According to **Table 5**, the CBR value increased as the particle size increased. The maximum particle size of different soils were different. If the particle size is large, soaking in water will not cause much effect or result in much changes in the particle size.

7. Conclusion

In short, the CBR test is a relatively complicated task, involving many procedures. If there is a problem in a certain step of the test, the overall results and accuracy of the experiment will be significantly affected. Therefore, in order to avoid these problems, the relevant staff and testing personnel need to strengthen their

understanding of the procedure and the technical points, so as to ensure the accuracy of the results, and provide effective data support for highway construction.

Disclosure statement

The author declares no conflict of interest.

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Analysis of Damage Pattern of Road Bridge Landslide in Mountainous Area

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Abstract: Through on-site defect investigation, special inspection, and finite element simulation calculation of a high-speed upper-span (30 + 32 + 30) m prestressed concrete box girder bridge, the overall sliding force of the bridge on the right side of platform 0# is analyzed. In this situation, typical defects such as overall girder slippage, support dislocation, pier column deviation, and pier bottom side cracks have occurred in the overpass. At the same time, combined with simulation calculation analysis, it is interpreted that the 0# and 1# foundation has been damaged at a certain position below the ground line. The occurrence of broken piles has provided a reliable basis for the later reinforcement and maintenance of the bridge and ideas for emergency inspection and analysis of bridges damaged by the same type of landslides.

Keywords: Landslide; Overpass in mountainous area; Damage pattern; Special inspection; Simulation calculation analysis

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1. Introduction

Debris flow, water damage, and landslides are common adverse geological phenomena in mountainous areas in China. In the past, the major impacts on bridges were debris flow and water damage. Even if there are landslides, the impact or loss caused by the low road standard and small scale is not large, and the problem is not very prominent. However, in recent years, high-grade highways have continued to extend to mountainous areas or areas with complex terrain and geological conditions. There are not only bridges across valleys, but also long bridges along slopes due to difficulties in roadbed design. The application range of bridges has been greatly expanded. The number of bridge defects caused by landslides is increasing day by day, and most of them occur during construction, and the scale is relatively large, causing a lot of losses, which deserves attention of relevant parties [1].

2. Project overview

An overpass bridge in a high-speed mountainous area in Yunnan, the structural form is (30 + 32 + 30) m is a prestressed concrete constant cross-section continuous box girder, the bridge width is 8.0m, and the total length of the bridge is 99.00 m. The longitudinal surface of the bridge is located on a straight line with a longitudinal slope of -2.2%. The plane is located in a straight line, the substructure of the bridge is arranged radially, the piers are solid vase piers (pier height 19.5 m), the abutments are column abutments, and the pier abutments are pile foundations. Design load: Highway - Class I, bridge deck width: 0.5 m (anti-collision barrier) + net 7.0 m + 0.5 m (anti-collision barrier), ad oblique angle: 90°.

The standard sections of the bridge elevation, plane, and main girder are shown in **Figures 1** and **2**, respectively.

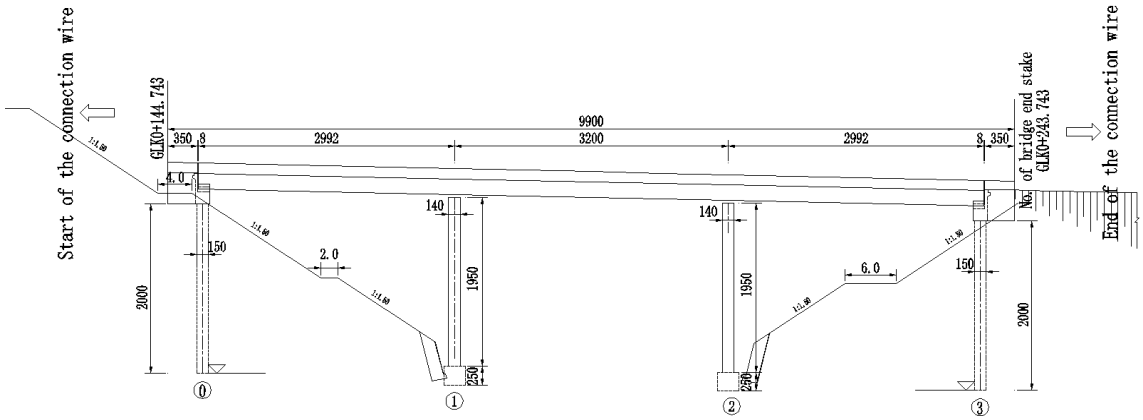

Figure 1. Layout of the sky bridge elevation (unit: 1)

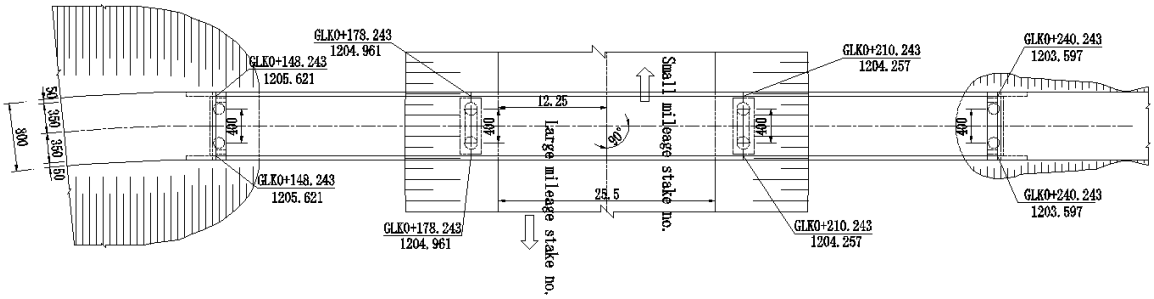

Figure 2. Layout plan of the 2- overpass (unit: cm)

3. Background of the project

Construction of the overpass began in October 2019, and it passed the third-party handover inspection on July 30, 2020, and was opened to traffic. On the morning of November 5, 2020, the construction personnel found that the support of the 1# pier of the overpass was misaligned with the steel plate at the bottom of the beam. Further inspection found that the support was damaged and the 1# pier was tilted. After the rainy season in mid-October 2020, excavation of the first-level slope on the right side of the bridge began. The third and fourth-level slopes have not been unloaded, and the first-level slope has not yet been protected. There are cracks caused by landslides on the slope, about 50 m in length and 3.0 cm in width. The overpass traffic was immediately blocked at the scene for monitoring. As of November 19, 2020, the monitoring results of the overpass by the construction unit are as follows:

(1) The accumulative displacement of the 0# platform cap towards the large mileage is 0.122 m on the left side, and 0.106 m on the right side towards the large mileage.

(2) The cumulative displacement of the left side of the 1# pier bottom towards the large mileage is 0.134 m, the cumulative displacement of the right side of the pier bottom towards the large mileage is 0.142; The cumulative displacement of the left side of the pier top to the large mileage is 0.378 m, and the cumulative displacement of the right side of the pier top to the large mileage is 0.406 m; the verticality of 1# pier deviates to the right by 0.042 m (the deviation to the right when the concrete surface of the pier body is formed is 0.019 m).

(3) The cumulative displacement of the left side of the 2# pier bottom towards the large mileage is 0.002 m, the cumulative displacement of the right side of the pier bottom towards the large mileage is 0.004 m; the cumulative displacement of the left side of the pier top towards the large mileage is 0.068 m, and the cumulative displacement of the right side of the pier top towards the large mileage is 0.057 m , the accumulative displacement of the transverse bridge is 0.004 m.

(4) The accumulative displacement of the left side of the 3# platform cap towards the maximum mileage is 0.035 m, and the cumulative displacement of the right side of the platform cap towards the maximum mileage is 0.031 m.

In order to further analyze the condition of the overpass defect and the specific cause of damage and provide a basis for the subsequent design of bridge reinforcement and treatment, a special inspection of the bridge and related theoretical simulation calculation analysis were carried out.

4. Appearance and special inspection results

4.1. Visual inspection results

Both the 0# platform and the 3# platform are in contact with the main beam, the concrete of the 0# platform is partially squeezed and damaged, and the back wall of the 3# platform has a horizontal crack; a total of 8 oblique cracks were found on the 0# platform (side wall, back wall, pile protection wall), with a length ranging from 90 cm to 360 cm and a width ranging from 0.20 mm to 4.00 mm; 6 horizontal through cracks were found on the longitudinal small pile surface at the bottom of the 2# pier, within a range of 0.3 m to 1.8 m from the bottom of the cap, with a spacing of 20~30 cm, length 350~466 cm, and crack width range 0.18~0.24 mm. The crack distribution diagrams are shown in **Figures 3** and **4**.

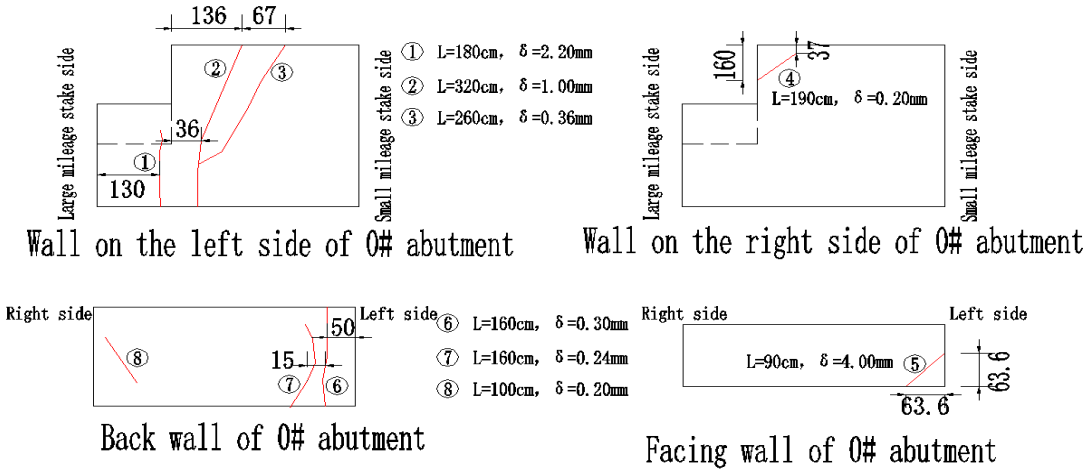

Figure 3. Distribution map of vertical and oblique fractures in platform 0# (L is fracture yield, δ is fracture width)

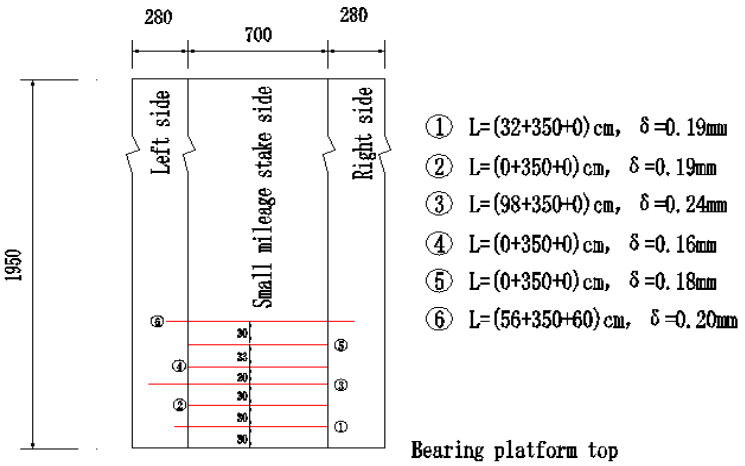

Figure 4. Distribution of horizontal cracks on the side of the bottom of 2# pier (L is the fracture rate, δ is the crack width)

4.2. Special inspection results

Test results of the verticality of the pier body

The verticality of the 1# pier-2# pier body was measured, and the verticality of each pier column was measured respectively in the longitudinal and transverse directions. The lateral deviation to the right is positive, and the opposite direction is negative [2]. The relative deviation of the pier body varies with the height of the pier, as shown in **Figures 5** and **6**.

