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Research Article

Analysis of Air Pollution Control Measures in Environmental Engineering

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Abstract: The air quality of the ecological environment is closely related to people's health. However, due to the rapid economic development in recent years, it has indirectly led to the continuous deterioration of the quality of the atmospheric environment. Effective control of air pollution in environmental engineering is an important measure to improve the ecological environment and the quality of people's lives. Therefore, this paper combines the main causes and hazards of air pollution to analyze environmental protection measures in-depth.

Keywords: Environmental engineering; Air pollution; Control measures

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1 Introduction

With the gradual acceleration of industrialization, various pollutants discharged into the atmosphere are also increasing. If these pollutants cannot be effectively treated, the quality of the atmospheric environment will be threatened. Especially in the process of industrial processing and production, a large amount of gas will be generated, so it is necessary to implement comprehensive air pollution control measures to effectively solve the problem of air pollution[1].

2 Analysis of Current Status of Air Pollution

As haze and other air pollution seriously affect people's quality of life, relevant national environmental protection agencies have begun to formulate environmental protection targets. With continuous efforts, the content of polluting gases such as sulfur dioxide and nitrogen dioxide has been determined, thereby gradually achieving the emission reduction target[1]. However, the large amount of waste gas generated by the huge base of Chinese industrial enterprises still has a serious impact on the natural environment, mainly.

2.1 There are too Many Types of Air Pollutants

The air pollution problem has become more and more serious, mainly due to the emergence of forest resources, domestic sewage, incineration and marine emissions, which have seriously affected air quality and the environment, and causing air pollution. Under the current overall background of environmental quality management, there are still problems in supervision and governance. In the process of environmental governance, the business process of the environmental protection department is restricted, and it is difficult to effectively control air pollution. It has a serious impact on environmental protection. Therefore, only by proposing the right development plans for air pollution and environmental problem can we propose effective pollution control measures right from the source[2].

2.2 Government Policy Biases

The management of relevant government departments often pursues economic benefits, which affects the development of the local economy. In addition, local assistance policies are applicable to some industrial companies with severe air pollution. In the inspection process, the government usually cooperates with the relevant management personnel of the enterprise, which brings certain obstacles to the environmental inspection work. In addition, the management personnel of the environmental inspection department will be restricted by the government in terms of the scope of management and supervision.

3 The Sources and Harms of Air Pollution

3.1 Sources

3.1.1 Car Exhaust

The rapid development of China's economy has greatly improved people's quality of life. People's consumption concept, level and structure have undergone tremendous changes. Cars have basically become people's daily necessities and their first choice for transportation. The number of individual differences is also increasing. The increase in the number of cars not only facilitates people's travel, but also causes certain harms to the environment. Car exhaust contains a lot of itch-inducing nitrogenous substances, which are directly released into the air. With the gradual increase in car ownership, car emissions also increase, which has a negative impact on the quality of urban control. Therefore, the government should pay attention to the issue of vehicle emissions, incorporate it into environmental governance and give priority to its control[3].

3.1.2 Industrial Pollution

Industry is an important part of the global economic structure and an important driving force for the development of the national economy. However, industry not only promotes the development of the national economy, but also causes certain harms to the environment and seriously affects air quality. Industrial production has the characteristics of large-scale production. Industrial engines generally use combustion methods. During the combustion process, a large amount of toxic and harmful gases are directly discharged into the atmosphere, causing serious air pollution, and it is difficult to carry out environmental and air pollution control.

3.1.3 Soot-type Pollution

Coal is a necessity for people's daily production and life. Urban centralized heating and industrial production both need a lot of coal. During coal combustion, a large amount of dust and harmful gases will be produced, which will seriously affect the natural ecological balance and severely pollute the air. The government should encourage the use of green methods for heating and industrial development, such as paying attention to issues of coal burning and switching to using natural gas to reduce the amount of coal consumption and effectively control air pollution.

3.2 Harms

The damages caused by the atmosphere to the human body can be divided into direct damage and indirect damage, and these damages are irreversible. Direct damage refers to the threat of human health by inhaling air containing substances harmful to the human body, and indirect damage refers to harmful gases that destabilize the atmosphere. Spacecraft enter the surface of the earth and affect the human body and crops by causing radiation damage. The smog phenomenon is the most intuitive phenomenon of air pollution that people can feel. In a smoky environment, people are more likely to suffer from respiratory diseases, which directly affect human health. In addition, harmful substances in the atmosphere enter rivers and soil in the form of precipitation, causing water and soil pollution, and ultimately affecting the sustainable development of society. Indirect damage severely affects economic and cultural development. Even today, China’s economic development is quite different from that of developed countries[4].

