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Research Article

Application Strategy of Carbon Fiber Composite Materials in Bridge Reconstruction Project

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Abstract: Initially, the materials used in the process of bridge construction were mainly wood, stone, etc., and gradually the concrete, steel and other types of special materials currently in-use were developed. With the current vigorous development of science, technology and social economy in China, the development of bridge projects has also been accelerated to a large extent. In recent years, China has not only studied on how to strengthen the performance of concrete, steel and other materials in bridge projects, but also the performance of the recently developed smart, nano-, fibrous and other types of materials. This paper focuses on the application strategy of carbon fiber composite materials in bridge reconstruction projects to serve as a reference.

Keywords: Carbon fiber; Composite material; Bridge reconstruction

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1 Introduction

As far as carbon fiber composite material is concerned, it is a new type of fiber material with high performance, and has application properties in terms of acid and alkali resistance, corrosion resistance, and electrical and thermal conductivity. On the whole, it has very broad development prospects. It is widely used in the fields of automobile, chemical industry, machinery, etc., especially showing excellent application effects in bridge projects. Based on carbon fiber composite materials, this paper analyzes its application strategies in bridge reconstruction projects, showing certain practical research significance.

2 Overview of Carbon Fiber Composites

The so-called carbon fiber is produced by a series of heat treatment conversion of the original organic fiber. Among them, the inorganic high-performance fiber with carbon content higher than 90% is a new type of material with certain application advantages developed in the current mechanical performance research. On the one hand, it has the inherent characteristics of the carbon material itself; on the other hand, it also has the soft and processable characteristics of the textile fiber, which is the most recent reinforcing fiber being developed.

3 Application Strategy of Carbon Fiber Composite Materials in Bridge Reconstruction Projects

3.1 Bridge Construction

The application of carbon fiber composite materials in bridge construction mainly refers to the production of carbon fiber composite materials into strands and rods, and then mixing them with steel bars for use. Carbon fiber composite materials can also directly replace the steel bars. Therefore, it plays a role in strengthening the concrete structure in bridge projects. The advantages of carbon fiber composite materials in terms of corrosion resistance and alkali resistance stand out when they are applied in concrete. Anger will corrode the metals, which will affect the lifespan of bridges. In the early 1990s, carbon fiber composite materials were made into strands and used in the

construction of post-tensioned pre-stressed concrete high-speed bridges for the first time in Germany, where a wedge-shaped system was adopted to anchor the bridge[1]. Overall, the application of carbon fiber composite materials in bridge construction, especially the production of strands and rods for use in bridge pre-stressed tendons and external tendons, provides a good basis for the application of this material in cable materials for larger-span bridge projects in the future.

3.2 Cables of Cable-stayed Bridge

When the cable-stayed bridge is in use, the main reason for the damage of the cables and slings is the corrosion of the components. As far as the engineering properties of cable-stayed bridges are concerned, the requirements for material fatigue and corrosion resistance are relatively high, and carbon fiber composite materials have good performance in corrosion resistance and fatigue resistance. Under such research background, some scholars have made carbon fiber composite materials into cable and sling materials used in cable-stayed bridges. For example, the Winterthern Storchenbrucke Bridge in Switzerland was partially constructed with carbon fiber composite materials. On the whole, the cable-stayed part of the bridge was made of 2 carbon fiber composite bars, and each cable was assembled from 241 of 5mm carbon fiber composite tendons. With the vigorous development and progress of science and technology in the current era, the performance of carbon fiber composite materials in bridge projects will also be greatly improved, and it can further reduce the investment in cost at the same time. The strength of materials such as cables and slings incorporated with carbon fiber composites will also be improved.

3.3 Bridge Reinforcement

For the application of carbon fiber composite materials in bridge reinforcement, it specifically refers to the use of resin materials to bind carbon fiber composite materials to the surface of the bridge structure or bridge components. In this way, the structural part becomes a composite. The purpose is to promote the existing reinforced concrete and carbon fiber in the bridge to form a bearing surface, so as to further strengthen the bending and shearing capacity of the bridge project structure.

The reinforcement of carbon fiber composite materials can be divided into two types, one is reinforcement by carbon fiber cloth; and the other is reinforcement by carbon fiber board[2]. For the reinforcement in bridge projects, carbon fiber cloth is mainly used, and it has the following advantages:

First, it has very prominent reinforcement effects. Through epoxy resin, the carbon fiber cloth and the reinforced concrete components are bonded together to promote the cooperation between the two, thereby increasing the strength of the bridge. Meanwhile, the bearing capacity of the concrete structure and components in the bridge will also increase to a certain extent, thereby exerting functions on repair and reinforcement.

Secondly, it has the anticorrosion effects against acid, alkali and other media. Carbon fiber cloth is used in the reinforcement of bridges. During this period, the epoxy resin material is needed while other types of metallic materials are not required, so there will be no rusting issues and no need for carrying out regular rust prevention and maintenance of the bridge with the sticking steel method. This is especially suitable for the reinforcement of components where the bridge is located in a relatively harsh environment, especially in coastal areas and areas with relatively high air humidity.

Thirdly, it has the advantages of convenient and quick construction. As far as the nature of carbon fiber cloth itself is concerned, it has the characteristics of relatively low density, relatively light-weight, and good flexibility. It is used in the reinforcement of bridge projects, and the size is tailored according to engineering requirements, with very strong operability. During the construction period, small electric tools can be used to carry out the corresponding operation and construction, with no need of using large machinery and equipment, and no need of installing fixed facilities on the construction site. The occupied area is relatively small, and the requirements for the spatial environment of the operation are relatively low. In addition, the processing speed is also very fast. Compared with the sticking steel reinforcement construction, the reinforcement effect of carbon fiber is between 4 times and 8 times greater.

Fourthly, it can ensure that the original bridge structure is not altered and improve the aesthetics of the bridge. This part of advantage is not only reflected in the multi-layer carbon fiber cloth binding on the original surface of the bridge structure, but

also the ability to tailor and bind the carbon fiber cloth according to the bridge components, and these operations will not alter the original bridge structure. Meanwhile, the ornamentality of the bridge and the safety and reliability in actual operation can be further enhanced through decorative coatings, fireproof materials and other drawing operations on the outer layer of the bridge[3]. In addition to the above, as the carbon fiber material itself has the characteristics of light-weight and thinness, its thickness is only about 1mm after a single-layer carbon fiber cloth binding and the unit area weight after binding does not exceed 1.0kg, where this part of the weight includes the resin material. Based on the above, after the completion of the construction work, there will be no excess mass and system for the bridge components; in addition, the bolts do not need to be anchored in the epoxy resin binding process, so there will be no new damage to the original structure of the bridge, and multi-layer carbon fiber cloth binding can be carried out according to the stress of the bridge.