It can be seen from the verticality measurement results in the table below: (1) 1# pier is displaced 25.1 cm longitudinally to the large pile number, and 4.2 cm laterally to the right; (2) The 2# pier is displaced longitudinally by 5.5 cm to the large pile number, and laterally by 0.6 cm to the left.

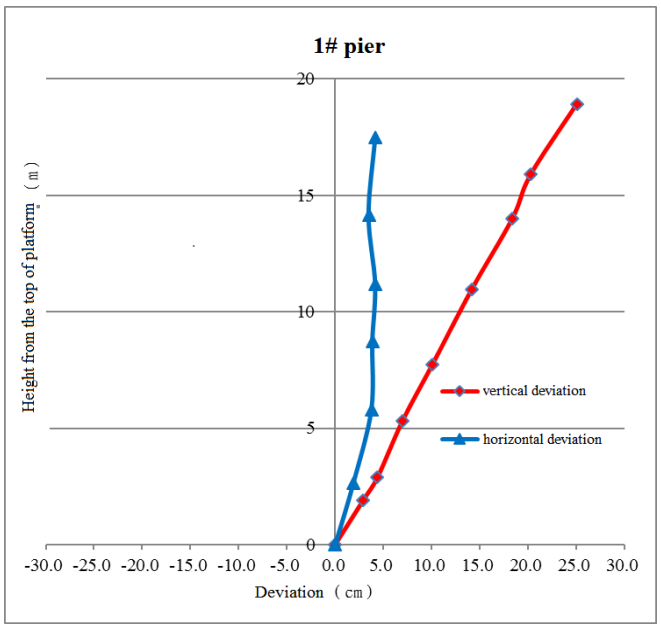

Figure 5. Measurement results of verticality of 1# pier body

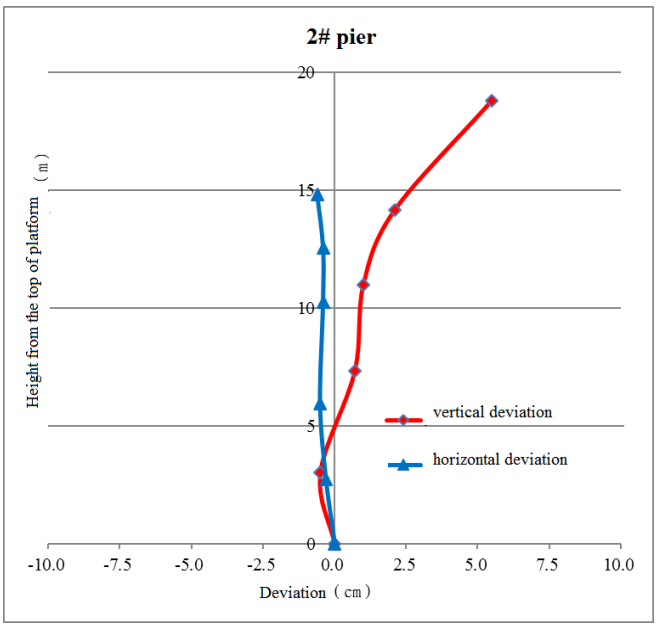

Figure 6. Measurement results of verticality of 2# pier body

4.3. Bearing appearance and displacement test results

It can be seen from the test results that the vertical displacement of the 0# platform support to the large pile number is 4.0~7.5 cm, while the longitudinal relative displacement of the 1# pier support to the large pile number is 21.5~22. The displacement is 3.5 cm, and **Figures 7**–**10** show the typical diseases on site.

Figure 7. Longitudinal large pile number displacement of 1-1# support

Figure 8. Longitudinal large pile number displacement of 1-1# support

Figure 9. PTFE slide plate warping of 1-1# support

Figure 10. Longitudinal large pile number displacement of 1-2# support

4.4. Summary of other special inspection results

Here, the distance between the expansion joints, the relative offset of the support, the relative offset of the pier top, and the coordinate offset of the main beam have been checked in detail [3].

4.5. Cause analysis of bridge defects

According to the above appearance and special inspection results, it is inferred that the main causes of bridge defects are as follows:

(1) Offset of 0# platform and 1# pier: the overall slip of the slope at 0# platform causes the displacement of the pier abutment. Due to the inconsistent displacement of the main beam and pier column, it also causes the movable support to be adjusted up and down to level the steel plate. There is a offset between them.

(2) The displacement of the main girder and the distance between the expansion joints become smaller: the displacement of the side slope at the 0# platform causes the displacement of the top of the 0# platform, which in turn causes the main beam to move to a larger pile number and the spacing of the expansion joints becomes smaller.

(3) Oblique cracks in the 0# platform body: Due to the displacement of the soil slope on the top of the 0# platform, the 0# platform received excessive earth pressure, and the concrete tensile stress of the platform body exceeded the concrete tensile stress, causing cracking.

(4) Horizontal cracks on the side of the small pile number at the bottom of the 2# pier: the main beam displaces to the side of the large pile number. Since the 2# pier is a consolidated support, the main beam drives the pier column to cause deformation, and, ultimately, the tensile stress at the bottom of the pier exceeds the limit.

5. Finite simulation calculation results

5.1. Calculation instructions

According to design specifications, design documents, geological survey data and other documents, combined with deviation monitoring, appearance inspection, entity inspection and other data, the following descriptions are made for the model:

Due to the side slope slip of the 0# and 1# pier of the bridge, the soil produces longitudinal earth pressure on the main girder, 0# abutment, 1# pier cap, etc., which, eventually, the main girder, 0# abutment,

1# pier and pile foundation will be greatly deviated. The range of earth pressure load is from the surface to the base. The force point with the bridge structure is the 0# platform and the 1# pier cap (direct contact point with the slope). The friction force of the support is applied to the pad stone position of the support on the top surface of the cover beam in the form of concentrated force. The direction of action can be judged according to the offset between the support and the main beam, and the size can be determined comprehensively according to the reaction force of the support and the coefficient of friction. The m method is used to simulate the interaction between piles, soil, and bedrock [4], and the overall model of the whole bridge, the 0# platform and pile foundation, the 1# pier and pile foundation local calculation and analysis models are established respectively. Schematic diagram of structural force analysis is shown in **Figure 11**.

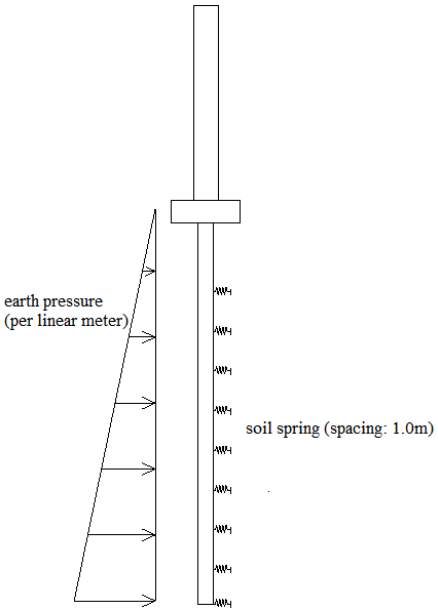

Figure 11. Schematic diagram of structural force analysis

5.2. Computational model

Using Midas finite element software, the overall calculation model, 0# pile foundation calculation model, and 1# pile foundation calculation model were respectively established for structural simulation analysis and calculation. The calculation model of the whole bridge (mainly used to calculate the reaction force of the structural support and the overall displacement of the beam) is shown **Figure 12**.

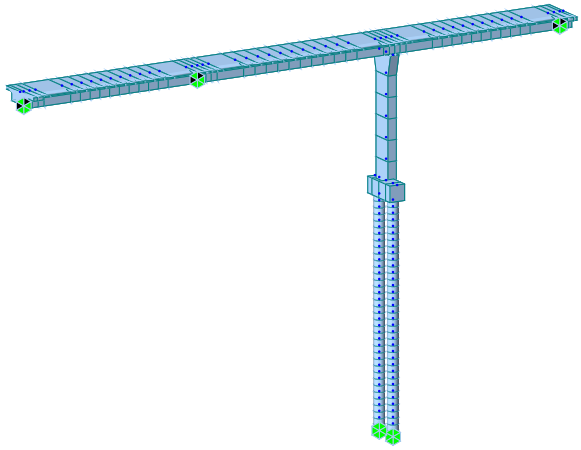

Figure 12. Calculation model of 2bridge

5.3. Calculation results

5.3.1. Calculation results of 0# pile foundation

The simulation calculation analysis is mainly divided into the calculation of the maximum crack width (0.20 mm) of the pile foundation and the yield state of the steel bar and is compared with the actual monitoring of the deflection data of the pier abutment to infer the damage status and position of the pile foundation of the 0# platform. The 0# pile foundation is controlled by the pile foundation crack limit of 0.20 mm, and the maximum displacement limit of the pile top is 63 mm; the 0# pile foundation is controlled by the pile foundation steel yield stress of 400 MPa, and the maximum displacement limit of the pile top is 107 mm; The actual monitored displacement values (0.122 m on the left side of platform 0#, and 0.106 m on the right side) all exceed the theoretically calculated displacement limit, and it is inferred that the pile foundation of platform 0# is 7.0 m away from the bottom surface of the cap, and there is a possibility of pile breakage [5].

5.3.2. Calculation results 1# pier pile foundation

The simulation calculation analysis is mainly divided into the calculation of the maximum crack width (0.20 mm) of the pile foundation and the yield state of the steel bar and compared with the actual monitoring of the deflection data of the pier abutment, inferring the damage status and position of the 1# # pile foundation. The pile foundation of 1# pier is controlled by the pile foundation crack limit of 0.20 mm, and the displacements of the pier bottom and pier top are 70 mm and 155 mm respectively; the pile foundation of 1# pier is controlled by the pile foundation steel yield stress of 400MPa, and the displacements of the pier bottom and pier top are respectively 107 mm, 235 mm; the actual monitoring displacement value (The cumulative displacement of the left side of the 1# pier bottom to the large mileage is 0.134 m, the cumulative displacement of the right side of the pier bottom to the large mileage is 0.142; the cumulative displacement of the left side of the pier top to the large mileage is 0.378 m, and the cumulative displacement of the right side of the pier top to the large mileage is 0.406 m; The verticality of 1# pier deviates to the right by 0.042 m) all exceed the theoretically calculated displacement limit, and it is inferred that the pile foundation of 1# pier is 8.0 m away from the bottom surface of the cap and there is a possibility of broken piles [5].

6. Conclusions and recommendations

Through the inspection of the defect status of the whole bridge and theoretical simulation calculation analysis, it is preliminarily concluded that the bridge 0# pile foundation and 1# pile foundation have the possibility of broken piles at the positions of 7.0 m and 8.0 m below the ground respectively. It is necessary to further verify the feasibility of broken pile reinforcement, determine the specific reinforcement plan, restore the deviation of the main beam and pier column, and replace the 1# pier support. Prior to the bridge reinforcement treatment, priority should be given to the treatment of the mountain slope at the 0# platform, and at the same time strengthen the slope stability monitoring at the bridge location and the displacement monitoring during the later bridge operation.

Disclosure statement

The authors declare no conflict of interest.

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Shallow Tunneling Method and Control Measure for Ground Surface Settlement

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Abstract: In order to ensure that the tunnel deformation and surface settlement are controlled within the allowable range during the construction process, the design unit has compiled technical measures and monitoring schemes for ground settlement control of this project. Based on the example of a shallow tunneling project on Subway line 8, this paper analyzes and discusses the shallow tunneling method in detail and puts forward corresponding technical measures for ground settlement control.

Keywords: Shallow tunneling; Ground surface settlement control; Advance ductule

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1. Introduction

With the rapid development of China's economy and the continuous acceleration of urbanization, the construction of urban rail transit has attracted greater attention. The shallow tunneling method is used mostly and preferably in urban rail transit construction. However, this method cannot be used for construction in some areas due to the limitations of economic and technical conditions; hence, the open-and-cut method is used. As a consequence of the limited land area for urban construction, the construction of underground works can only be carried out on the ground. Certain hidden safety hazards and engineering quality problems have emerged during the construction process as a result of influencing factors such as stratum, geological conditions, construction methods, and environmental conditions [1-3].