Currently, heavy industry still accounts for a large part of China's economic development, and this proportion still prevents China's environmental pollution problems from being solved for a long time. Therefore, this economic development model is not a long-term, but a temporary or limited economic development process. In order to realize environmental protection and healthy economic development, it is necessary to start from the perspective of energy saving and the use of new technologies, and finally achieving a new form of economic and environmental development. In other words, the economic development in the early stages of heavy industry development sacrificed the environment, while air pollution adversely affected and slowed down economic development. In addition, air pollution greatly restricts cultural development. Currently, the concept of harmonious development between man and nature has been proposed. If this concept is not effectively implemented, it will not only damage people's daily life, but also damage the diversified development of Chinese society and culture.

4 Control Measures of Air Pollution

4.1 Strengthen Monitoring and Establish a Public Monitoring System

Air pollution control in environmental engineering is a long-term comprehensive project. The long-term mechanism requires a variety of pollution control measures to maintain and strengthen the control effect. Therefore, in the treatment process, the environmental protection department must first fully understand its responsibilities and roles in the air pollution treatment process, use advanced concepts and ideologies to guide treatment operations, and continuously innovate and optimize its working methods to understand the causes of air pollution[5]. Secondly, combined with the current situation of air pollution in the field of environmental engineering, comprehensively analyzed the characteristics and causes of air pollution, to propose corresponding treatment measures and establish standardized treatment procedures, treatment standards and related management systems.

And on this basis, establish a public monitoring system that shares information with the public and enables the public to participate in the monitoring of natural resources. Increase public awareness to promote the public's sustainable use of resources, and pay attention to the ecological environment and protect it. Relevant departments should organize inspection teams to effectively implement natural resources and ecological environment management. For some companies, regular inspections need to be done by the environmental protection department. The relevant units need to be modified, and production can only start after reaching the corresponding standards. We are implementing a system of pay to use of natural resources. Whether as a group or as individual, resources must be used consciously and rationally, and damage to the ecological environment must be limited.

4.2 Balance the Relationship between Economic Development and Environmental Protection

First of all, relevant departments must strengthen the investigation and management of enterprises in the region, register polluting enterprises, and manage them centrally. Companies that do not meet the emission standards must shut down for rectification, establish specific overall measures, clarify rectification goals, and track the effectiveness of rectification. Secondly, it is necessary to optimize and adjust the industrial structure, such as improving production methods, relocating or closing polluting enterprises to reduce the possibility of air pollution. At the same time, local governments should support clean energy companies through policies and funds, and encourage more individuals and businesses to use clean energy to reduce air pollution. Finally, tighten the emission control of urban vehicles. Vehicles with excessive emissions are strictly prohibited from driving on the road, and at the same time strengthen the control of unqualified fuel.

4.3 Introduction to Cloud Computing Technology

Nowadays, cloud computing technology is not only developing rapidly, but is also applied in air quality monitoring and early warning systems. The application of cloud computing technology can not only help current environmental monitoring tasks, but also improve the accuracy of air pollution control. Cloud computing technology can not only reflect the urban environment more accurately, but also improve the atmospheric trend prediction based on past environmental development and weather patterns[6]. At the same time, it can work normally and stably in the air pollution management process. From a software perspective, only in-depth analysis of existing data can provide more effective recommendations for air pollution control.

4.4 Development and Utilization of New Clean Energy

Carbon-based energy will cause huge damage during the combustion process, so scientific and reasonable methods must be actively adopted to solve the problem. All regions should focus on the current situation, thoroughly analyze the energy consumption situation, actively develop new environmental and clean energy suitable for the human environment, and strive to reduce air pollution. The state should emphasize on the development of clean new energy, fully integrate with actual industrial production, and develop various new energy sources. The use of these new clean energy sources can reduce emissions and has little impact on the atmospheric environment. If all kinds of clean energy can be used scientifically and effectively, it will not only reduce the use of traditional energy, but also solve the problem of air pollution and maintain the ecological balance of the earth.