Fifthly, in addition to the above advantages, the cracks in the closed concrete structure of the bridge can be treated accordingly to help further extend the service life of the concrete structure; in addition, in the process of strengthening the bridge, carbon fiber composite materials have the characteristics of relatively simple operation, relatively short construction time, and also great flexibility. It can be used for various types of bridge reinforcement and repair operations without being restricted by factors such as component structure type, shape, and construction location. Meanwhile, this is also an advantage that many current structural reinforcement methods cannot match.

Regarding the application principle of carbon fiber cloth in bridge reinforcement construction, specifically, with the help of external force, the adhesives can concentrate the strength of the carbon fiber threads itself to promote the carbon fiber threads into forming a collective force in the carbon fiber cloth, thereby exerting a binding force on the core concrete, which can play a role in avoiding the yielding of the main reinforcement, further strengthen the bearing capacity of the reinforced concrete in the bridge, and play a role in strengthening the bridge.

4 Conclusion

In summary, the application of carbon fiber composite materials in bridge reconstruction projects can reduce the cost of reconstruction and has good application effects, and it is also the first choice for bridge reconstruction and construction; whereas the use of carbon fiber composite metals as the tendons in the pre-stressed concrete of the bridge, the cable or sling in the cable-stayed bridge, etc., can maximize the application characteristics of the materials, thereby reducing the proportion of steel in the bridge projects, continuously improving the application comparison of carbon fiber composite materials, which is of positive significance for the healthy development of China's bridge industry.

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Journal of Architectural Research and Development

Research Article

Analysis of Detection and Treatment Schemes of Highway Tunnel Lining Cracks

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Abstract: Highway tunnels play a very important role in people's daily life. Among them, lining is an essential part of tunnel engineering, and the quality of lining greatly affects the overall quality of the tunnel. On this basis, the causes of lining cracks and the detection methods of existing highway tunnel lining cracks are analyzed, and the treatment countermeasures for highway tunnel lining cracks are proposed.

Keywords: Highway tunnel; Lining; Crack detection; Treatment

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1 Introduction

With the continuous development of society and economy, the transportation system plays an increasingly important role in economic development, and the construction of tunnels also plays a very important role. Tunnel cracks are the most common disease in tunnels and in turn, the cause of other tunnel diseases. Therefore, strengthening the maintenance of tunnel cracks becomes more and more important. The application of tunnel automatic detection technology in China is mainly focused on the detection of road pavement cracks, while the automatic detection of highway tunnel lining is still in its infancy[1]. The types of tunnel lining commonly used today include anchor spraying, assembly, composites and concrete. The construction company selects the appropriate lining form according to the specific needs of the project to ensure the quality of the highway tunnel. Regardless of the type of lining, due to the influence of natural and human factors, long-term use of highway tunnels will inevitably lead to certain crack quality problems. If appropriate detection methods can be used to determine the impacts of diseases and seek for scientific solutions, the operation of road tunnels can be better secured by finding appropriate methods to eliminate defects in tunnel projects.

2 Treatment Principles

2.1 The Principle of Adaptability

When dealing with cracks in highway tunnel linings, the principle of adaptability should be adhered to. In other words, starting from the cause of cracking, the corresponding treatment plan must be formulated according to the actual detection of the lining crack. In crack treatment, we first use special tools to detect lining cracks, and comprehensively analyze the length, depth and characteristics of the cracks to provide reliable data support for future crack treatment plans[2].

2.2 The Principle of Technology

When dealing with road tunnel lining cracks, relevant personnel should adopt corresponding treatment techniques so that the tunnel lining cracks will not cause new risks during the cracking process. Meanwhile, the quality of the repaired tunnel can meet relevant standards to ensure the overall quality.

2.3 The Principle of Research

Before dealing with cracks in the lining of road

tunnels, the crack treatment area must be checked to prevent errors and leaks and to ensure the quality of tunnel crack treatment.

2.4 The Principle of Preparation

After dealing with the cracks in the lining of each highway tunnel, the relevant personnel must organize and collect data, improve the corresponding tunnel files, and provide strong data support for the treatment of cracks in the highway tunnel lining.

3 Analysis on the Causes of Lining Cracks

Comprehensive analysis of the causes of cracks in highway tunnels. First of all, several cracks with different crack shapes appeared on the side wall of the tunnel end. Combined with the construction technology and the actual crack size, the judgment is directly related to the concrete mix ratio. The inspection of the concrete structure showed that the thickness of the upper concrete structure did not meet the original design requirements. According to statistics, most of the cracks in the tunnel section appear on the sidewall of the tunnel section and have irregular shapes. Analysis shows that the problem is mainly caused by stressless deformation caused by unreasonable concrete mix ratio. Some of the cracks appear at the top. Tests show that the safe has a lot of space, and part of the lining does not reach the thickness required by the design. It is assumed that the construction process is not standardized. At the same time, due to the small ascension span of the entire tunnel project and the relatively shallow depth of the surrounding rocks, the secondary lining will face greater environmental rock pressure in the vertical direction, and other reinforcements, leakage prevention and earthquakes measures were not considered in the design process[3]. The stressless deformation of the loaded tunnel bolts causes the lining to crack in the tunnel structure. Meanwhile, the secondary and tertiary stresses of the surrounding rocks bear greater pressure, and the technical problems of construction support and leak-proof construction are concentrated, and local stress and water pressure are too large, causing cracks in the highway tunnel lining. Meanwhile, it was found that the thicker part of the secondary lining has more cracks and the thinner part has fewer cracks. Through comparative analysis, it can be determined that the thermal stress and shrinkage stress of mass concrete caused by the heat of hydration have a direct impact on the occurrence of cracks.

4 Non-destructive Testing Method for Cracks

4.1 Spectroscopic Analysis Technology

The principle of spectroscopy technology is similar to the traditional tapping method, which uses tapping instruments to determine whether there are cracks in the original tunnel structure in the building. However, unlike traditional percussion instrument methods, the accuracy and detection efficiency of spectroscopic analysis technology are more ideal, and the original tunnel structure will not be damaged twice during the detection process. Spectroscopic detection technology mainly uses the propagation speed of sound waves in different media and analyzes the propagation speed to deduce the actual situation of the detected object. The advantages of this technology are fast detection speed and wide application range, but in the early stage of application of this technology, construction personnel must prepare for the installation of the sensor[4].