2. Project overview

The total length of the subway station line in this project is 1,180 m. The Tuling-Beijie stations section is a newly built tunnel located in an urban area. It passes through many existing subway lines, such as lines 1, 2, 4, and 7. The project subway line crosses line 1, whereas line 2 crosses line 7 in the Tuling-Beijie stations section. The strata that the section tunnel crosses are mainly argillaceous siltstone, and the overlying soil layer is mainly silty clay, with a small amount of medium sand in some parts. The buried depth of the tunnel is relatively shallow (about 15–20 m). The tunnel passes through the existing buildings, where the bearing capacity of the foundation for the existing buildings is 200 kPa, and the maximum settlement is only 5 mm.

2.1. Technical difficulty: Shallow buried depth and complex formation

This project is a tunnel evacuated with the shallow tunneling method, and the buried depth of the interval tunnel is relatively shallow (about 15–20 m). It is a rare tunnel in an urban area, as the buried depth is relatively shallow compared to other urban areas, and the settlement control requirements for the ground

surface and buildings are relatively high. The overlying strata where the project is located are mainly silty clay and a small amount of medium sand, and the thickness of argillaceous siltstone is about 15–20 m. Among them, the silty clay is up to 30 m thick and partially contains a small amount of medium sand, while the overlying soil layer is mainly silty clay and a small amount of medium sand. Under such complex geological conditions, construction is difficult, and the safety risks are high.

2.2. Technical difficulty: Inclusion of buildings and strict requirements for ground surface settlement control

Considering many existing buildings and pipelines included in this project, where most of them are located in the city center, the requirements for the control of ground surface settlement are relatively high during the construction process. According to data, the maximum ground settlement value of the Beijing Subway tunnel project is -50 mm, and the maximum ground surface settlement value is -20 mm, while the maximum settlement value of this project is only 5 mm. In addition, the buildings traversed by this project are all old buildings of different degrees, some with long durability, and the current building foundations are in poor condition, so the impact on them should be minimized during construction. Meanwhile, the project passes through multiple existing subway lines such as Lines 1, 2, 4, and 7, and the crossing point is located in the center of the city, so the control requirements for land settlement are more stringent.

3. Construction technology of shallow tunneling

3.1. Construction plan

The center cross diaphragm (CRD) method was applied for this project, where it began with the excavation of the pilot tunnel, followed by the implementation of the primary support and the construction of the secondary lining. This can effectively prevent surface settlement and tunnel deformation. During the excavation of the pilot tunnel, the excavation method of short distance, dense interval, and short steps, which defines the principle of “shallow, dense, and short,” was adopted. The face of the tunnel was supported in time after excavation. The stabilization time took up to 1.5–3 days, and the construction of the next step could only be carried out after the face of the tunnel was stable. To ensure the construction safety of the pilot tunnel, the construction methods of advanced curtain grouting to strengthen the ground, small conduit advance support, large pipe shed and small conduit joint support, and timely follow-up of an inverted arch and secondary lining were adopted during the excavation of the pilot tunnel. The section size of the tunnel is 10.68 m × 9.72 m, of which the excavation section is 81.42 m long; the pilot tunnels on both sides are 21.1 m long, and the side pilot tunnels are 30.0 m long. The height of the upper and lower steps of the tunnel section is 3.0 m, that is, the height of the upper step is 11.95 m, and the height of the lower step is 9.93 m. The arch of the tunnel structure was constructed using the three-step method, where the upper and lower steps were alternately carried out in cycles of upper, middle, and lower construction steps; the maximum excavation step distance is 12.1 m. In the construction of the three-step method of the arch, the excavation of the pilot tunnel was carried out in the order from nearest to furthest. According to the ground surface settlement monitoring results, the maximum settlement of the tunnel vault is 30 mm when the construction is symmetrical from the surface to the tunnel arch, whereas the maximum settlement of the tunnel vault is 40 mm when the construction is symmetrical from the vault to both sides of the tunnel. Therefore, it is essential to be attentive to closing the tunnel face in time during tunnel excavation. When the CRD method was used for construction, the arch, secondary lining, and primary support (arch shotcrete + secondary lining) were supported in time after the excavation of the pilot tunnel, and primary concrete was poured in the pilot tunnel. At the same time, monitoring and measurement were strengthened, and construction parameters were adjusted promptly at each stage. With the stability of the tunnel face and the increase in the strength of the initial support concrete, each process was adjusted and optimized in time.

3.2. Shallow tunneling construction

The characteristic of the shallow tunneling method is that the excavation section is small, and the arch is the main part. When the arch is excavated, the secondary lining should be applied as soon as possible. Under normal circumstances, when the soil layer is thick, the construction of the partition wall can be carried out immediately after the construction of the upper steps is completed. However, when the soil layer is thin, the construction of the partition wall can be carried out after the construction of the upper steps is completed. Since the main structure of the station is located in the Yangtze River, special technical measures were taken to ensure that the station structure is not affected by the river water. In order to avoid accidents during construction due to water level changes, the construction and maintenance of temporary drainage systems must be done in time [4-6]. Meanwhile, the surrounding rock deformation and settlement must be strictly controlled when excavating the station. During the construction of the secondary lining, it is necessary to ensure its good combination with the primary support to prevent cracks. After the construction of the station structure is completed, the construction of the secondary lining is required.

3.3. Advance ductule grouting construction

The arch part of the standard section of the primary branch tunnel adopts a single row of advance ductule, DN 32 × 3.25 mm steel welded pipes, the circumferential distance is 0.3 m, the arch part is drilled within 180 degrees, the angle is 16 degrees, and the length is 2.0 m. Each structure was calibrated as mentioned, and a schematic diagram of a single row of advance ductules is shown in **Figure 1**.

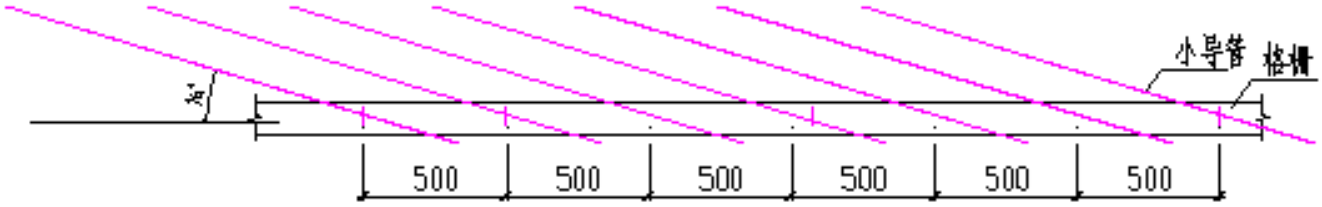

Figure 1. Schematic diagram of laying a single row of small catheters with primary branch structure. Translation (from left to right) Advance ductule, Grille

3.3.1. Manufacturing of small catheters

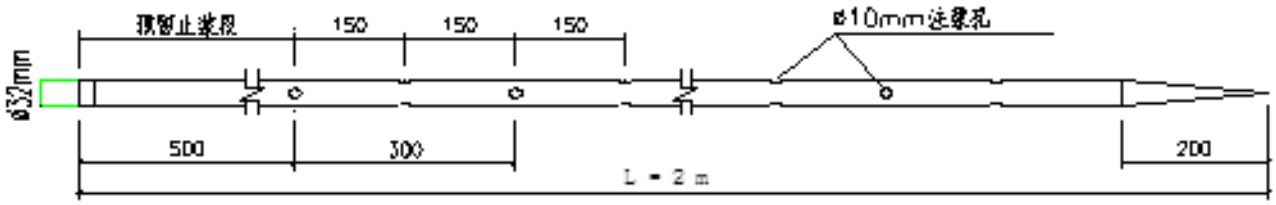

Figure 2. Grouting pipe processing diagram. Translation (from left to right): Reserved for grout stop, Grouting hole

The advance ductule is made of DN 32 × 3.25 mm welded steel pipe, and the front end of the advance ductule is processed into a tapered shape to facilitate insertion and prevent slurry from rushing forward. Drill holes with a diameter of 6–10 mm in the middle of the advance ductule, arranged in a plum blossom shape (to prevent dead angles in grouting), with a spacing of 150 mm, and no holes are drilled within 0.5

m of the tail to prevent grout leakage (**Figure 2**).

3.3.2. Layout and installation of advance ductule

For tunnel excavation, DN 32 × 3.25 mm welded steel pipes are used for advanced grouting to strengthen the formation. The advance ductules pass through the arch grid and are connected to the grid by spot welding. The circumferential distance is 0.3 m, the arch is drilled within 120°, and the elevation and extrapolation angles are 16°.

The advance ductule is constructed by the jacking method, and the ductule is directly jacked manually using a hand-held pneumatic drill. For sandy soil, if there is hole blocking, use a 32 mm diameter steel pipe to make a blowpipe, slowly insert the blowpipe into the soil, perforate with high-pressure air, insert a small ductule after the hole is formed, and seal the nozzle with a cotton cloth.

3.3.3. Grouting

The grouting is mainly made of cement water glass slurry. Fifty mm thick C25 concrete is sprayed on the working face outside the core soil of the upper step to seal and prevent grout leakage, followed by cleaning up the accumulation in the small ductule with high-pressure air. The grouting sequence is from the bottom to the top, and it can be either single-pipe or multi-pipe parallel grouting.

3.4. Advanced curtain grouting construction

The construction steps of the advanced curtain grouting process can be divided into construction preparation, drilling, and grouting, adjustment of grouting amount, bolt grouting sealing and grouting reinforcement, etc., according to the above project overview and conditions, respectively.

3.4.1. Construction preparation

After the tunnel excavation is completed, to ensure the construction quality and safety, it is necessary to carry out pre-grouting construction in front of the tunnel and carry out geological exploration in advance. Before construction, it is necessary to measure the ground surface, underground obstacles, and groundwater level in the site, as well as establish a relevant coordinate system. After the tunnel is penetrated, all boreholes can be treated uniformly to ensure the stability of the front wall structure of the tunnel and meet the requirements of the overall construction and geological conditions. After the tunnel is excavated to the design depth, all drilling rigs are stopped at the same time, and on the premise of completing all the drilling holes, water injection is performed on the remaining undrilled holes [7].

3.4.2. Drilling and grouting

The orifice should be uniform, the maximum rate should not exceed 30 cm, and ensure that there is no water leakage in all holes. When the mud pump needs to be lifted to be flushed with the drill pipe for drilling in the broken ground, the height of the mud pump should be kept consistent. When the drilling is completed, the drill bit should be drilled to a depth of 15–20 cm from the grouting hole.

3.4.3. Adjustment of drilling grouting volume

During the construction process, grouting fluid from the lower part of the borehole is poured with clean water and injected into the formation cracks. When the grouting fluid is injected, it is enough to form a continuous structure. The grouting pressure is generally 0.2 MPa. Both ends of the hole need to be grouted to the surroundings, and each hole must have enough cement slurry to fill the hole. As the amount of grouting in each section of drilling is different, grouting in stages and directions are required, and differential pressure control must be applied during grouting to achieve the purpose of a uniform and

consistent pressure.

3.4.4. Anchorage grouting

After the drilling is completed, steel wire rope or lead wire rope is used to tighten the hole wall, followed by arranging each anchor cable evenly in the hole in the form of a single anchor with a length of 1.5–2 m. When anchoring, the size of the hole must be strictly controlled to ensure it forms a whole, and at the same time reserve a row spacing of 2 to 3 mm in the hole wall, so that the number of anchor cables can be accurately laid out when drilling. The hole's diameter is not less than 25 mm, the length of the steel bar should not exceed 3 m, and the spacing should not be less than 1 m. Steel wires should be high-quality steel wires with a tensile strength greater than or equal to 500 MPa (grade 2). During production and installation, they should be evenly distributed within 50–100 mm from the center of the drilling hole to prevent cracks on the hole wall, where each cable joint shall be firmly connected and meet the design requirements (tensile strength not less than 50 MPa), and no less than 2 test operations (drilling for more than 30 d or working pressure greater than 1.0 MPa) must be performed during installation. Before grouting, lime powder is put in the hole (amount of 40–50 kg/m^3), followed by putting it into the mud pool, adding a small amount of water to dissolve it, and then drill into the hole for circulating grouting.