4.5 Rectify Illegally Emitting Enterprises

In the process of air pollution control, national departments and governments play a very important role. At the same time, it is necessary to find the root cause of environmental pollution and strengthen the comprehensive management of pollution problems. At this stage, many industrial enterprises in China have not carry out reasonable treatment in the exhaust gas emission process. Industrial enterprises are the main pollutant discharge enterprises. Relevant government departments must severely punish and impose corresponding penalties for enterprises that have this phenomenon. In the process of corporate governance, the relevant environmental protection departments should stand at the starting point and play a leading role in imposing penalties in accordance with relevant policies, laws and regulations.

5 Conclusion

In conclusion, severe air pollution seriously affects people's health and does not help social and economic development, nor does it contribute to sustainable social development. Therefore, it is necessary to implement various long-term air pollution control measures. In the long run, strengthening and expansion of the effects of air pollution control will create a better living environment for the people.

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Research Article

Design and Construction Strategy of Arched Continuous Rigid-frame Bridge

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Abstract: With the current rapid development of urbanization in China, people's living standards have been greatly improved. In the context of such a development background, the requirements for road traffic are getting more stringent, especially for bridge projects. The arched continuous rigid-frame bridge was developed under this social background. The advantage of the bridge lies in the design of a bridge model that integrates various functions such as transportation, landscape, and sightseeing. Based on the above, this paper first refers to the case to analyze the design and construction strategy of the arched continuous rigid-frame bridge, in hope of providing a valuable reference for relevant personnel.

Keywords: Arch; Continuous steel structure; Bridge design; Construction

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1 Introduction

The use of arched continuous rigid-frame bridges in bridge design and construction can display the ecological, sightseeing and artistic features of the area where the bridge is located, which serves to build a landscape-like bridge. In the actual design and construction, economics, safety and aesthetics are taken as the principles, which are in line with the requirements for bridge construction in the current urban development. Based on the case study, this paper discusses the design and construction strategy of the arched continuous rigid frame bridge in detail, which has practical research significance.

2 Project Overview —— Taking XX Project as an Example

The area where the bridge construction of the XX project in a certain city is located is in the key project that connects the major road networks in the city. According to the analysis and research on multiple plans, it was finally decided that the construction plan of an arched continuous rigid-frame bridge with a main span of 21m + 30m + 21m be adopted for the project. The length and width of the entire bridge project are 78.16m and 30m respectively, and the entire project was designed in left and right sections. The following is a discussion on the design and construction strategy of the arched continuous rigid-frame bridge based on this project.

3 Overall Structure Design of Arched Continuous Rigid-frame Bridge

3.1 Superstructure

For the superstructure design of the project, pre-stressed concrete continuous box girder was mainly used. The structure of the main girder section is a variable cross-section single-box multi-chamber structure for construction. The purpose is to achieve a relatively low structural height while gaining a very large structural rigidity. The sectional height of the bridge was varied according to the calculation principle of the circular curve equation. A beam of equal height was set in the middle of the bridge with a length of 4 m; The heights of the pier-top beam and the mid-span beam in the V-shaped part of the main beam are 170 cm and 120 cm respectively; the requirements for the width of the top-plate, the width of the bottom-plate and the cantilever are 15 m, 10.6m and 2.2 m respectively; the requirements for the thickness of the top-plate and bottom-plate and the width of the girder web are 20cm, 20cm and 40cm respectively; for the top of the beam section, the thickness of the bottom-plate gradually changed from the previous 20cm to 40cm, and the girder web changed from the previous 40 cm to 80 cm. A total of 4 cross-beams with a thickness of 100cm were designed for the entire bridge project, which are mainly used to transmit forces between the superstructure and substructure of the bridge[1]; the side-span, mid-span, and side-to-mid span ratios of the bridge are 21m, 30m, and 0.7 respectively. The side-span design is relatively large. The main consideration is to use the long side-span to balance the horizontal force on the pile top and reduce the positive bending moment of the mid-span simultaneously.

3.2 Substructure

Firstly, when designing the bridge pier part, as the bridge pier of this project is designed with V-shaped piers, the design of the V-braces on both sides mainly adopts the design of variable cross-section rectangular plates, and the arc line is mainly used in the design of the changing curve part. The thickness of the plate is required to be between 0.6m - 0.8m, and the width of the plate is 10.6m. In addition, the V-braces on both sides of the V-shaped pier are in a consolidated state with the beam body and the cap, and C50 reinforced concrete structure is mainly used for its construction. For the cap part, the specification of the rectangular section is 12m×1.8m ×1.5m, the foundation is constructed with bored piles, and the pile diameter is 1.2m.