4.2 Imaging Technology

Infrared imaging and laser holographic imaging are the most commonly used imaging techniques in the detection of tunnel lining cracks. Among them, the main principle of infrared imaging is using the corresponding heat released by molecules in the process of change. Therefore, there are certain differences in the heat emitted by substances with different structures. The construction staff can use the corresponding infrared detection equipment to analyze the temperature of the tunnel structure surface to determine whether there are cracks and damages inside the tunnel structure.

4.3 Ground-Penetrating Radar

Radar waves are mainly generated by the excitation of the equipment itself. Staffs use the device to transmit electromagnetic waves to the measured area, and obtain sampling signals from the road surface by reflecting and receiving electromagnetic waves. Meanwhile, the corresponding software, hardware and graphic display system conversion are performed on the collected sampling signals, and the detection results are analyzed. In this technology, the radar pulse can detect the difference of the underground medium in the detection area during the propagation process. Some radar pulses are reflected off the

detection area to receive information, while the other one is used to receive media signals from the detection area.

4.4 Ultrasonic Technology

The application of ultrasonic technology in highway engineering is mainly to transmit ultrasonic waves to structures in specific areas, and then the personnel use ultrasound receiving equipment to compare the received parameters with standard parameters to achieve the purpose of structural quality inspection of road and bridge constructions. This technology uses sound waves to detect defects and problems in the object to be tested and meets the requirements of non-destructive testing technology. However, this technology has certain professional difficulties.

5 Tunnel Crack Treatment Scheme

5.1 Seamless Drainage System

Construction joints are a common part of leakage and seepage, and some cracks will also leak. Therefore, it is necessary to install Yas half-pipes for permanent drainage according to the actual conditions of the surrounding rocks before treatment. During the construction process, in order to meet the requirements for various forms of cracks on the surface of the surrounding rocks and prevent the blockage caused by the direct inflow of the surrounding rock sediments, the groundwater was sealed outside the tunnel, and then the water left in the ditches on both sides of the tunnel is used for the pipes. Drain from the outside.

5.2 Concrete Mix Ratio Design Optimization

In order to improve the impermeability of concrete, air-entraining agents are usually used to improve the pore structure of the concrete, block the infiltration channels and increase the density of concrete and self-compressive concrete. Meanwhile, the water-cement ratio of concrete should not be too high. In the construction process, the main method is to reduce the weak links of concrete pouring and ensure the quality of continuous concrete pouring.

5.3 Grouting Treatment of Lining Cavity

There should be a certain distance of PVC grouting holes on the bolts, and the grouting holes should protrude from the inner edge of the bushing to facilitate the connection with the grouting pipe. In special areas, grouting pipes that can be held along the circumferential direction can be installed in the construction joints to fill the lining cavity when concrete is poured after lining. Meanwhile, in order to prevent the arch back cavity from protruding stress, structural cracking, damage and leakage, the arch back should be grouted in time as soon as the secondary lining strength reaches the design strength, so that the initial support is tightly combined with the waterproof board and the secondary lining.

5.4 Crack Treatment

Reinforce the exterior of the cave. As far as project cracks are concerned, lining cracks are closely related to the natural environment of the external slope of the cave. To this end, the construction company has formulated a plan to strengthen the exterior slope of the tunnel to minimize the occurrence of shallow slip at the tunnel exit, ensure the stability of the slope soil, prevent further lining cracks, and strengthen the tunnel lining. According to the project technical requirements and the actual causes of the cracks, the construction engineers adopted comprehensive reinforcement measures for the anchor piles and anchor cable frame beams to reduce the possibility of landslides.

Strengthen the tunnel lining. Use mortar bolt plum reinforcement method, and add steel plate at the end of the bolt. In the lining reinforcement treatment, the anchor rod is constructed first, and then the backfill grouting is performed immediately. After solving the crack problem, check again after half a year, and the crack will not grow. If there is no new crack problem, the corresponding processing data can be classified and saved.

6 Conclusions

In conclusion, the detection and treatment of cracks in the highway tunnel lining is a necessary means to prolong the life of the highway tunnel and improve the safety and stability of the highway tunnel.

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Research Article

Study on the Installation and Construction Technology of the Transfer Stairway on the Track Platform on Bridge——Taking the Construction of the Jialing River Bridge in Zengjiayan of Chongqing City as an Example

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Abstract: The bridge deck on the Yuzhong side of Zengjiayan Jialing River Bridge is close to subway lines and light rail stations. It is necessary to set up transfer stairways on both sides of the bridge. The construction technology of installing and replacing with tunnel under special conditions is discussed to provide reference for bridge construction.

Keywords: Track platform on bridge; Transfer stairway; Bridge construction

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1 Introduction

The Zengjiayan Jialing River Bridge in Chongqing is a cross-river passage of the Zengjiayan Bridge Project and Track Line 10, located between the Huanghuayuan Bridge and the Jialing River Bridge. The upper part of the lower deck on the Yuzhong side of the Zengjiayan Jialing River Bridge is Metro Line 10 and its station, and the lower deck is the light rail station of Line 2 that crosses spatially. In order to secure the pedestrian transfer from the subway station to the light rail station, transfer stairways are constructed on both sides of the bridge. The platform section of the transfer stairway adopts a box-shaped section, with a beam height of 0.9m and a width of 3.5m. The transfer stairway on each side of the bridge consists of three segments, which are supported on the concrete corbel on the pier and the steel corbel on the main truss respectively. The steel corbels were installed on the lower chord respectively.

2 Construction Requirements

The bridge installation of this project has the following characteristics: the coordination of the bridge and the river is required, and the construction of the 3D crossing. The construction environment is poor and the hoisting space is limited. High-altitude operations require high level of coordination between operators and cranes. The structural size of the components is large, the hoist load is heavy, the components are eccentric, and the hoisting requirements are high. The hoisting space is limited, and the main boom of the crane needs to pass through the stiffened suspension. The transfer stairway is located directly below the upper sidewalk and could not be directly hoisted in place, and must be dragged and installed horizontally. Two cranes were used to carry out the hoisting installation, and the requirements for hoisting command and hoisting technology are high. Across the Jialing River, navigation under the bridge requires high level of safety and environmental protection. It is located in a high-density residential area and the surrounding environment is complex, such as the highway along the river under the bridge.