3.4.5. Bolt grouting sealing and grouting reinforcement

Before excavation and support, the prestressed anchor (φ12) is grouted in the "integral + segmented" way, and grouting holes are set on the grouting section of the prestressed anchor (φ12). The quality of anchor bolt grouting can be found through observation. The grouting resistance and grout flow rate of the anchor (Φ12) grouting hole are related to the viscosity of the injected grout and the viscosity of the grout. With the increase of the drilling depth, the injection pressure gradually increases. In order to prevent ground settlement and water gushing from endangering adjacent buildings, a layer of the hose should be laid at the bottom of the pit to connect the slurry discharge pipe and a row of slurry holes should be set. The slurry discharge hole and the slurry discharge pipe are connected at a distance of about 200 m from the bottom of the pit. When the aquifer on the ground is discharged, the slurry discharge pipe should be blocked in time.

4. Ground settlement control measures

The ground settlement control measures include the following:

(1) Strictly control the deformation of the surrounding rock and support structure during construction, and strictly control the grouting pressure and grouting volume when carrying out soil nailing support on the excavation surface. According to the surrounding rock, stratum, hydrogeological conditions, and buried depth of the tunnel, the surrounding rock of this project is mainly silt, fine sand, and muddy clay, where the stratum is soft, the bearing capacity is low, and the self-stabilization ability is poor. Therefore, the composite lining structure is used in the construction to provide secondary support for the surrounding rock and the supporting structure. Meanwhile, strengthen the connection grouting between primary support and secondary lining. The primary support uses small ductules to pre-grout in advance to strengthen the formation [8-10].

(2) Strengthen construction management and monitoring and measurement work. Real-time monitoring of the deformation of tunnels, ground surfaces, and pipelines during the construction process through construction monitoring and measurement, and timely analysis and summary, to take measures to ensure the normal use and operation safety of the ground surface and pipelines.

(3) During the construction process, protective measures shall be taken for ground buildings to control the occurrence of ground settlement . Before the construction of the tunnel between Tuling-Beijie stations, the surrounding buildings, and pipelines shall be investigated and reinforced, and then the tunnel

construction shall be carried out. In order to ensure the normal use and operation safety of surrounding buildings and pipelines, the following measures are taken in this project: (1) reinforcement of surface buildings through the use high-pressure rotary grouting piles for reinforcement, while strengthen the monitoring of the surface buildings during the construction process, and if the surface settlement is too large or unstable then the excavation is stopped immediately and dealt with it in time; (2) pipeline reinforcement through the use of high-pressure rotary grouting piles to reinforce the pipelines around the subway tunnel, effectively reducing the impact of subway tunnel construction on pipelines; and (3) pipeline protection measures, where the underground diaphragm wall is used to close the ground surface settlement area around the subway tunnel during the construction process, which its sealing effect is to reduce the disturbance to the surface buildings during the excavation of the subway tunnel, thereby controlling the ground settlement .

5. Conclusion

In the construction of urban rail transit, the shallow tunneling and underground excavation method is a construction method suitable for better strata, smaller sections, and poor surrounding rock. The shallow burial and underground excavation method in the construction of urban rail transit must be designed following the actual geological conditions, reasonable selection, and improvement of construction methods and processes while monitoring work to ensure the safety and smooth completion of the construction process. Meantime, the construction of urban rail transit projects has a great impact on the surrounding environment, and the control of ground settlement during the construction process is the key. The safety of the tunnel structure and the surrounding environment can be ensured through a reasonable selection of control technical measures and monitoring methods, as well as the use of information-based construction technology.

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Design Strategies of Expressway Routes and Interchanges

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Abstract: Road traffic conditions can have an important impact on the economic development of various regions. Under the background of rapid social and economic development, more and more expressway construction projects are initiated in various regions, including both new expressways and expansion of old expressways, and interchange design plays an important role. Scientific and reasonable interchange design can not only realize energy saving and low carbon footprint, but also be people-oriented and promote regional economic development. Therefore, this paper mainly analyzes the highway route and its interchange design strategy for reference.

Keywords: Expressway; Route; Interchange design strategy

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1. Introduction

When designing expressway routes and their interchanges, it is necessary to consider the traffic demand, town layout, road network distribution, management requirements, and surrounding geographical environment, etc. Besides, it is also necessary to fully understand the preconditions such as relevant opinions, approvals, and previous experiences before initiating the project. Then, the perspective different parties should be considered, and various design schemes should be compared to determine the most scientific and reasonable design scheme [1]. For the design of expressway interchanges, it is necessary to fully understand the relevant conditions such as the intersecting highways, interoperability, traffic volume, and related control conditions. Moreover, it is important to ensure that the design content is fully consistent with the Highway Route Design Specifications, can improve the road network, traffic volume, and can promote the economic level of the area along the route. Therefore, it can be seen that it is very important to discuss the expressway route and design strategy of interchanges.

2. Overview of expressway routes and interchange design

For the design and planning of expressway network, the design of expressway routes and interchanges play an important role. Improving the rationality of the designs of the main expressways and interchanges can make travelling much more convenient for locals, and it can also improve the level of economic development in the region. Therefore, before designing the route, it is necessary to fully investigate the traffic situation in the region and development needs to ensure that the various types of transportation can continue to be in a balanced state, and the role of the interchanges can be maximized. In this way the regional transportation system can be optimized, and the coverage of the road network can be maximized. Interchanges are nodes for the connection and transformation of the road networks in the area. Therefore,

in the design of interchanges, it is necessary to fully consider the long-term traffic demand, reasonably select the roads that are to be intersected, and ensure that the distance of the interchanges are scientific and reasonable, so as to maximize the function of the interchange and promote the improvement of economic and social benefits. In addition, the direction of vehicle traffic and the state of regional development should be considered, to ensure that the highway routes and their interconnected routes are consistent with the existing local routes and is coordinated with the surrounding buildings. It is also important that the routes meet the local transportation needs and at the same time effectively provide an important foundation for local socio-economic development [2].

3. Expressway routes and basic strategies for their interconnection design

3.1. Key points of expressway route selection and design

3.1.1. Ensuring safety

The first principle in selecting expressway lines is to ensure safety. Highway safety does not only refer to the safety of the main structures such as the roadbed, bridges, and tunnels of the expressway itself, but also the safety when driving on the expressway. Therefore, when selecting highway routes, care should be taken to avoid unfavorable geology such as landslides, debris flows, high-seismic areas, fault zones, and areas with soft soils. Other factors that affect the safety of road operations such as explosives and electricity should also be avoided to improve the safety of the line.

3.1.2. Improving economic efficiency

Expressways are one of the main arteries of social and economic development, and the main purpose of expressway construction is to improve economic benefits. The construction and maintenance of expressways are costly, so we must pay attention to the economic benefits. For expressways, economic benefits refer to the usage and service life upon completion of the expressway. Particularly, if the expressway passes through areas with complex terrain, it needs to be reasonably modified, which will lead a further increase in the cost of construction. Therefore, when selecting expressway routes, the development of major economic support industries in the region should be considered, such as the service industry and tourism, to maximize the cost-effectiveness of expressways and their role in driving local economic development [3].

3.1.3. Meeting environmental protection requirements

The building and construction of expressways will inevitably affect the surrounding environment to a certain extent. Therefore, when designing expressway lines, we should try our best to ensure the environmental friendliness of the project, especially the effect on water sources, historical relics, nature reserves, farmland, etc. The line can be appropriately extended to bypass the above-mentioned areas, and it is also important to avoid damage to environmentally sensitive points along the line during the construction process.

3.1.4. Adapting to local conditions

The expressway route should be reasonably designed according to the actual geological conditions and terrain characteristics of the area, and the route should be coordinated with the terrain and compatible with the geology to the greatest extent, so as to ensure that the expressway integrates into the natural environment to reduce construction difficulty and save construction cost.

3.2. Expressway interchange design

There are many forms of expressway interchanges. At present, interchanges are usually constructed in cities

at the municipal level and in counties below the city level, because the population in counties are usually scattered, and the number of vehicles is relatively small, which may lead to relatively less congestion. The four-branch interchange is usually used in cities with a large population and rapid urban development. In this type of cities, the population and number of vehicles is large, so traffic congestion is more likely to occur. In addition, common expressway interchange designs also include multi-branch interchanges, which contain multiple lines and are relatively complex [4].

Before designing the interchange, the overall actual situation in the road section should first be understood, mainly including the traffic flow, the layout, the data, etc., of the road network. Besides, the surrounding geological conditions should also be considered, such as the geographical environment, hydrological characteristics, and other aspects [5]. It should be noted that because the service life of the interchange is relatively short, and it can also be affected by various natural factors, the frequency of maintenance should be appropriately increased after the construction is completed. In addition, the location of the interchange should also be strategic and suitable for setting up toll stations. Moreover, it is important to pay attention to maintaining an appropriate distance between the parking area and the toll stations to ensure the normal passage of vehicles [6].

4. Basic principles of expressway routes and interchange design

The scientific and reasonable design of expressway routes and their interchanges can greatly improve traffic efficiency, thereby effectively relieving traffic congestion, reducing the incidence of traffic accidents to a certain extent, and at the same time improving the travel experience and transportation of the people. Therefore, ensuring the safety of various types of transportation vehicles in expressway routes and their interchanges can maximize role and advantages of the routes and further improve the road network [7]. Therefore, in order to ensure the rationality and effectiveness of the expressways and their interchanges, it is important to adhere certain principles, as shown in **Table 1**.

Table 1. Basic principles of expressway routes and interconnection design

Serial number	Principle	Content
1	Fulfill the four traffic development requirements	Resource saving, energy saving and high efficiency, construction environmental protection, green service
2	Low cost	Comparing multiple construction plans and strictly controlling the quantity of work
3	People-oriented	Ensure the safety, comfort, and integrity of the route
4	Harmonious development of multiple industries	Maintain an optimal relationship between the expressway and surrounding agriculture and industry
5	Promote regional development	Urban planning and regional economic development must be considered comprehensively when designing schemes

5. The specific situation of expressway routes and interconnection design

5.1. Basic information

Taking the north-south expressway as an example, the starting point is the expressway in Area B in the area where it is located. The main purpose of this project is to connect the north and south ends of the expressway to optimize the transportation network in the area, while reducing the detour distance of vehicles. Before officially launching the design scheme of the interchange, a comprehensive on-site survey should first be carried out, and photographs should be taken of the existing cultural relics, schools and other important

environmentally sensitive areas. If there are high-voltage lines, factories, etc. in the area, the relevant authorities should be consulted in advance to ensure the rationality and feasibility of the design scheme, and areas such as cultural relics and schools must be avoided [8]. Factors such as urban planning, traffic planning, social and economic development status, and development needs in the area should also be considered to select the most economical, safe, environmentally friendly and beautiful design. It should be noted that continuous communication and coordination with relevant local government departments should be carried out to ensure that the interoperability design scheme fully adapts to social impacts and economic development needs [9].

5.2. Design plan

Based on the highway route design specification and the actual situation, several design schemes were put forward. A 1:10000 topographic map was used to study the rationality of the route. After selecting multiple schemes, 9 design schemes with high comparative value were determined , namely Line A , Line B , Line C , Line D , Line E, Line F, Line G, Line K, and Line K2. After fully considering the regional development plan, social impact and geological conditions along the line, K line was chosen as the final design scheme, as shown in **Figure 1**.