Secondly, in the design of the abutment part, the heights of the abutments on both sides are designed to be 4.5m and 3.5m respectively, and the height of the platform cap is 1.2m. In addition, the slope protection on both sides of the abutment and the upper-span landscape belt are linked, and the design and requirements for the foundation and pile diameter are the same as the above-mentioned bridge pier design[2].

Thirdly, the design of other parts of the bridge is mainly on the bridge deck, which uses 8cm cast-in-place concrete and 9cm asphalt concrete for paving operations. For the expansion joints, D-80 expansion joints are mainly adopted.

3.3 Structural Calculation of Arched Continuous Rigid-frame Bridge

3.3.1 Structural Internal Force

For the construction of arched continuous steel bridge structures, as the mechanism is mainly the formation of a steel structure system after the consolidation of piers and beams, the entire process from the formation of the steel structure system to the structure bearing pressure is mainly divided according to the three construction phases and operation phases. The division of the construction phase is as follows: the construction phase of the pouring of bridge piers, side-spans and mid-span box girder (which does not include the 2m mid-span closing-segment part)[3]; stretching the pre-stress of the main girder (including the construction of the supporting parts and the construction phase of the main girder 2 m closing-segment through pouring and stretching the pre-stress); the main girder and pier supports are removed, and the construction phase of the system is transformed. For the operation stage, factors such as the constant load force on the bridge, the pre-stressing force, the load generated during the driving of cars, the temperature rise (or drop) of the entire bridge by 35 ℃ , and the shrinkage of the concrete are mainly considered. Perform calculations and analyze the combined internal forces and stresses under the working conditions in each construction phase to adjust the bridge segment sizes and pre-stressed steel strands accordingly. Through the above processes, it can be ensured that the forces and stresses in each construction phase can be maintained within safe and controllable ranges.

3.3.2 Pre-stressed Steel Strands

Regarding the XX project, the pre-stressed layout design was carried out according to the calculation results. The main girder is designed according to the pre-stressed A-type components, and the V-shaped pier of the bridge can be designed with ordinary reinforced concrete components. The pre-stressed steel strands are arranged in the main beam, and the diameter specifications of the steel strands, the area of the steel strands, and the standard tensile strength are Φ15.2mm, 139mm^2, and 1860MPa respectively; it is recommended that the tension control stress mainly be 0.75f_{pk}, elastic modulus E_p = 1.95×10^{5}MPa.

In order to effectively reduce the impact of the pre-stressed secondary internal force, the longitudinal pre-stressed steel strands of the main girder can be arranged in the following steps: for the side span of the bridge, the top of the V-shaped pier and the bottom of the mid-span, a relatively short positive-bending moment strand is used for layout, with its single-end in tension state and anchored in the transverse beam; the girder web bundle can be arranged in segments, with its two ends in tension. The layout of the steel bundle is shown in Figure 1:

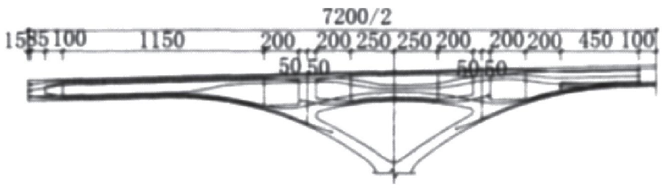

Figure 1. The Arrangement of Steel Beams

4 Construction Strategy of Arched Continuous Rigid-frame Bridge

Regarding the construction of the arched continuous rigid-frame bridge, as the nature of the project belongs to a high-order hyperstatic system, taking effective measures to reduce the secondary internal force is the key point in the design and construction of the entire bridge project. Based on the above, for the main structural part of the bridge project, the construction is mainly carried out by the cast-in-place method with full-floor brackets. The specific construction steps are as follows: First, in the entire bridge construction, the first step is to carry out construction work on the cast-in-place piles and the platform part; secondly, carry out the pouring construction of the joint between the V-brace part on both sides of the V-shaped pier and the main beam[4]; thirdly, carry out pouring on the side-span, V-pier top and mid-span box girder. During the pouring process, a post-cast segment of 1m should be reserved for the top of the V-pier, and a closing-segment of 2m should be reserved for the middle of the mid-span; fourthly, the 1m post-pouring segment of the V-shaped pier is poured first, and then the girder web steel beams, the side-span bottom-plate beams and the V-pier top- and bottom-plate beams are stretched, and finally the mid-span closing-segment is poured; fifthly, the closing-segment steel beams are stretched, and then the 50cm post-pouring belts on the left and right sides of the bridge are poured. Through the above processes, the bridge deck is built into an entirety, and finally other systems and auxiliary facilities on the bridge deck are constructed.