Project construction requirements: All steel stairways must meet the design requirements before leaving the factory, and unqualified steel components are strictly prohibited from being transported to the construction site. The equipment

used for the installation of the stairway platform shall have a certificate of conformity, and the operation shall strictly comply with the requirements of safe production. The protection of the platform edge must be carried out simultaneously during its operation, and it must meet the requirements of current construction regulations and mandatory safety standards. The project leadership system must be strictly implemented during the whole construction process of the stairway platform. Carry out full inspection of the equipment before hoisting operations, and strictly implement the inspection and log system. When hoisting heavy objects with two cranes, the weight allocated to a single crane shall not exceed 80% of the allowable hoisting capacity of the crane, and the total weight of the components shall not exceed 75% of the sum of the rated hoisting capacity of the two cranes, and unified command is required. The method of hoisting equipment or components to target position by two cranes: When hoisting, conduct a trial hoisting first, so that the operators coordinate with each other in actions and keep the operating speed of the cranes as unified as possible. The hoists are directed by experts, and at the same time, ensure the smooth communication of the hoisting and the upper and lower level of operations. All special operation personnel must be licensed to work. Strictly implement the three-level technical disclosure and annotation, and all operators must be trained and qualified before they can work.

3 Construction Technology

3.1 Construction Preparation

130t truck crane machineries and other small machineries were organized to enter the site. Enter the site with corbels installation operating platform components, construction labor protection supplies, life-saving supplies and other materials. Before construction, the Corbel 3 and Corbel 4 should be installed on the support, and the elevation should be re-measured. Water and electricity supply on site should meet the construction requirements. Before the components were brought to the site, trials of components hoisting were conducted in the processing plant. The same spreader slings to be used on site were used in the trials. Check that the components were hoisted smoothly and are safe and reliable before conducting construction on site. Various quality certificates of the products were collected and checked in time. The transfer stairway needs to be constructed in segments, as shown in Figure 1.

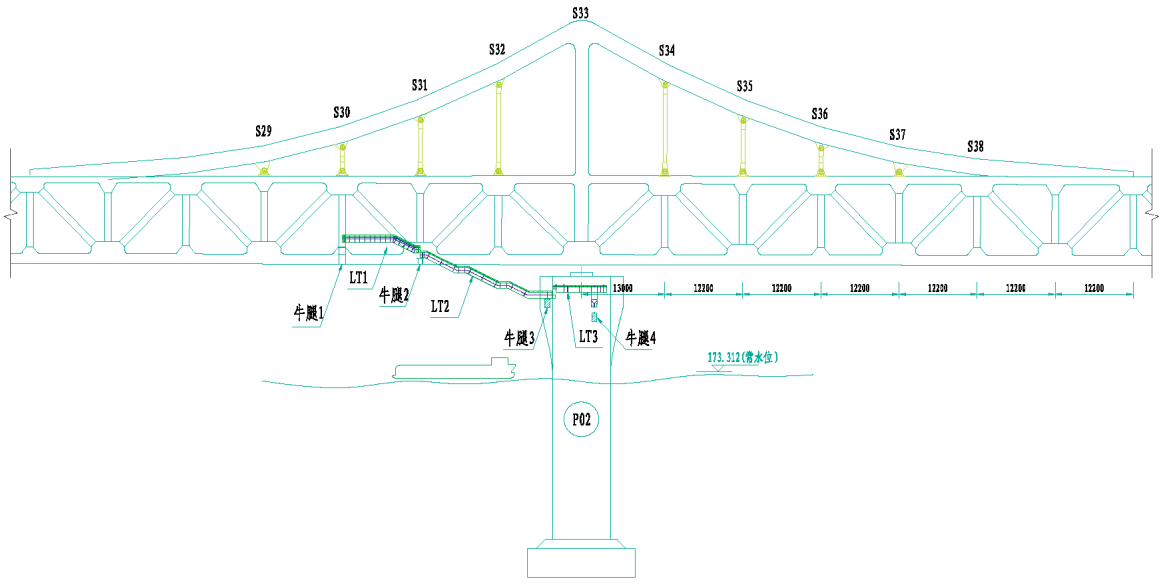

Figure 1. Segmental Diagram of the Transfer Stairway

3.2 Operation Platform

The under-bridge inspection trolley was used as the operating platform for personnel to go up and down and assist with the installation. Meanwhile, a section steel pylon was put up on the steel corbel after installation, which served as a platform for later-stage stairway parallel-shifting personnel to suspend guiding chains and assist with operations. Personnel operated from the top of the pier onto the corbel. Meanwhile, a protective railing was installed around the concrete corbel. When installing Stairway 3, the personnel on one side stood on the installed Stairway 2 to assist with installation. After Stairway 3 had been roughly positioned, the hoisting point was not removed, and the personnel walked through Stairway 3 to the position on Corbel 2, and then suspended a steel bar hanging frame on the concrete Corbel 2 as a personnel manipulation platform for precise positioning. Stairway 1 was put up on the lower bridge deck with suspension points, and the guiding chain was used to drag the platform into position. The steel bars embedded in the concrete corbel were used as the anti-pull points on Stairway 2, and the guiding chain was suspended for horizontal dragging.

3.3 Corbel Installation

The manufacturing of corbels and stairway unit components (segments) was completed in the factory. The segment of Stairway 2 was assembled from the original two segments into one in the factory. The bridge was hoisted in whole segments, and steel transfer stairway platforms were put up on both the upstream and downstream sides of the steel truss beam. The construction of the steel stairway on the upstream side was carried out first, and the construction of the steel stairway on the downstream side was carried out after the upstream side construction had been completed. The corresponding components were transported on transport ship to directly below the bridge installation site via the Jialing River, and the transport ship was anchored after reaching the assigned position. The corbel was hoisted and installed by a single 130t crane. The 130t machinery carried out hoisting on the upper bridge deck and the wire rope was passed through the top of the stiffened suspension cable. The hoisting distance was 10 meters, the rated hoisting weight was 30t, and the corbel weight was 1.6t, fulfilling hoisting requirements. After the corbel was installed, a rubber pad was installed on the corbel and its top surface was measured. The top surface of the corbel is required to be flush and the elevation met the design requirements[1]. Figure 2 illustrates the hoisting installation of the corbel.