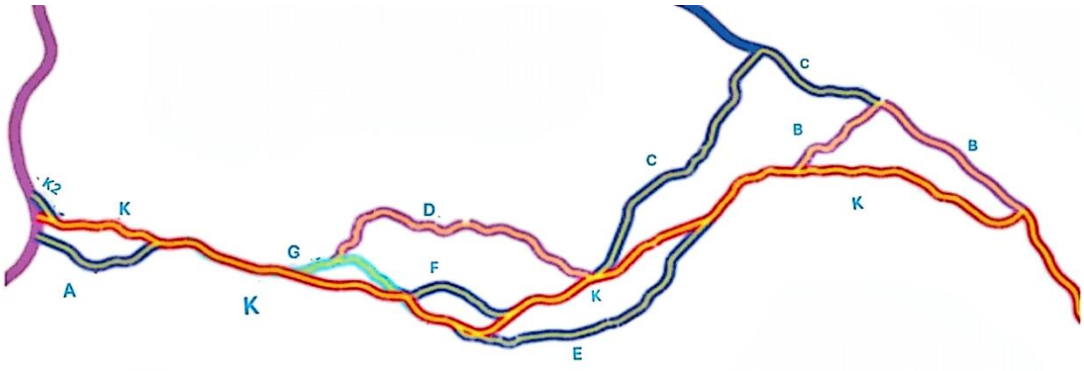

Figure 1. Schematic diagram of the design scheme

According to **Figure 1**, Line K is able to connect the entire line. Through field surveys and taking local opinions into consideration, except for Line K, most of the route schemes have obvious shortcomings, and they are not ideal in terms of economy and feasibility. As far as the comparison between Line A and Line K is concerned, a special curved bridge need to be built in Line A, and the route is 193 meters longer than Line K. Therefore, Line A comparatively less ideal compared to Line K. In terms of comparison between Line B and Line K, the plane index of Line B is poor, and there are detours in the route. The actual distance of Line B is 33 meters longer than that of Line K. Therefore, Line B is less ideal compared to Line K. After several comparisons, Line K is the optimal solution, and Line K should be taken as the main line, with a total length of 91.4 km. At the same time, Lines A and B were compared at the initial stage of design. The lengths of the two alternative lines A and B are 25.4 km and 12.6 km respectively, accounting for 41.64% of the overall length of the line.

5.3. Analysis of interoperability

A project has been initiated to solve the problem of traffic conversion between urban ring and ring roads. The design speed limit of the main expressway is 120km/h, and the roadbed width is 34.5 m. Because the position of the interchange of the project is within the flood storage area, the main line of the urban ring road is a bridge. The volume of subgrade of the road section is large. At the crossing position, the upspan method is used to ensure that the flood control requirements are met. Within the range of the interchange,

all main lines adopt the form of bridge overspan, and the part of the interchange ramp is also a bridge [10]. Therefore, the scale of the project's interchange is relatively large, and the cost is relatively high. According to the function of the interchange and the traffic demand, the designed speed of the main traffic flow of the interchange part is 60 km/h, the minimum radius of the circular curve is 150 m, the ramp part is double-lane, the width is 10.5m, the entrance and exit part is single-lane, and the maximum longitudinal slope is more than 4%. The secondary traffic flow is connected by the inner ring ramp. The design speed of this part of the ramp is 40km/h, the width is 8.5m, the minimum radius of the circular curve is 60 m, and the maximum longitudinal slope does not exceed 4%. Two parts of the inner ring ramp are on the right side of the main line, and there are multiple entrances and exits on the right side of the main line. Therefore, in order to reduce the impact of the ramp-turning traffic on the straight traffic on the main line, the method of lane distribution and/or merging exits should be adopted to ensure the consistency of interchange entrances and exits.

Through the design of the interchange, the road network between the expressway in Area A, the expressway in Area B, and the urban ring road in Area C has been effectively connected and transformed. This is how the hub-type interchange has greatly improved the traffic efficiency and safety in this area. Due to the beautiful interchange and the many and irregular free areas formed between the ramps, the green landscape of the interchange area is also one of the key points in the design of the interchange. Greenery is often the main highlight in the entire expressway project. In the process of greening design, natural forms should be mainly used to fully display the local natural landscape, improve the external aesthetics of expressway routes and interchanges, and then realize the full integration of natural environment and transportation, which will in turn achieve the "harmonious coexistence between man and nature" [11].

6. Conclusion

Expressway routes and their interchanges are one of the key points in road traffic planning, which can have an important impact on the integrity and rationality of the overall design of the highway. Scientific and reasonable expressway routes and their interchanges can effectively relieve urban traffic pressure, and improve the efficiency of highway, making the travelling more convenient, and the economic level of the region can also be improved. Therefore, when designing expressway routes and their interchanges, it is important to consider various factors such as urban development planning, road network composition, management conditions, traffic demand, and topographic and geological conditions, so as to ensure the interoperability of the expressway routes and interchanges.

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Discussion on Test and Detection Technology of Highway Asphalt Pavement

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Abstract: The road traffic industry in China has been developing rapidly in recent years. Asphalt has become the main material in road construction because of its seamless connection and short construction period, and it has an important impact on the overall quality of highway construction. Therefore, it is necessary to conduct scientific and reasonable tests and detections for highway asphalt pavement. This paper presents a discussion on the test and detection technology of highway asphalt pavement for future reference.

Keywords: Highway; Asphalt pavement; Test and detection technology

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1. Introduction

Although choosing asphalt as the pavement material comes with many advantages, it is difficult to guarantee the quality of asphalt pavement due to factors like construction technology, construction management, post-maintenance, and other factors, which may affect the traffic and transportation in the future. In order to reduce risk events, prolong the service life of the pavement, and reduce maintenance costs in the future, it is necessary to conduct appropriate tests on asphalt pavements. It is necessary to focus on the items tested, including aggregate, proportion of materials in a mixture, road compaction, and other aspects [1]. In order to improve the quality and safety of highway asphalt pavement, it is necessary to conduct an in-depth discussion on the test and detection technology of highway asphalt pavement.

2. Quality requirements for highway asphalt pavement

To improve the testing of highway asphalt pavement, the basic quality requirements of highway asphalt pavement should first be determined. According to the situation and needs of our country's road traffic, the current quality requirements of highway asphalt pavement mainly include the following aspects (**Table 1**).

Table 1. Quality requirements for highway asphalt pavement

Serial number	Requirement	Effect
1	Able to withhold high pressure	Prevent inelastic deformation structural damage
2	Good aging resistance	Delay pavement aging and prolong road service life
3	Stable	Resist deformation and lateral flow caused by passing vehicles
4	Strong temperature resistance	Prevent pavement cracking in low temperatures
5	Appropriate road surface roughness	Prevent skidding and improve driving safety

3. Highway asphalt pavement testing and detection technology

3.1. Quality inspection of the aggregate

Besides asphalt, one of the key raw materials used in road asphalt pavement construction is aggregate, which mainly plays a supporting role in the pavement structure. For the aggregate testing, the sample taken should be representative, and it should be uniform. The performance tests can then be carried out including the testing of needle-like particles, mechanical properties, and density. A gauge or a vernier caliper is used to measure the needle-like particles. A press is used to test the maximum bearing capacity of the aggregate, and the basket method is used to test its density. The dry weight, wet weight, and saturated weight of the aggregate is measured, and then the polished stone value is measured by a grinder [2].

3.2. Mixture quality inspection

3.2.1. High temperature anti-rutting performance testing technology

Ruts on the asphalt road cause traffic accidents easily. To prevent rutting, a high temperature anti-rutting performance test can be carried out. First, the temperature of the test environment should be set at 60°C and, with the wheel pressure at 0.7MPa. The sample is rolled over several times with a distance of 230 mm ± 10 mm, the reciprocating speed is 42 times/min ±1 time /min, and the test is carried out continuously for 60 minutes, and the rutting depth of the specimen is observed. An asphalt pavement analyzer (APA) can also be used to set up different test environments, where the loading wheel is rolled on the test piece with a constant pressure, and the data generated during this process will be collected and analyzed by a computer.

3.2.2. Low-temperature crack resistance performance testing technology

The pavement can shrink when the temperature drops, which can cause low -temperature cracking. The low temperature crack resistance of asphalt pavement, the following methods can be measured using several methods. (i) Indirect tensile test: taking an asphalt mixture specimen with a specification of 101.6 mm × 63.5 mm as an example, the loading layer test is carried out, and the splitting strength, horizontal deformation, and vertical deformation is measured through a sensor. (ii) Direct tensile test: taking an asphalt mixture specimen with a specification of 101.6 mm × 63.5 mm as an example, the sample is first paste it on the drawing plate and stretched at a speed of 1.2×10^{-3}–2.5×10^{-3} mm/min. The cracking temperature can be estimated according to the relationship curve between the strength and temperature [3].

3.2.3. Anti-slip detection technology

The skid resistance of asphalt pavement can have a major impact on the safety of road use. The surface structure depth, polishing resistance, particle shape, etc. of mineral aggregates can all have an impact on the skid resistance of asphalt pavement. The skid resistance can be measured using a few methods. (i) Pendulum method: firstly, the road section is sampled randomly, and the pendulum is placed on the road surface measurement point; then, the pendulum is allowed to swing in the driving direction, and the switch is turned on; the pendulum value shown when the pendulum passes is the skid resistance value of the road surface; this test should be performed a few times, and the average value will be taken as the final road surface skid resistance. (ii) Depth test: After selecting a measuring point, the road surface of that area is cleaned, some sand with uniform density is poured on it and spread into a perfect circle as much as possible; then, its diameter and length is measured in a vertical direction, and the average value is calculated. (iii) Sideway force coefficient test vehicle: test wheels are installed on a vehicle, and keep an angle of 20° between its angle and the driving direction of the vehicle; when the test starts, the water supply system will automatically sprinkle water, and the test wheel touch the ground; load is then applied on the vehicle, and the sensor the vertical and lateral force acting on test wheel will be detected by a sensor, the greater the sideway force coefficient, the stronger the anti-skid ability of the road surface.

3.3. Road compaction test

After the asphalt mixture is paved, it needs to be compacted. Compaction can have an important impact on the overall stability and smoothness of the road surface, so it is necessary to test the degree of compaction of the road surface. Core sampling method is usually applied in testing the degree of compaction. This test can only be performed after the paving and rolling of the asphalt mixture is completed. After the temperature of the pavement drops to room temperature, core sampling can be carried out, and the samples are brought back to the laboratory. The degree of compaction is determined based on the density of the mixture. The core sampling process is relatively complicated, and it might damage the pavement, especially if the sampling method is inappropriate or that the detection method is unscientific, which may affect the accuracy of the results, thus affecting the compaction correction process. The sand filling method is also a commonly used method for testing the compaction of asphalt pavement. The test is performed and after compaction, and the volume of sand consumed by the two sand fillings are compared. However, this method is inaccurate. Therefore, a new type of nuclear density meter is being used. The nuclear density meter can be used directly on the construction site to detect the compaction degree of asphalt mixture. The whole detection process is relatively simple, fast, efficient, and the results are accurate, so it has high application value [4].

3.4. Road surface roughness detection

The smoothness of the road surface is crucial in ensuring road safety. Several methods can be used to detect the smoothness of the asphalt pavement.

3.4.1. Road flatness meter

When using a road flatness meter, it is necessary to use a vehicle or manpower to pull the instrument on the road. The small measuring wheel on the instrument can move up and down with the unevenness of the road and move the displacement measuring rod in the instrument. As a result, the positive and negative poles and the magnitude of the external output potential of the sensor change continuously, and the smoothness of the road surface can be determined according to the potential difference. This method is only suitable for the detection of road surface roughness, it is not suitable for roads that are severely damaged or have a large number of potholes.

3.4.2. Laser level method

The instrument is composed of a laser sensor and a distance sensor. It detects the longitudinal section of the road surface. The height of the road surface is determined through the vehicle’s wheel marks. Therefore, the longitudinal flatness of the road surface can be determined according to the change of the vehicle's wheel marks when the vehicle is running. As this method is highly accurate, it is suitable for application on roads with high requirements such as urban roads, expressways, and airport runways [5].

3.4.3. Vehicular bump-integrator method

The vehicular bump-integrator method is convenient, cheap, and fast. The instrument is mainly composed of a data processor, a sensor, and a micro-printer. The sensor is located on the floor of the detection vehicle. The smoothness of the road surface is then determined based on the driving speed and vibration [6].