In the construction steps above, it is necessary to install a 1m post-pouring belt on the top of the V-shaped pier, and the main reason for pouring the closing-segment after the completion of the steel strand tensioning process is because that the shrinkage, creep and secondary internal stress caused by pre-stressing during construction can be reduced when the above-mentioned construction stages are split up, which will maximize the scientific rationality of the structural force, and the scientific application of pre-stressing can effectively ensure the quality of bridge construction.

5 Conclusion

In summary, in the process of modern bridge construction, on the one hand, it is necessary to meet the functional requirements for transportation in the city; on the other hand, it must also meet the contemporary aesthetic requirements for bridge construction and build bridges that integrate functions and aesthetics based on construction quality to contribute to the process of urbanization.

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Research Article

Analysis of Non-destructive Testing and Disease Diagnosis Technology of Tunnel Projects

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Abstract: Engineering incidents caused by the quality of tunnel construction and geological diseases occur from time to time, which not only causes many problems in engineering geophysical prospecting, but also provided a broad space for the application and development of engineering geophysical prospecting technology. Non-destructive testing technology has made great progress. Combining the diagnosis and treatment of tunnel diseases, the ground penetrating radar non-destructive detection technology is discussed.

Keywords: Tunnel engineering; Non-destructive testing; Disease diagnosis

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1 Introduction

In recent years, due to the tremendous increase in tunnel projects, the requirements for the quality of tunnel projects are getting higher and higher. Traditional tunnel quality inspection and control methods are heavy-duty, low-efficiency, high-cost and lowly-representative. Compared with traditional engineering testing methods, non-destructive testing technology has obvious advantages and does not require the use of other reagents or extensive preparation. Meanwhile, it has more prominent functions than traditional testing methods, such as non-destructive testing, random testing, remote testing, and field testing, etc. Whether the tunnel structure can achieve the expected function is a comprehensive process. Tunnel conditions diagnosis usually uses a combination of on-site prospecting and non-destructive testing. The diagnosis results of tunnel structural diseases can scientifically evaluate the health of the tunnel structure. However, the application of these methods is not yet universal across China. Many project technicians and managers do not understand the principles, detection methods and existing problems of these geophysical prospecting methods. This not only hinders the solving of engineering problems, but is also not conducive to the wide application of engineering geophysical technology. Currently, non-destructive testing technology has played a very important role in China's tunnel projects. Commonly used non-destructive testing methods are ground emission radar method, infrared method and ultrasonic method. With the continuous improvement of China's technical level, various non-destructive testing technologies have made considerable progress. With the help of non-destructive testing technology, the safety of various tunnel projects is greatly guaranteed. The research on non-destructive testing technology has a significant impact on the future development of highway tunnel engineering in China. Therefore, it is necessary to strengthen research and investment in this technology, and continuously improve the quality and efficiency of non-destructive testing technology.

2 Non-destructive Testing and Disease Diagnosis Technology

Tunnel condition diagnosis usually uses a combination of on-site prospecting and non-destructive testing. The diagnosis results of tunnel structural diseases can scientifically evaluate the health of the tunnel structure. However, the national application of these methods is not yet universal. Many engineering technology and management personnel do not understand the principles, detection methods and existing problems of these geophysical prospecting methods. This not only hinders the solving of engineering problems, but also hinders the wide application of engineering geophysical technology. In addition, it is difficult to fully and accurately grasp the state of highway tunnel projects only through on-site investigation in the status detection of tunnels. Therefore, it is necessary to accurately understand the internal conditions of highway tunnels. As non-destructive testing technology can effectively detect and analyze various quality defects and voids on the surface, interior, surrounding rocks, and between surrounding rocks and the lining, it has been widely used in road tunnel structural testing.

2.1 Non-destructive Testing Technology

Non-destructive testing is to analyze the structural rationality, material characteristics, design defects, and physical parameters, etc. of the test objects through acoustic wave, electromagnetic wave, infrared and spectroscopic analysis under the premise of ensuring the integrity without damaging the test objects. How to discover problems. In tunnel lining, non-destructive testing methods are usually used to detect the thickness of the lining, the gap behind the lining, the gap between the intermediate layers of the synthetic lining, and the distribution of lining steel bars. The non-destructive testing methods commonly used for tunnel linings in actual projects include acoustic wave method, ground-penetrating radar method and optical analysis method.