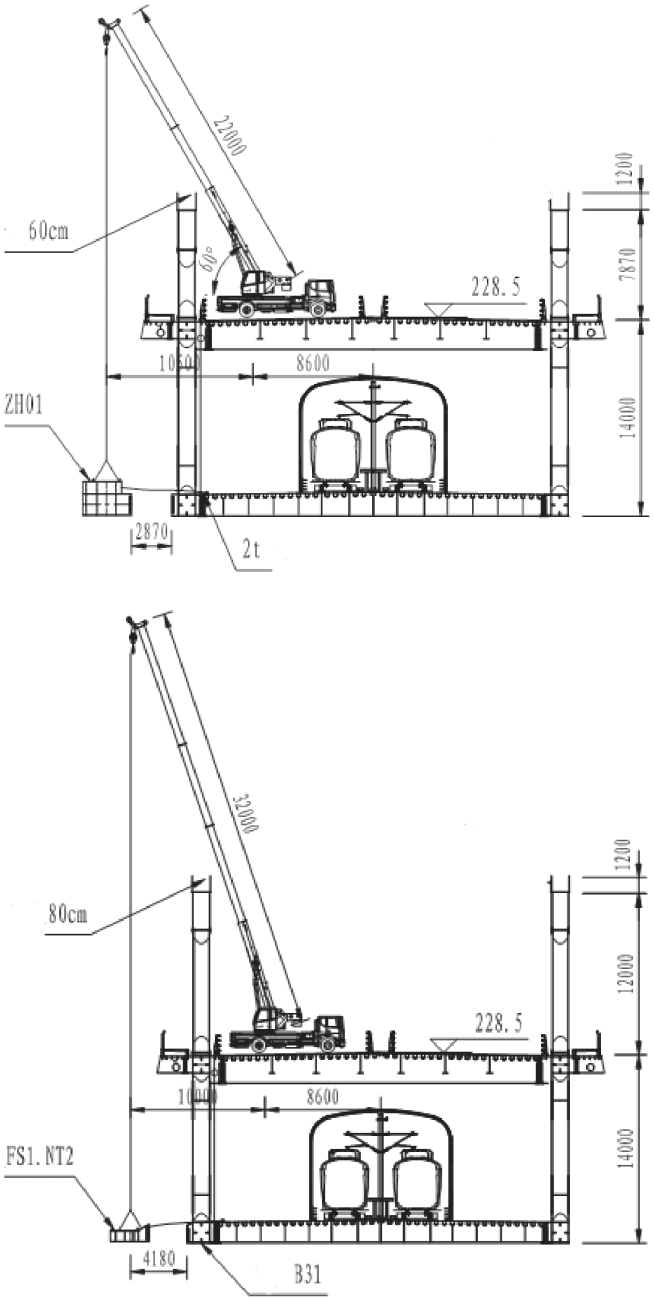

Figure 2. Schematic Diagrams of the Hoisting Installation of the Corbels.

3.4 Stairway 2 Hoisting Installation

The Stairway 2 was hoisted and installed by two 130t cranes, the center of Crane 1 was aligned with S31, the center of Crane 2 was 7.5m from the upper S32 node, and the center of the hoisting point was

8.6m from the center line of the bridge deck. The installation of Stairway 2: the hoisting distance of Crane 1 was 11.5 meters, the rated hoisting weight was 31t, and the hoisting weight was 22t (pulling separation taken into consideration), which meets the hoisting requirements. Stairway 2 has the heaviest weight and the largest structural size, making it difficult to install. In order to prevent the installation of Stairway 2 from colliding with other stairways, Stairway 2 was installed first. The rod components were transported directly below the installation site on barge. When hoisting, Crane 1 started hoisting first and shifted into the installing conformation, then the two cranes carried out hoisting in tandem. During the hoisting process, Crane 2 gradually raised the arm to adjust the posture. When hoisting, a sliding rope must be used for the components to avoid rotation of the components during hoisting. After hoisting to a slightly higher height than the installation height, on the steel corbel side of Stairway 2, lifting lug was welded on the bridge deck as anchor point for dragging components. On the concrete corbel side of Stairway 2, using embedded bars as anchor points for dragging, the components were dragged horizontally to right above the corbel with the 10t guiding chain, lowered to the corresponding position, and then lowered and fixed in place. On the steel corbel side of Stairway 2, the construction workers allocated on the lower chord rod components of the side stringer dragged and positioned Stairway 1, and then unhooked the lugs after the installations were in place. On the concrete corbel side of Stairway 2, the construction workers climbed down the stairway through the steel beam to the concrete corbel to carry out construction work.

3.5 Stairway 1 Hoisting Installation

Stairway 1 was installed by two 130t cranes. The center of Crane 1 was aligned with S30, the center of crane 2 was aligned with upper S31, and the center of hoisting point was 8.6m from the center line of the bridge deck. The main booms of the crane all passed through the top of the rigid suspension cable. The maximum hoisting distance of crane 1 was 12.1 meters, the rated hoisting weight was 37t, and the hoisting weight was 4.9t (pulling separation taken into consideration), which meets the hoisting requirements. Crane 2 has a maximum hoisting distance of 11.5 meters, a rated hoisting weight of 29t, and a hoisting weight of 4.8t (pulling separation taken into consideration), which meets the requirements of hoisting. The rod components were transported directly below the installation site on barge.

Crane 1 started hoisting first and shifted into the installing conformation, then the two cranes worked in tandem. When hoisting, a sliding rope must be used for the components to avoid rotation of the components during hoisting. After the hoisting was slightly higher than the installation height, lifting lugs were welded on the bridge deck as anchor points for the component dragging. The components were dragged horizontally with a 10t guiding chain to right above the corbel and lowered to the corresponding positions, and then lowered and fixed in place. The construction workers allocated on the lower chord rod components of the side stringer dragged and positioned Stairway 1, and removed the lugs after the installation was in place[2]. Figure 3 illustrates the hoisting installation of a stairway.

3.6 Stairway 3 Hoisting Installation

Stairway 3 was installed by a 130t crane, the center of the crane was 9.56m from the S32 node, and the center of the hoisting point was 8.6m from the center line of the bridge deck. The main boom of the crane was 32m long, passing through the lower part of the rigid suspension cable. The net distance of the rigid suspension cable boom of the lifting section was 0.7m, and the hoisting installation main boom m was 3m away from the rigid suspension cable. Installation of Stairway 3: the maximum hoisting distance of the crane was 14.4 meters, the rated hoisting weight was 27t, and the hoisting weight was 8t (pulling separation taken into consideration), which meets the hoisting requirements.

The rod components were transported directly below the installation site on barge. Long and short wire ropes were installed, where the long wire ropes were about 7m long and the short wire ropes were about 5.5m long. Trial hoisting was carried out to adjust the installing conformation. After the overall hoisting was slightly higher than the installation height, the main boom was raised directly above the installation position on Stairway 3. After the components were lowered to the corresponding positions, they were fixed in place. A sliding rope must be used for the components to avoid rotation of the components during hoisting. Construction workers

used steel beams to climb down the stairway to the concrete corbel for dragging and positioning, and after installation is in place, unhooking was carried out[3]. Figure 3 illustrates the hoisting installation of the Stairway 3.