3.5. Pavement strength test

The Beckman beam method is one of the most popular methods for strength test. In this method, the rebound deflection value of the pavement under the extremely slow loading state or the static loading state is determined, which can reflect the overall pavement strength, that is, the larger rebound deflection value,

the smaller the bearing capacity, and the smaller the strength of the pavement, and vice versa [7]. For this method, a Beckman beam deflection tester is required, which mainly includes three parts, namely the Beckman beam, the dial gauge, and the gauge frame. It is necessary to inspect the vehicle before carrying out the test to ensure that its brake system is working properly and the inflation pressure is sufficient. After loading the aggregate in the vehicle groove, the weight of the rear axle of the vehicle is determined to make sure that it complies with the relevant regulations. The weight of the vehicle should be constant when it is running, and several measuring points are set in the test road section. Then, the vehicle is driven when the whistle is blown [8]. During this process, the dial indicator pointer moves with the deformation of the road surface. At the same time, the forearm of the Beckman beam is connected to the ground, and the rear wall is connected to the dial indicator. The displacement is displayed according to the change of the pointer's position. Then, the deformation of the forearm endpoint is determined according to the principle of similar triangles, and the obtained value is the rebound deflection of the road surface, which will be the strength of the road surface [9].

3.6. Pavement thickness detection

To detect the thickness of asphalt pavement, ground penetrating radar can generally be used. Detection errors are prone to occur in traditional ground penetrating radar systems. Detection errors are mainly caused by changes in driving speed, so high-frequency electromagnetic waves are mainly used nowadays. Signals are transmitted to the asphalt pavement, and different media can reflect different corrugations.. At this time, radar detects the time difference between the corrugations, the node orientation is then displayed, and the burial depth of asphalt pavement can be calculated, which will be the thickness of the pavement. Because this method is highly efficient, there will be no damage or breakpoints, and hundreds of kilometers can be measured in a day. With this method, any cracks or voids can be detected easily [10].

3.7. Mixture ratio detection

Before the construction of the asphalt pavement, it is necessary to determine an appropriate ratio of materials in the asphalt mixture through the test data. This is because the mixture ratio has a significant impact on the quality of pavement construction. Generally, simulation tests can be done by selected organizations. During the test, the effects of different mixture ratios are verified. Therefore, the amount and proportion of different raw materials in the mixture can be optimized accordingly [11]. After the most suitable mix ratio is determined, the mix ratio should be used to make a mixture sample, and the sample should be tested on the construction site. The main parameters to be tested include low temperature crack resistance, thermal stability, water stability, and anti-crack performance. When testing low temperature crack resistance performance, low temperature bending creep test can be used, and a graph can be plotted to analyze the low temperature crack resistance performance. To test the thermal stability, the road surface temperature should be set at a temperature of 60°C, and then a test vehicle is used to carry out repeated rolling several times to confirm the dynamic stability of the road surface. To test the water stability, a freeze-thaw splitting test is first carried out to test the strength of the pavement, and the water stability of the pavement is evaluated based on it.

4. Conclusion

The test and inspection of highway asphalt pavement is not only important to ensure the quality of the road surface, but to ensure driving safety. Besides, it can have a certain impact on the service lives of the road surface and the vehicle. We should first clarify. The basic quality requirements of the pavement such as compression resistance and aging resistance should first be determined, and the appropriate time and technology to should be used to ensure the qualities of the aggregate, mixture, and the pavement's

compaction, smoothness, strength, thickness, and other aspects. In this way, the quality and construction effect of highway asphalt pavement can be controlled as much as possible, thus improving improve the use effect and driving safety of highway asphalt pavement.

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Research on Prefabricated Interior Renovation of Existing Buildings

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Abstract: Requirements for the quality of housing have been increasing in recent years. Many existing buildings can no longer meet the needs of residents due to functional, layout, and other issues, and need to be renovated. However, traditional renovation methods have problems such as high pollution and high consumption. With the rapid development of prefabricated construction and green environmental protection concepts, the problems of traditional interior renovation can be resolved using prefabricated interior decoration. As a new and advanced method of renovation, prefabricated renovation reduces construction segments, workload, pollution, and waste, and it promotes the upgrading of the traditional renovation industry.

Keywords: Existing buildings; Prefabricated building; Wet construction; Dry construction

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1. Status and pain points of renovation of existing buildings

1.1. Necessity of renovation

Most existing buildings have many problems as they age, and they are gradually becoming unable to meet the requirements of residents. Some even have significant safety hazards. Therefore, it is necessary to renovate existing buildings.

Firstly, the current needs of users far exceed the functional scope of existing buildings. For example, the layout design is inappropriate: the total area is small, especially the kitchens and bathrooms are too small, and some layouts do not have independent functional spaces such as bathrooms, entrances, workspaces, and storage. The overall interior space is enclosed, with poor lighting and ventilation, with limited functions.

Secondly, because some buildings were constructed a long time ago, their building performance is poor, and there are problems like aging and disorganized pipelines, which lead to significant safety hazards. The doors and windows are aging, and the interior insulation and airtightness have deteriorated. The drainage pipelines are easily blocked due to overwashing, and because of poor ventilation, there are serious odors. The problems of gas and heating supply are difficult to solve, in which the circuit load is small and cannot meet the requirements of many electrical appliances being used together.

1.2. Pain points of renovation

1.2.1. Huge time and energy investment

Unlike new residential renovations, the renovation of existing will affect the daily lives of the residents, and they will need to temporarily move out. The renovation process is difficult to control, and there may be problems such as delayed construction progress, which requires homeowners to spend a lot of energy

and time, resulting in indirect cost increases.

1.2.2. Renovation safety hazards

Space reorganization will usually be carried out in the renovation of existing buildings, and walls are the basic components of the building structure. Due to the lack of understanding of the building by the homeowner or construction personnel, the structural safety of the building is at risk. In addition, aging wiring can also cause fire hazards during the construction process.

1.2.3. Environmental and noise pollution

The process of dismantling and renovating old structures is noisy, which will cause noise pollution to neighbors and the surrounding environment. Moreover, the construction waste generated while dismantling and renovating can also cause pollution to the nearby environment.

1.2.4. Unstable renovation quality

There may be some problems that are difficult to solve thoroughly even with renovation, such as rusting water pipes, peeling off of electric wire insulation layers, and damp walls. If these problems are not well resolved, they will reappear as time goes by.

1.2.5. Material selection and storage

Most of the buildings renovated are located in residential areas, and the old communities have limited space for material storage and transportation. Secondly, homeowners generally do not understand the characteristics of the materials used in the renovation. Therefore, the selected materials for renovation might interfere with the existing material, making the effect of renovation less ideal.

2. Comparison of traditional interior decoration and modular interior decoration

2.1. Disadvantages of traditional renovation methods

The traditional wet-work construction method has been popular in China for many years, and the traditional "guerrilla-style" renovation method involves complex construction processes, long construction periods, difficulties in ensuring quality, and over-reliance on manual construction methods. Additionally, the traditional decoration process has caused a series of problems that make industry regulation difficult, such as environmental pollution, noise pollution, and the use of substandard materials. In summary, the disadvantages of traditional decoration are mainly manifested in the aspects below.

2.1.1. Poor workmanship

Quality problems have long been present in traditional renovation, such as floor water seepage, hollowing and cracking of waterproof layers in bathrooms, various leaks caused by different reasons, uneven floors, and accumulation of salt on tiled surfaces. In kitchens, tiles may fall off, pipes may break, and large cracks may appear due to dimensional errors during installation. In addition, other indoor rooms are also prone to problems such as moldy walls, damp and crumbling walls, ceilings deforming, peeling or falling off, uneven floors or floor joints, and floor pipeline failures. The level of workmanship of construction workers, the quality of materials and equipment used during construction, the weather and site conditions during construction, and other factors all affect the final quality of the completed project. Due to the multitude of factors that can influence the quality of construction, it is difficult to control and ensure quality in traditional renovation.

2.1.2. Labor shortage and low construction efficiency

The labor force is shrinking steadily as China's birth rate continues to decline, and the demographic dividend is gradually disappearing. The construction industry is inherently labor-intensive, and the new generation is less willing to enter this industry, while the existing young labor force is also gradually leaving. Moreover, the traditional interior renovation industry has a long industrial chain, with a large amount of labor required for the manufacturing and design of materials in the early stages, as well as the construction and maintenance services in the middle and later stages. Nowadays, systematic training is also needed for these kinds of jobs. In traditional construction, most of the work is done manually, and the materials and methods need to be compatible with the original material used in the building. In addition, the construction efficiency is also very low due to factors such as weather and temperature, which may delay construction time (**Figure 1**).

Figure 1. On-site cutting

2.1.3. Safety hazards during the decoration process

During the construction process, due to on-site operations and the lengthy and complex procedures, there may be violations such as the unauthorized use of electrical welding tools and open flames, and the arbitrary placement of flammable materials and construction waste can lead to fires and other dangers. For example, workers smoking at the construction site, cooking with fire, or violating electrical usage regulations by private wiring, overloading electricity, and so on (**Figure 2**). In addition to electrical safety, during the renovation process, the openings and grooves in the wall may cause certain damage to the building structure, which could potentially lead to safety issues such as building collapse.

Figure 2. Violation of electricity regulations

2.1.4. Health and environmental pollution

Because the parts for renovation are made on site, the materials and techniques used are subject to significant limitations, leading to indoor environmental pollution and renovation waste pollution.

Indoor environmental pollution is mainly caused by the extensive use of chemical agents such as latex paint, oil paint, and adhesives, which results in indoor air pollution that dissipates extremely slowly. According to a survey by China Indoor Environmental Monitoring Center, air pollution caused by renovations leads to 111,000 deaths each year in China, with 800,000 to 1.2 million children born with congenital disabilities.

The waste generated during the renovation process is also a significant factor in environmental pollution. If the waste is discarded indiscriminately, it will pollute the soil and be difficult to degrade. When it is left in public places for a long time, the volatile chemicals emitted from it can harm people's health (**Figure 3**).

Figure 3. Dust pollution

2.1.5. Excessive resource wastage

The main cause of excessive resource wastage is mainly due to "secondary renovation". "Secondary decoration" refers to the removal of interior renovations by homeowners after purchasing a pre-decorated or second-hand house due to dissatisfaction. Most homeowners remove the floor tiles, walls, and sanitary ware after buying a new house, resulting in the rampant phenomenon of "smashing and replacing," leading to a large amount of resource wastage and environmental pollution.

2.2. Concept of prefabricated interior renovation

2.2.1. Dry assembly

Reliable support and connection structures are achieved through anchor bolts, structural adhesives, supports, etc., making the construction process relatively fast.

2.2.2. Separation of pipelines and structures

Pipelines are set outside the structural system and buried in the cavity between the structure and surface layer.

2.2.3. Integrated customization of parts

The renovation parts are integrated and customized and produced in a factory. Through on-site measurement and data collection, various standard and non-standard parts are centrally produced in the factory.

2.3. Advantages of prefabricated construction

2.3.1. Reduction in material waste

By utilizing building information modelling to simulate construction scenarios during the design stage, material waste can be reduced from the outset. Prefabricated parts and components are industrialized and produced in factories, eliminating the need for on-site processing and ensuring that all materials are utilized with minimal waste during construction.

2.3.2. Reduced construction time

Traditional renovation methods require over 20 workers from different trades and a construction period of 30 to 40 days. In contrast, prefabricated construction technology only requires four workers and can be completed in six days, significantly reducing construction time.

2.3.3. Improved quality

All installed parts are quantitatively produced by factories, ensuring the quality and performance of each part. There is no need to rely on workers' experience and expertise to create the parts on site, and the use of wet construction methods is avoided, thus ensuring the overall construction quality from the parts to the final product.

2.3.4. Increased construction efficiency

Traditional construction requires over 20 construction procedures, including water and electricity installation, waterproofing, and tiling, which can be time-consuming and laborious. Prefabricated construction simplifies on-site construction procedures by centralizing production in factories, with installation being the only on-site process. In this way, construction efficiency can be improved significantly.