Ground-penetrating radar close to the surface of the geophysical prospecting can accurately detect targets such as shallow structures. As the ground-emitting radar works, high-frequency broadband short pulse electromagnetic waves are sent to the target and reflected by the transmitting antenna, then return to the ground and received by the receiving antenna. By analyzing the waveform, width and time-varying characteristics of the reflected electromagnetic waves, we discussed the performance of the lining structure and tested the construction quality of the lining structure. The conductivity is different from the dielectric constant, and the electromagnetic wave reflected at the interface of different materials will be different. The resolution of ground-penetrating radar (GPR) is usually inversely proportional to the measurement distance. The choice of antenna frequency is based on the measurement range. In order to improve the resolution, the measurement range and antenna frequency must be comprehensively considered according to application requirements.

2.2 Tunnel Disease Diagnosis Technology

Seismic tomography is the application of CT technology in the field of geophysics. The seismic wave attenuation observation data can accurately and reliably reflect the internal structure of the geological body. On the other hand, when the medium has high speed and high density, it is related to the high elastic modulus and high shear strength of the medium. Therefore, it can also effectively explain the distribution boundary of various rocks and soil and the degree and distribution of rock mass fragmentation. It is usually used in engineering geological prospecting to detect the location, shape and mechanical strength of bad geological bodies (structures), such as fault zones, joints, aquifers, karst caves and weathered zones. It can also be used for 2D and 3D geological imaging by observing geological conditions (such as drilling, tunnels, slopes, mountains and ground).

3 Analysis of Non-destructive Testing Technology Application

3.1 Site Preparation

In order to ensure the quality of the tunnel lining, the non-destructive testing of the lining structure can be effectively guaranteed. Technological innovation and development have effectively controlled the quality of tunnel lining. Record the construction site, determine the applicable radar antenna types according to the guidance of relevant technical standards, and select the personnel who can correctly place the prospecting ship on this basis. The integral characteristics of the test objects were comprehensively evaluated. Good at designing parameters of ground penetrating radar. Finally, determine the dielectric constant of the area. Non-destructive testing technology is affected by environmental factors and has a narrow application range. It requires a large amount of parametric calculation to directly connect with the tunnel lining structure in the area. When constructing the tunnel lining, corresponding treatment and backup should be carried out according to the service life and rigidity of the structure. Various non-destructive testing techniques can be combined with the characteristics of actual testing to ensure smooth testing.

3.2 Placement of Markers and Measuring Lines

When placing markers and measuring lines, two-dimensional objects should be used as the reference. Based on this, a high degree of parallelism can be achieved before the measuring lines, and all measuring lines must be perpendicular to the target axis. For 3D objects, you need to use the grid method to place the measurement lines. The layout specification of the master-slave measuring instrument requires five for each hole. If there are special requirements, a comprehensive level measuring instrument must be installed. When performing horizontal wiring, the test requirements must be strictly followed. If some segments fail in the actual test process, tightening measures must be taken to meet the test requirements.

3.3 Construction Site Environmental Records

Geological radar technology is prone to influences from the wild environment. Therefore, it is necessary to prepare before construction, to understand the geological conditions of the area by referring to environmental data, etc., and to record the site environment as a basic guide for subsequent data processing.

3.4 Data Processing and Disease Diagnosis

The signal received by GPR is converted from analog to digital, and then transmitted to the computer. After processing a series of data (such as filtering and gain recovery), a radar detection image is formed. GPR image is the basic image of data interpretation. As long as there is an electrical difference between the target and the surrounding medium, it can be reflected in the contour of the radar image. The wave traveling time t of the target reflected wave can be determined by tracking the phase axis. The depth of the target layer can be calculated according to the electromagnetic wave velocity V of the underground medium and the propagation time of the radiation wave. And according to the analysis of this section, the final result of the entire prospecting area is the map. Since the thickness of the decorative layer and the impermeable layer is too thin, an effective response cannot be obtained by the detection unit. The interfaces in different layers have different events, and the distribution of steel bars has diffraction. When the original rock wall attached to the initial support is destroyed, reflected signals will appear when partially filled with water, and the scattered signals will increase.