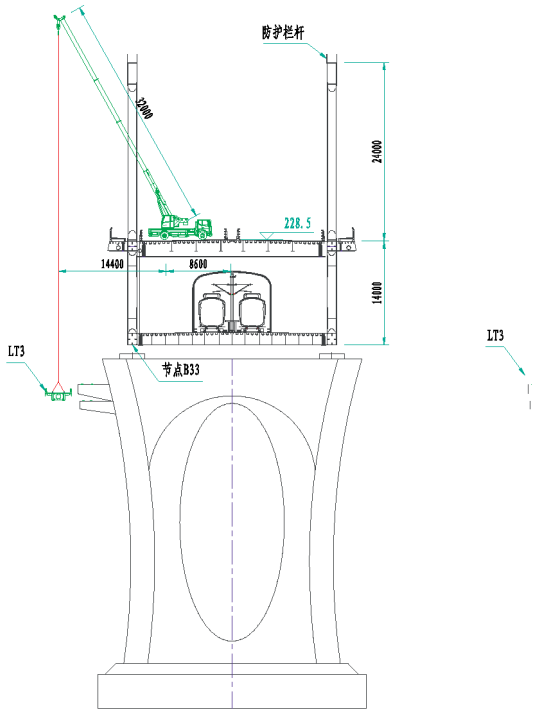

Figure 3. Hoisting Installation of Stairway 3.

3.7 Auxiliary Railing Hoisting Installation

After the stairway is installed, install the stairway railing and other auxiliary facilities.

4 Conclusion

Select installation techniques and mechanical equipment for stairway installation according to local site conditions to prevent dangerous operations and ensure installation quality.

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Journal of Architectural Research and Development

Research Article

Comprehensive Management Strategy for Tunnel Construction Quality Inspection and Monitoring

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Abstract: With the increase in the number and scale of tunnel projects in China in recent years, the comprehensive management for quality inspection and monitoring measurement in the tunnel construction process is receiving more and more attention. Based on this, this paper analyzes the comprehensive management of quality inspection and monitoring during tunnel construction to ensure the quality of tunnel construction.

Keywords: Tunnel construction; Quality inspection; Monitoring and measurement; Comprehensive management

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1 Introduction

In the process of tunnel construction, scientific and reasonable quality inspection and comprehensive monitoring management are the keys to ensuring the overall construction quality and improving the overall project safety. Therefore, in specific construction, relevant units must do a good job in this work to ensure the construction quality of tunnel projects and meet the actual needs of the society for tunnel project quality.

2 Tunnel Construction Quality Inspection

2.1 Geological Radar Inspection

The ground penetrating radar detection is mainly applicable to the inspection of the initial support of the tunnel project, the thickness of the secondary lining, the cavity at the back and the detection of discontinuous concrete surface. In the actual inspection, the data signal is monitored with the help of geological radar, and it can be transmitted and received in real-time, and the actual situation at the site can be inspected in real-time by the close combination of antenna and concrete. Currently, the main specifications of radar geological inspection antennas include 400MHz and 900MHz types. With the help of these antenna devices, the thickness of concrete and its internal voids during tunnel construction can be scientifically inspected to determine concrete construction defects.

During inspection, the relevant information is assessed mainly by the reflection characteristics and the initial phase of the reflection wave. If the phase of the reflected wave is opposite to that of the incident wave, and the energy signal is very strong, it means that there is a cavity in the concrete; if the signal energy is weak, it means that the concrete is not dense enough. If the phase of the reflected wave is the same as that of the incident wave, and the energy signal is weak, it means that the concrete has no defects.

2.2 Clearance Section Inspection

The coordinate method is used as the detection principle, and the clearance section is inspected with the aid of a laser profiler. Set a physical direction as the starting direction, and measure the distance value of the vector diameter between the contour line during the specific excavation process and the focal position of the instrument's rotational center through the unique spacing. Meanwhile, the angle between the vector diameter and the measurement direction is measured. Perform measurement and connect the end-points of the vector radius to obtain the contour

shape in the specific excavation process. With the help of the specific control of the construction wire in the cave, the directional fixed-point data of the short coat can be obtained, and then the automatic design can be carried out through the computer software. After the excavation contour line is designed, it needs to be compared with the construction space, and then matched into a corresponding graph, displaying and outputting the distance and area value between each inspection point and the design. In the measurement of the specific excavation effects of the contour line of the tunnel excavation surface, the laser profiler can be used to measure it to simplify the inspection procedures and improve the inspection accuracy, which is in line with the modern tunnel construction quality inspection requirements.

2.3 Acoustic Reflection Detection

With the aid of sound wave reflection detection technology, the length of the anchor rod and the grouting density in the tunnel construction can be inspected. In the process of construction inspection of the tunnel project system consisting concrete mortar, bolts and surrounding rock structures, elastic waves can be emitted from the top of the bolt and scattered by the bolt body, undergoing multiple transmissions and reflections between the bolt and mortar and between the mortar and surrounding rocks, and eventually propagated in a very complicated path. Through the analysis of the tunnel's anchoring variable cross-section system, it was found that if the form of material or cross-sectional area of the bolt changes, the transmission and reflection positions of the incident wave will be located on the cross-section, and the changes in the actual area of the cross-section and the impedance phase of wave drag will directly affect the magnitude of the transmitted waves and reflected waves. If the surrounding rock structure, mortar, and bolt have a relatively high density, there will not be a huge difference in wave impedance between these three. At this time, most of the energy will be transmitted to the surrounding rock, and only a small part of the energy of will be transmitted back through reflection, and the reflected signal is also very regular. If the construction mortar has quality problems such as poor uniformity or insufficient compactness, the mortar is prone to problems such as cavitations. At this time, the transmission and reflection of sound waves will occur at the end of the bolt. If there is any change in a construction parameter, the change in reflection will increase and the reflection effect will be enhanced. On the contrary, if all the parameters on the interface remain unchanged, the changes in reflection and reflection effect will gradually weaken. In specific inspection, in order to achieve further improvement on the assessment capability, the inspection should be combined with the exact sound wave reflection time and reflection intensity, so as to achieve further control of the effective information, and actively process the corresponding data to obtain more accurate testing results.