2.3.5. Health and environmental benefits

Prefabricated construction materials are selected based on their characteristics, such as waterproofing, fire resistance, and durability, and materials such as bamboo fiber and aluminum alloys that do not contain harmful chemical components are used. The use of chemical reagents like adhesives and glue is avoided by replacing them with joint assembly, thus significantly reducing the release of harmful gases such as formaldehyde. This ensures a clean, pollution-free, and noise-free construction environment that is safe, environmentally friendly, and healthy.

2.3.6. Convenient post-maintenance

In prefabricated construction, pipelines and the main structure are separated, and standardized parts and components are used, which are designed with post-replacement and maintenance in mind, making maintenance easier and more convenient.

2.3.7. Reduces resource waste in secondary renovation

Modular interior decoration is independent of the main structure, allowing for flexible and adaptable indoor spaces without generating waste or affecting the building's lifespan. In this way, the building's lifespan can be extended while accommodating different needs for different demographics.

2.3.8. Facilitates supervision

Due to the centralized and quantifiable production in factories, quality checks can be conducted throughout the production of parts and components, making the process transparent and easier to supervise. In this way,

the quality of the parts can be ensured compared to traditional methods that relies on manual labor.

3. Renovation ideas for existing buildings

Different from traditional decoration methods, prefabricated interior renovation can fully realize the design concept in the project. By analyzing the pain points in renovating existing buildings, the principles and ideas for modular interior decoration is more focused on synergy, new technology, and humanization.

3.1. High synergistic effect

Renovating existing buildings involves many issues, such as building structure, heating, water supply, electricity, air conditioning, and more, due to prolonged usage and mismatched user needs. The process of prefabricated interior renovation should be synchronous and coherent, with the user's needs and problems as the main concern. The data and details of the building that is to be renovated can be integrated into the building information modelling system, and the overall coordination in the design, production, and installation stages can be carried out, ensuring efficient and synchronous renovation.

3.2. New technology

Problems such as aging pipelines and reduced structural stability are prevalent in existing buildings. The old method of pipeline renewal and renovation through wall slots is no longer suitable. Protecting the stability and load capacity of the building structure is the focus of modular interior renovation. Therefore separating the wall and pipeline using new technologies can best protect the safety and stability of the existing building structure. Additionally, the high flexibility of construction technology can ensure easy maintenance and upgrading, thereby reducing costs.

3.3. Humanization

Since the buildings are going to be used for a long time, the changes in the users and their ages should be considered during renovation. The users who will occupy the room after renovation should be identified and reasonable adjustments should be made to the indoor space according to the needs of the users. In particular, for key indoor spaces such as bathrooms, kitchens, and bedrooms, intelligent and age-appropriate designs should be made to meet user needs.

Furthermore, indoor spaces should consider possible changes in personnel within the user's family over time, and prefabricated wall structures can be used to flexibly divide and combine spaces, ensuring that the renovation can meet user needs in the long term.

4. Applications of prefabrication technology

4.1. Wall engineering

Prefabricated walls are installed by first placing a framework of metal studs and tracks, and then embedding pipes and wires into the wall cavities. The cavities are then filled with rock wool or fiberglass insulation for soundproofing and fire resistance. Lastly, decorative panels are attached to the studs with connectors to complete the installation (**Figure 4**).

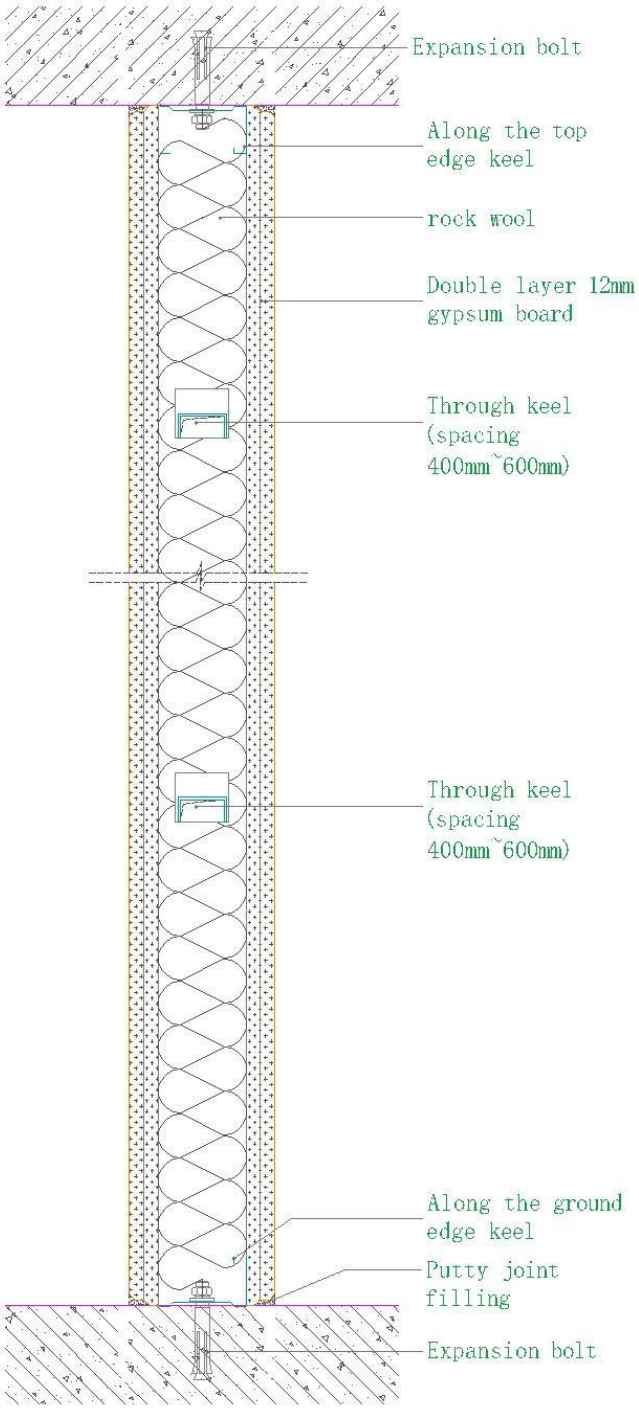

Figure 4. Prefabricated wall

Many wet construction procedures such as wall grooving, leveling, and wallpaper pasting can be eliminated through using prefabricated walls. Besides, environmental and noise pollution can also be reduced, and dry construction can reduce workload and improve construction quality. Prefabricated walls can also be quickly disassembled and modified in future upgrading and maintenance processes.

4.2. Ground engineering

In prefabricated floors, adjustable metal supports are used to suspend the base plate and form a suspended floor module. Then, insulation floor modules, underfloor heating pipe modules, followed by decorative

surface layers are installed (**Figure 5**).

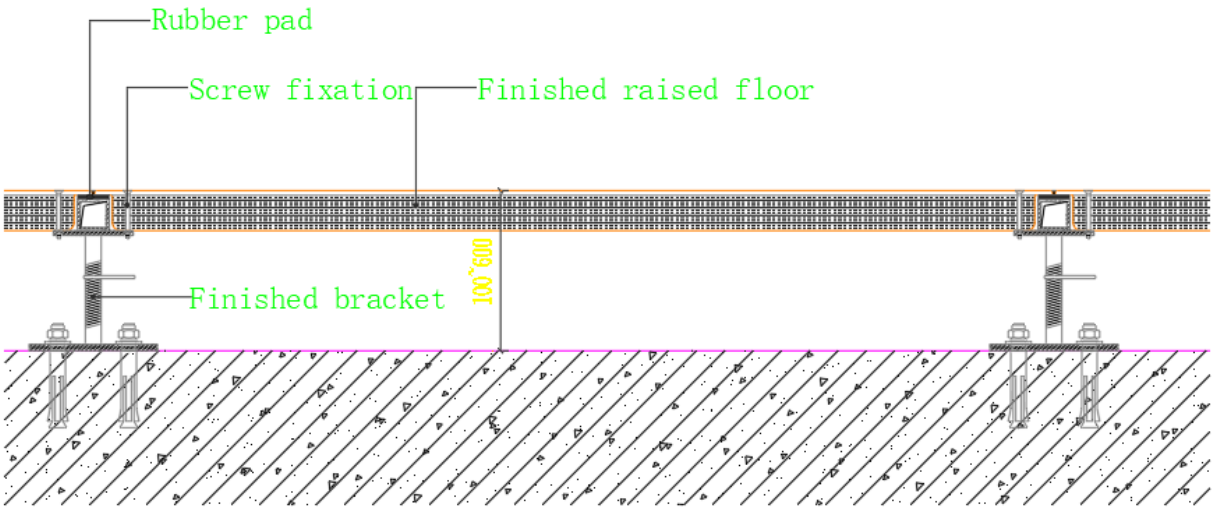

Figure 5. Prefabricated floor

Prefabricated floor systems can reduce traditional construction methods such as leveling and avoid wet construction. The height of the floor can also be controlled, and electrical and plumbing lines can be routed through the space formed by the raised floor, separating them from the original structure. The prefabricated floor system improves construction efficiency and quality, and also ensures the effectiveness of underfloor heating.

4.3. Integrated kitchen and bathroom

The integrated kitchen and bathroom system integrates the wall structure, materials, water and electricity pipelines, and furniture of the kitchen and bathroom through reasonable planning. The prefabricated components such as wall panels, floor panels, and cabinets produced in the factory are assembled through modular construction. In the construction of the integrated kitchen and bathroom system, an integrated waterproof base is made, and cabinets are mounted on the wall, and the pipeline structure is separated from the structure, resulting in good waterproof effect, easier maintenance and replacement, and improved efficiency of the kitchen and bathroom space.

5. Conclusion

Prefabricated interior renovation has the advantages of being environmentally friendly, high quality, efficient, flexible disassembly, and easier maintenance. Prefabricated interior renovation is an important part of industrialization and factory production in the construction industry. It has the ability to improve living quality, enhance the happiness and sense of achievement of users, and promote the sustainable development of buildings. However, prefabricated interior renovation still needs to be further studied and improved, and its application should be popularized.

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Analysis of Construction Technology for River Regulation and Bank Protection in Water Conservancy Projects

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Abstract: There are many problems and deficiencies in traditional bank protection methods, which cause certain damage to the ecological environment of river channels. Recently, the issues of river management, improving bank protection technology, formulating reasonable construction measures, and ensuring the smooth and efficient implementation of construction have been receiving increasing attention.

Keywords: Water conservancy engineering; River management; Bank protection; Construction technique

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1. Introduction

Construction technology for river regulation and bank protection in water conservancy projects effectively prevents the adverse effects of river regulation construction on the surrounding river landscape and ecological environment, maintain the balance between construction and the ecology, ensure the safety and quality of water conservancy construction, ensure the safety of people's lives and property, and provide more high-quality services for the people. In addition, this technology can enhance the sustainability of water storage and drainage and act as a water storage during floods and natural disasters. At the same time, water conservancies can be used for irrigation, therefore effectively safeguarding the interests of many.

Traditional measures of river management have had varying degrees of impact on the surrounding environment. Bank protection can effectively improve the overall appearance of the river, maintain the balance of its ecosystem, and achieve coordinated and unified development of water conservancy project and environmental protection to a large extent, thus fully leveraging the important role of this technology in preventing soil erosion and flood control and drainage. The use of scientific and reasonable bank protection technology can further optimize the protective effect on the river environment, achieve a harmonious development between humans and nature, and ensure the performance of water conservancy projects, and promote better and faster development of China's socio-economy.

There are a few principles of water conservancy engineering, river management, and bank protection construction technology management. (i) General principle: The management of water conservancies should be in line with the overall planning and development of the city; it is important to prioritize the natural function of the river channel and make sure that it is not damaged, and that it can operate normally during river management. It is necessary to fully understand the overall ecological function, water quality, ecological landscape, and so on of the river channel; safety should be emphasized in the activities that are

going to be carried out. (ii) The overall order of rivers should be the main aspect in river management. It is also necessary to maintain the continuous operation of natural resources while protecting them and try to avoid human traces. The best way to protect ecology is to not damage it, that is ensuring good plant growth, retaining more plants in the natural environment, thus laying a solid foundation for ecological restoration work. In this way, the original natural landscape and ecological safety can be retained. The primary goal is to restore the natural ecosystem of the river channel. (iii) In the process of river management, it is necessary to establish the core idea of being people-oriented, emphasize the harmony between humans and nature, and pay attention to the guiding role of the environment for humans. Creating a good ecological environment while creating a green environment that can broaden one's horizons can subtly affect people's emotions, improve their self-cultivation, and ensure a harmonious relationship between humans and nature.