3.5 Organize Analysis and Diagnosis Results

Then they are drilled to identify each problem point to ensure the reliability of the diagnosis. Prepare the final disease distribution table based on the on-site investigation and diagnosis results. The content of the distribution table provides the scientific basis for the final research plan, including mileage, station number, station pictures, radar outline function description, disease type and condition description, condition deductions, condition levels and preliminary treatment plan.

4 Conclusions

Compared with the conventional methods, the non-destructive testing method can effectively solve the problem of lining damage caused by the conventional testing methods and eliminate potential safety hazards. It can be seen that non-destructive testing methods play an irreplaceable role in the diagnosis of tunnel diseases, and selecting appropriate technical parameters for field testing is an effective method to improve the quality of tunnels.

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Research Article

Research on Construction Control Technology of Large-Span and Small Clear Distance Underpass High-Voltage Line Tunnel

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Abstract: Hanping tunnel is a control project of national highway 310 Dahejia to Qingshui highway project. It needs to cross a 330kV high-voltage transmission line under the condition of small clear distance, which requires high construction requirements. In view of the difficulties such as shallow buried depth of tunnel and small clear distance between tunnel and tower of high-voltage line, multiple excavation blasting method is adopted, and smooth blasting, charge quantity control and damping hole setting are comprehensively used to reduce the impact on the tower and structure of high-voltage line. In order to ensure the smooth progress of the project, the large-scale finite element analysis software is used to simulate the whole excavation project. The influence of the full-section method and the middle partition wall method (CD method) on the surrounding rock and the high-voltage electric tower is compared. It is found that the CD method can effectively control the displacement of the surrounding rock and the tower on it and the uneven settlement.

Keywords: Large-span tunnel; High-voltage tower; Construction control

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1 Introduction

The construction process of the tunnel is a process of rebuilding the balance between the rock mass and the tunnel. In this process, it will inevitably bring about certain impact on surrounding existing buildings with the change in stress. Minimizing the adverse effects caused by the construction and ensuring the safety and performance of existing buildings are important considerations in tunnel construction. High-voltage transmission

lines play an extremely important role in the national grid. They are the main force for power transmission to remote areas. Once they are affected by tunnel excavation, they will tilt and subside, which will directly affect the realization of their power transmission functions, leading to power problems in some areas[1,2]. In such cases, the strategy of avoidance is generally adopted to ensure the safety of high-voltage lines. However, due to the limitation of line selection, some tunnels need to be close to or pass through high-voltage towers. In view of this, it is necessary to carry out the whole-process construction simulation and monitoring of the situation of large-span and small-distance under-passing high-voltage lines to ensure the safety of construction.

Currently, some experts have conducted systematic research on this aspect. Regarding the highway tunnel underpassing high-voltage lines, Hu

Huanxiao and Shen Zenghui conducted construction simulations using the Lijiachong highway tunnel as an example, and explored the method of surface grouting to control the effects of high-voltage tower subsidence[3,4]. Yang Junsheng and others conducted in-depth research on large-section under-passing high-voltage line towers from the aspects of technology and scheme, analyzed the pros and cons of various construction strategies, and laid a solid foundation for subsequent construction research[5,6]. Other scholars delve into numerical analysis to study the influence of various construction methods on the deformation of the towers and various internal forces, so as to reveal the deformation and failure of the towers[7,8]. This type of research is mostly aimed at large-section separated highway tunnels. For large-span and small-distance tunnels, there is still a lack of a complete set of construction simulation and research of control technology. For this, this paper takes the Hanping tunnel control project on National Highway 310 as an example and analyzes the impact of large-span and small-distance tunnel construction on the high-voltage iron tower in combination with numerical simulation.

2 Project Overview

The Hanping Tunnel is located in Hanping Village, Qingshui Town, Xunhua County. It is a key project of the National Highway 310 Dahejia to Qingshui Highway Project. It is located in the middle and lower section of the left bank slope of the Yellow River. The Hanping Tunnel is a short tunnel, and the tunnel construction boundary adopts the same width as the roadbed section: hard road shoulder entrance design. The maximum depth of the left tunnel is about 57m, and the maximum depth of the right tunnel is about 49.5m. The excavation width of a single tunnel is about 15.6m, and the design distance between the left and right tunnels is 15.68m. It is a small-distance tunnel and adopts composite lining.