3 Comprehensive Management of Tunnel Construction Monitoring Measurement

In specific tunnel construction, strengthening the monitoring and measurement of each process can ensure the quality and safety of the tunnel project on the basis of ensuring the orderly implementation of the project. Therefore, in the specific construction, it is necessary to strengthen the research on the comprehensive management of monitoring and measurement, and adopt reasonable measures to carry out the comprehensive management of monitoring and measurement in each process.

3.1 Comprehensive Management of Displacement Monitoring and Measurement

In the comprehensive management of tunnel construction monitoring and measurement, good monitoring of surrounding rock displacement is the key content of stability assessment for surrounding rocks and construction guidance. As far as traditional displacement inspection is concerned, there are two main technical methods, the specific details are as follows:

Table 1. Details of the Two Types of Displacement Monitoring Techniques

Serial No.	Monitoring Technology	Monitoring Method
1	Manual Monitoring	During the construction, the measurement section is set up, and the measurement is carried out by dedicated personnel at fixed time interval through the corresponding mechanical convergent gauge, or through a mechanical-electronic convergent gauge.
2	Instrumental Monitoring	Use tunnel profiler to measure at fixed-point and fixed-timing.

The advantages of these two measurement techniques are that the instruments and equipment are relatively simple, but they cannot perform real-time monitoring of displacement. The measurement is dangerous and will cause great interference to the construction, the data is not reliable enough, and the measurement cost is relatively high. In order to effectively overcome these shortcomings in traditional displacement measurement, real-time and effective measurement can be carried out by setting up a laser real-time monitoring system in specific tunnel surrounding rock displacement measurement. For example, in the process of tunnel collapse, the system can be used to realize real-time knowledge of the supporting structure and surrounding rock stability of the collapsed construction section.

3.2 Comprehensive Management of Stress Monitoring and Measurement

If the tunnel has relatively stable surrounding rock conditions, the actual requirements of monitoring and measurement can be effectively fulfilled with the help of geological observation of working face and surrounding rock displacement monitoring. However, if the tunnel does not have relatively stable surrounding rock conditions, or the tunnel structure is very complex, or the stratum has serious deviations, more sensitive measurement techniques are needed to fully obtain low stress information to ensure the quality and safety of tunnel construction. In the specific stress monitoring and measurement, the results of the displacement monitoring around the tunnel and the infiltration monitoring results of the tunnel roof can be used as the basis, and the stress on the side of the back-stress retaining wall can be measured by a steel string compressor. In this way, the stress can be monitored and controlled reasonably, construction quality and safety can be guaranteed, and the overall management efficiency can be further improved.

3.3 Comprehensive Management of Anchor Rod Axial Force Monitoring and Measurement

In the construction of tunnel projects, it is usually necessary to use a large number of anchor rods to render support. Therefore, in the specific construction, a comprehensive knowledge of the specific working status of the anchor rods at a specific position is of vital importance to the economics and safety of the entire support system. In the specific monitoring measurement, three sensors can be set on each anchor rod to be tested, so that it can measure the axial force values at three different positions on the anchor rod. When the anchor rod is under tension, its axial force is positive; and when it is under stress, its axial force is negative. The difference between the actual load and the design load value of the anchor rod is assessed by the measurement of the maximum absolute value of the axial force and its occurring position. Axial force distribution is used to determine whether the forces on the anchor rod are tension or stress and to analyze whether if the forces on both sides of the anchor rod are symmetric. Only in this way can the concrete supporting structure and surrounding rock conditions be reasonably tested after the tunnel excavation, so as to ensure the overall tunnel construction quality and meet the requirements for actual tunnel construction.

4 Concluding Remarks

In summary, tunnel construction has become more and more common in the construction of traffic facilities today. The tunnel construction technology will have a direct impact on the quality and safety of tunnel use. Therefore, relevant units should conduct inspections of construction quality through geological radar detection, clearance area inspections, and acoustic reflection detection technology during construction; and monitor and measure surrounding rock displacement, stress, and bolt axial force. In this way, the overall improvement of inspection of tunnel construction quality and management quality of monitoring measurement can be achieved. This will have a very positive impact on the improvement of the construction quality of subway tunnels, the fulfillment of the actual needs of social transportation and the well development of social economy.

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Journal of Architectural Research and Development

Research Article

Control and Management Measures of Highway Project Cost under the PPP Model

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Abstract: In recent years, China's society and economy has been developing very rapidly, and various industries are showing a trend of vigorous development. The importance of control and management of project cost in highway project management is becoming more and more prominent. PPP model has been widely used in the control and management of highway project cost with its own unique advantages. The author analyzes the important advantages of the PPP model and the existing problems in the cost control and management of highway projects, and puts forward effective measures for the cost control and management of highway projects using the PPP model, in hope of helping with the smooth implementation of the work.

Keywords: PPP model; Highway project; Cost; Control and management

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1 Introduction

There are many drawbacks in the traditional model of highway project cost control and management work, and it has been difficult to apply to the current highway project construction. The effective development of highway project cost control and management under the PPP model can implement comprehensive control and management of highway project costs. For this reason, highway project construction corporates must conduct in-depth research on the PPP model to better implement highway project cost control and management.

2 Important Advantages of PPP Model

PPP refers to public-private partnership. The PPP model is an operation and investment model often used in the construction of public infrastructure in modern society. The important advantages of the PPP model are shown in Table 1.

Table 1. Important Advantages of PPP Model

Advantages of PPP Model	Main Manifestations
Easing financial pressure	Social capital effectively participates in the construction of highway projects, and the financial pressure on government departments has been significantly diverted, which can prevent highway construction from having to be interrupted or postponed due to problems such as construction costs exceeding budgets or broken capital chains.
Promote the stable development of social capital	Various actions in highway project construction are very transparent, and are supported by national policies and the society. Social capital will not have risks such as information asymmetry, information crisis, and accountability. Government investment actions are more service-oriented and constructive, not taking the acquisition of economic benefits as the main purpose. It can provide a strong guarantee for the improvement of the quality of highway projects. For the social capital side, it can also dilute its investment risks and help the steady development of social capital.
Improve the quality of highway projects	The relationship between government and social capital in highway construction is mutually complementary, and most social capital parties not only have rich experience, but also high industry skills, which can provide a high level of control and management guarantee for the operation of highway engineering project capital, and also help the government to exert the function of public supervision fully[1]. There is a mutually restraining relationship between government and social capital. There is a close relationship between the profit of social capital and the quality of highway projects. Only when the overall quality of highway projects is improved can the investors' profit increase significantly.