2. Deficiencies in the technology for river regulation and bank protection in water conservancy projects

At present, there are certain shortcomings in river regulation and bank protection in water conservancy projects, and it is necessary to improve the flood control and drainage of rivers.

However, the technology used in river management in China is somewhat backwards, making it difficult to achieve ecological environment protection of rivers. At the same time, bank protection is not added to both sides of the river in some water conservancy projects, resulting in poor flood control capacity. In addition, the facilities of water conservancy projects are subjected to varying degrees of erosion due to various factors, therefore affecting their actual function and efficiency, causing frequent depressions and collapses in river channels. In this case, the water conservancy management department did not put in enough effort in maintaining the river environment, leading to an increasingly serious problem of water and soil loss. After a long period of overloaded operation of water conservancy engineering facilities, the rivers become increasingly blocked, leading to river erosion and affecting the natural form of the river, causing the entire river to lose its flood resistance and drainage function, posing a serious threat to people's lives and property safety.

3. River regulation and bank protection technologies in water conservancy projects

3.1. The technique of lifting and filling in hydraulic engineering

Firstly, the soil should be properly selected, and the mining work should be done well, and construction personnel need to pay more attention to the management of embankment construction. During the process of selecting a suitable soil, it is important to ensure that the soil has strong anti-seepage ability and try to obtain materials from nearer areas to save construction time. Construction personnel need to have a comprehensive understanding and mastery of the soil quality, moisture content, mining conditions, and other related information of the soil material. For example, if the soil embankment is uniform, sub clay or medium loam soil should be used, whereas for anti-seepage embankments, soil with high viscosity should be used.

When mining soil, construction personnel should thoroughly clean the surface of the soil and select the best mining method based on the actual situation, so that the quality of soil can be controlled and that its parameters meet the relevant requirements.

Secondly, construction personnel should clean embankment foundation properly so that the subsequent embankment filling process can be carried out smoothly. Usually, the surface of the embankment is cleaned and garbage in the surrounding areas are cleared up. After cleaning the embankment and filling the first layer, corresponding compaction and leveling construction will be carried out.

Thirdly, construction personnel need to conduct compaction tests before formally filling the embankment to ensure the accuracy of the obtained data and that the construction requirements for

compaction quality are met. The moisture content of soil materials needs to be well-controlled, which is usually between 1-3%. In addition, construction personnel should set corresponding signs during the construction process to prevent leakage and other issues during segmented filling. At the same time, when compacting anti-seepage soil materials, it is necessary to control the amount of water sprayed to improve the actual construction effect.

Fourthly, during the process of filling the embankment, construction personnel need to comprehensively analyze and understand the relevant precautions and take targeted measures to ensure a safe and smooth operation. For example, if unevenness occurs during the filling process, it is necessary to fill the embankment layer by layer and take appropriate measures. In addition, construction personnel cannot perform paving and filling operations on sloping slopes. In cases where the slope of the embankment cross-section is large, corresponding construction techniques should be performed to reduce the slope.

3.2. Bank protection technology

Firstly, construction personnel use slope protection that is made of impact resistant materials to achieve the effect of bank protection. The construction personnel need to ensure the safety, reliability, and stability of the revetment, select appropriate construction materials, and minimize the scouring of the revetment, so as to prevent serious abrasion, thus preventing riverbed deformation and ensuring the overall construction effect of the project.

Secondly, a revetment can be constructed to protect the river and embankment, solve the problems of river erosion, and effectively enhance their resistance to flood disasters. Usually, it mainly includes dam structures, which cut off the water flow from the offshore embankment in advance to prevent significant erosion of the water flow. This technology has its own unique advantages, which are especially applicable in areas with high river flow and wide riverbeds.

Thirdly, the plant slope protection method can be adopted to form a comprehensive lake system. After excavating the slope, the interaction between plants and soil is utilized to protect and reinforce the surface layer of the slope, which is not only helpful to the soil layer, but also restores the damaged natural environment. When using this method, it is necessary to consider the climate, soil quality, and other actual conditions of the area to select the best plants. Usually, it is necessary to ensure that the plants have strong cold and drought resistance, and it is common to use soil fixing plants with strong resistance and immunity. In addition, ensuring a well-developed root system during the growth of the plants can effectively reduce the probability of soil erosion and help improve the overall landscape and ecological environment of the river, ensuring the harmonious and unified development of engineering and ecological environment.

The fourth method of protecting riverbanks is by building a revetment wall, where the revetment wall is built on the embankment. The construction method of revetment walls is relatively special and requires a large amount of investment. It is generally used in projects that intersect urban houses, and it is effective in limited locations. The use of this technology in river regulation and bank protection can effectively reduce the cross-section of the bank protection. Construction personnel need to be proficient in relevant construction techniques and standards to ensure the stability of the bank protection and effectively enhance its impact resistance.

The last bank protection method is the pine pile method. The pine pile method involves using a variety of trees such as larch, red pine, or Yunnan pine to ensure the straightness of the trees. In general, the curvature of one side should be less than 1% of the installed length, and piles with curvature on both sides cannot be used. In addition, the log pile should not have problems like decay and insect infestation. Protruding parts such as the bark should be removed, the central axis of the installation should be marked, and the pile head should be cut flat. If the pines are prone to decay if this method is done in a dry environment. Therefore, it is necessary to apply asphalt to the area 0.5 m above and below the water level

to provide protection. In order to effectively improve the integrity of the wooden pile and the upper wall foundation, it is generally necessary to ensure that the pine pile can penetrate deeper than 0.2 m of the foundation length. At the same time, a 5 m thick concrete layer should be installed on the foundation of the upper wall to control the length of the wooden piles. If a certain bearing capacity is required, there should be no joints in the pile. If the wooden pile is long, a vibratory pile driver cannot be used for sinking, and each pile can only have one joint. It is also necessary to ensure that the height difference between adjacent pile joints at a distance of 2 m below the ground at the street should be controlled at least 0.75 m. When dealing with the foundation of pine piles, they can be vibrated by excavators. If the conditions of the construction site are limited, other compaction methods can be used for vibration, and the order of piling should be from outside to inside. If the overall development depth of the mud is large, support piles need to be placed outside of the area with the wooden piles to avoid mud collapse.

4. Conclusion

China attaches great importance to the technology of river regulation and bank protection in water conservancy projects, promoting the coordinated development of engineering and ecological environment, and maintaining the safety of people's lives and property. Therefore, construction personnel need to master the construction standards of embankment filling technology and bank protection technology to ensure the overall safety and quality of the project. In addition, construction personnel should continuously innovate and reform construction techniques, enhance their scientific rationality, and promote the improvement of river management in water conservancy projects in China.

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Before your submission, please check that your manuscript has been prepared in accordance to the step-by-step instructions for submitting a manuscript to our online submission system. We recommend that you keep this page open for your reference as you move through the submission process.

If there are any differences in author guidelines between the print and online version, it is recommended that authors refer to the online version for use.

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Journal of World Architecture accepts manuscript that is in MS Word or LaTeX format. All manuscripts must be written in clear, comprehensible English. Both American and British English are acceptable. Usage of non-English words should be kept to a minimum and all must be italicized (except for e.g. and i.e.) If you have concerns about the level of English in your submission, please ensure that it is proofread before submission by a native English speaker or a scientific editing service.

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All submissions for *Journal of World Architecture* should include a cover letter as a separate file. A cover letter should contain a brief explanation of what was previously known, the conceptual advancement with the findings and its significance to broad readership. The cover letter is confidential and will be read only by the editors. It will not be seen by reviewers.

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The title should capture the conceptual significance for a broad audience. The title should not be more than 50 words and should be able to give readers an overall view of the paper's significance. Titles should avoid using uncommon jargons, abbreviations and punctuation.

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Articles must include an abstract containing a maximum of 200 words. The purpose of abstract is to provide sufficient information for a reader to choose either to proceed to the full text of the article. After the abstract, please give 3-8 key words; please avoid using the same words as those already used in the title.

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Please number all section headings, subheadings and sub-subheadings. Use boldface to identify major headings (e.g. **1**, **2**, **3**, etc.) and subheadings (e.g. **1.1**, **1.2**, **2.1**, **2.2** etc.) For the sub-subheadings, please distinguish it further using non-boldface numbers in parenthesis (e.g. (1), (2), (3), etc.)

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Introduction should provide a background that gives a broad readership an overall outlook of the field and the research performed. It tackles a problem and states its important regarding with the significance of the study. Introduction can conclude with a brief statement of the aim of the work and a comment about whether that aim was achieved.

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This section can be divided into subheadings. This section focuses on the results of the experiments performed.

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This section should provide the significance of the results and identify the impact of the research in a broader context. It should not be redundant or similar to the content of the results section.

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All authors are required to declare all activities that have the potential to be deemed as a source of competing interest in relations to their submitted manuscript. Examples of such activities could include personal or work-related relationships, events, etc. Authors who have nothing to declare are encouraged to add "No conflict of interest was reported by all authors" in this section.

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Authors should declare all financial and non-financial support that have the potential to be deemed as a source of competing interest in relations to their submitted manuscript in this section. Financial supports are generally in the form of grants, royalties, consulting fees and more. Examples of non-financial support could include the following: externally-supplied equipments/biological sources, writing assistance, administrative support, contributions from non-authors etc.

Appendix

This section is optional and is for all materials (e.g. advanced technical details) that has been excluded from the main text but remain essential to readers in understanding the manuscripts. This section is

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Reference citations in the text should be numbered consecutively in superscript square brackets. Some examples:

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Journal

Journal article (print) with one to three authors

[1] Yao Y., Xia B. Application of Phase Frequency Feature Group Delay Algorithm in Database Differential Access. Computer Simulation, 2014, 31(12): 238-241.

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[2] Gamelin F.X., Baquet G., Berthoin S., et al. Effect of high intensity intermittent training on heart rate variability in prepubescent children. European Journal of Applied Physiology, 2009, 105: 731–738.

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[3] Jackson D., Firtko A., Edenborough M. Personal resilience as a strategy for surviving and thriving in the face of workplace adversity: a literature review. Journal of Advanced Nursing, 2009, 60(1): 1–9,

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Book

Book with one to three authors

[5] Schneider Z., Whitehead D., Elliott D. Nursing and midwifery research: methods and appraisal for evidence-based practice. 3rd edn. 2009, Elsevier Australia, Marrickville, NSW.

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No author

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4. The text is single-spaced; uses a 12-point font; employs italics, rather than underlining (except with URL addresses); and all illustrations, figures, and tables are placed within the text at the appropriate points, rather than at the end.

5. The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines, which is found in About the Journal.

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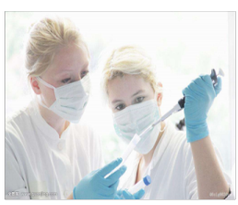
Cooperation Mode

Clinical Workers

In-service Doctors



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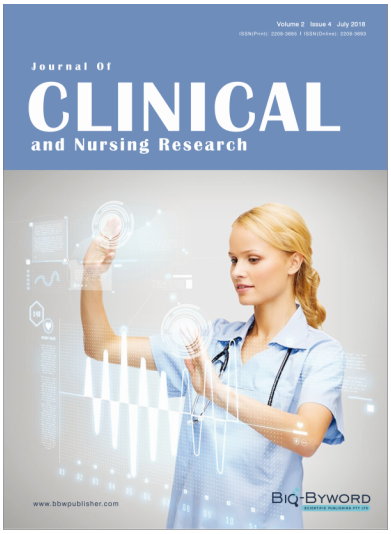

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