3 Problems in Highway Project Cost Control and Management

Although the PPP model has unique application advantages, there are still some problems in its application in the cost control and management of various stages of highway engineering, as shown in Table 2.

Table 2. Problems in Highway Project Cost Control and Management

Main Problems	Specific Manifestations
Problems in the preparation stage	The highway has a large amount of engineering and a long construction period. During this period, various uncertainties may be encountered, such as policy and climate factors. However, when applying the PPP model in the project preparation stage, make sure to fully consider these factors. The construction area of highway project is relatively large, project cost control and management is more difficult, and prone to various risks.
Problems in the design stage	Failure to fully grasp the overall management indicators of highway project cost and lack of cost control and management awareness in the design stage. The setting of goals in the design stage of highway project deviates from the goals of project cost control and management, which leads to a large discrepancy between the actual cost of the project and the cost target in the design stage.
Problems in the construction stage	The relevant internal management department of the enterprise has not received the project construction plan, project cost list, etc.
Problems in the settlement stage	In order to obtain greater profits, some enterprises adopt some inappropriate methods to obtain construction qualifications, such as falsely reporting project costs and prices, which will have a great impact on the normal settlement of the project.

4 Effective Measures for Developing Highway Engineering Cost Control and Management under the PPP Model

4.1 Application of the PPP Model to Project Cost Control and Management in the Planning Stage of Highway Projects

Under the PPP model, the government and social capital share the economic benefits of highway projects, and at the same time, both parties share various risks. Therefore, in the planning stage of highway projects, the government should conduct a comprehensive analysis according to the interests of all parties when setting the highway project cost control and management goals[2]. When applying the PPP model, government departments should actively get rid of the traditional control and management concepts dominated by themselves in the past. They should not consider their own profits too much, but should clarify the importance of their partners and participants in the construction of highway project and clearly protect the interests of all parties in black-and-white in the bidding contract and the project cost estimation plan. In addition, while clarifying the plan and objectives of highway project cost control and management during the planning stage, the important functions of government departments should be fully utilized to formulate reasonable project cost standards.

4.2 Application of PPP Model in Project Cost Control and Management during the Design Stage of Highway Project

When applying the PPP model in the design stage of highway projects, the engineering cost should be scientifically controlled and managed from the following four aspects.

Table 3. Application of PPP Model in Project Cost Control and Management during the Design Stage of Highway Project

Control and Management Measures	Specific Methods
Make project budget reasonably	On the premise of ensuring the quality and functions of highway projects, strictly control various factors that affect the project cost at the project design stage to ensure that the project cost budget is in line with China's quota standards.
Give some flexibility to the project budget	Through the estimation and consideration of various influencing factors such as policies, infrastructure, culture, market and society, it provides an appropriate flexible space for the project budget and strengthens the implementation of the PPP model in project cost control and management during the project design stage.
Strengthen the prevention of various risks	The process of highway construction is laden with various risks. In order to respond to these risks in a timely and effective manner, when applying the PPP model to project cost control and management in the project design stage, sufficient reserve funds should be added to the project costing system.
Acknowledge project cost scientifically	Clarify the important value of applying PPP model to project cost control and management, reasonably adjust the cost control and management plan based on the fluctuation of material market prices and policy changes

4.3 Application of PPP Model in the Project Cost Control and Management in the Construction Phase of Highway Projects

To apply the PPP model to the control and management of project cost during the construction phase of highway projects, it is necessary to conduct a comprehensive analysis of the construction contract, financing requirements, and financial status, as these factors will have a great impact on the smooth construction of the highway projects[3]. To this end, the relevant staff must have an accurate and in-depth understanding of the contents of the contract, so as to find out the traps in the contract in time, and avoid various risks due to the contract as much as possible. In the process of implementing financial management, relevant staff must strictly follow the corresponding procedures and regulations when performing their work. In order to apply the PPP model more reasonably to control and manage project costs, it is necessary to carry out financial management and financing simultaneously to achieve a high degree of unity between the two. In addition, under the PPP model, highway project investors have diverse characteristics. In order to guarantee the cost of highway projects, it is necessary to strengthen the comprehensive development of highway project financing, and strengthen the supervision of various financings. On the basis of ensuring that all funds are well-prepared, strengthen the analysis of market price fluctuations in conjunction with the actual usage of various funds, and make reasonable adjustments to the project cost budget to ensure the reasonable use of the funds for the highway construction.

4.4 Application of PPP Model in the Project Cost Control and Management in the Settlement Phase of Highway Projects

When the PPP model is applied to project cost control and management in the settlement stage of highway projects, the relationship between government departments and private enterprises should be clarified, and the interests of each party should be allocated reasonably[4]. Under normal circumstances, it is necessary to clarify the benefit distribution and acceptance criteria when the project is completed in the preparation stage of highway construction. When formulating project benefit distribution standards, it is not only necessary to comply with the pursuit of project interests by private enterprises, but also to protect the rights and interests of Chinese government departments and give full play to the cost control and management of the PPP model in the project settlement stage.

5 Conclusions

To sum up, the application of PPP model in highway project cost control and management has great advantages. For this reason, highway project construction corporates must strengthen the research on PPP model to carry out project cost and management work better.

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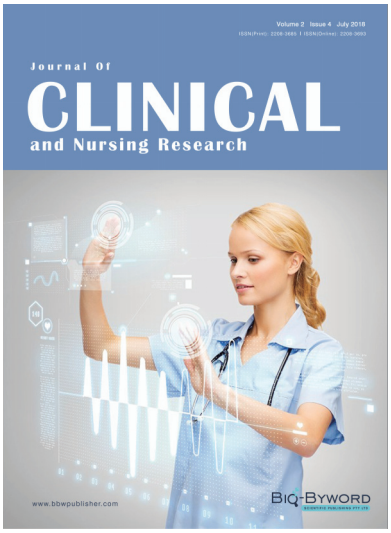

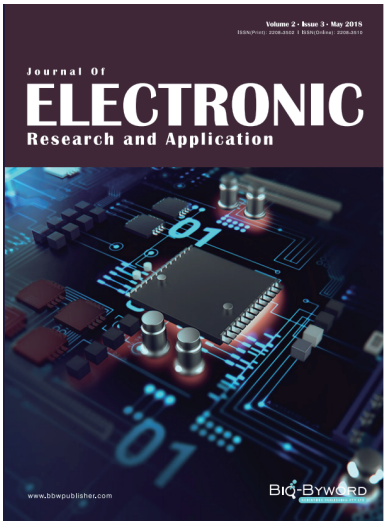

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