The left line of the Hanping Tunnel passes through the high-voltage tower, and the minimum vertical clearance between the tunnel and the high-voltage tower is 53m. Figure 1 shows the layout of the lining structure of the tunnel underneath the high-voltage tower section. The surrounding rocks are strong and moderately weathered conglomerate and sandstone. The joints and fissures are relatively developed, and the rock bodies are relatively fragmented. It has a fractured block structure or a medium-to-large thick-layer structure. The direction of the rock strata intersects the direction of the tunnel at about 25°, and the dip angle is between 5~10°. The type of groundwater is bedrock fissure water with weak water richness.

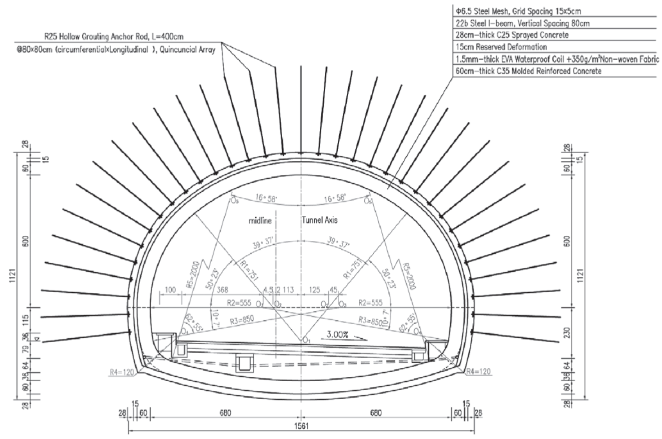


Figure 1. Schematic of the Tunnel Lining Layout

3 Numerical Simulation of Construction Method

In order to minimize the impact on the high-voltage tower, the CD method was used for excavation, and compared with the full-section excavation method to obtain the construction control effects. In order to evaluate the most unfavorable stress and deformation state of the existing building structure during the tunnel excavation process, the excavation process in the simulation calculation was consistent with the actual situation. The specific simulation steps of the CD method were: the excavation of the upper right pilot tunnel of the left tunnel, the excavation of the lower right pilot tunnel of the left tunnel, the excavation of the upper left pilot tunnel of the left tunnel, the excavation of the lower left pilot tunnel of the left tunnel, the excavation of the upper left pilot tunnel of the left tunnel, the excavation of the lower left pilot tunnel of the right tunnel, the excavation of the upper right pilot tunnel of the right tunnel, and the excavation of the lower right pilot tunnel of the right tunnel; while a program was used to simulate a full-section excavation for the full-section excavation method.

The load of the transmission tower is related to the selection of tower type, conductor cross-section, meteorological conditions, span, and geographic location. According to relevant design and construction experience, the weight of the transmission tower can be taken as 12t, plus the conductor load and other components without heavy weight, the total calculated load was taken as 20t here considering the most unfavorable conditions.

The foundation of the transmission tower is four independent foundations, and the distance between the foundations is about 5.5m. During the construction, the vertical load of the transmission tower is taken as the average load, and the load is 8kN/m^2.

In the simulation process of tunnel excavation, the lining adopted beam units. Each structure size of the model adopted a two-dimensional plane finite element model according to the design parameters, as shown in Figure 2. Boundary conditions of the model: the bottom side is a two-way displacement constraint, the side is a normal phase displacement constraint, and the top is a free-surface except for the foundations under load.

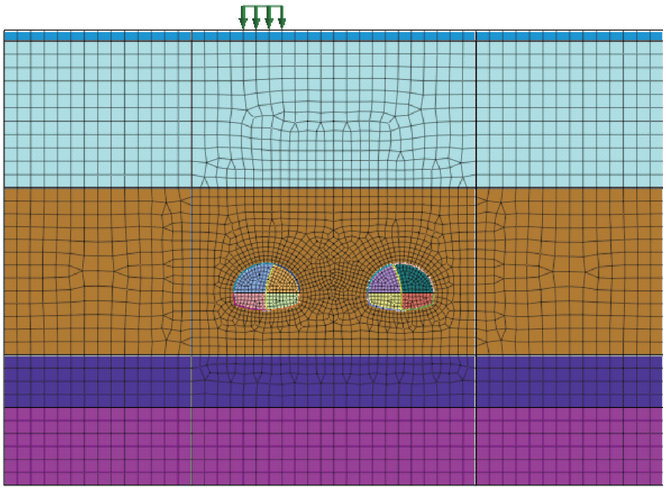
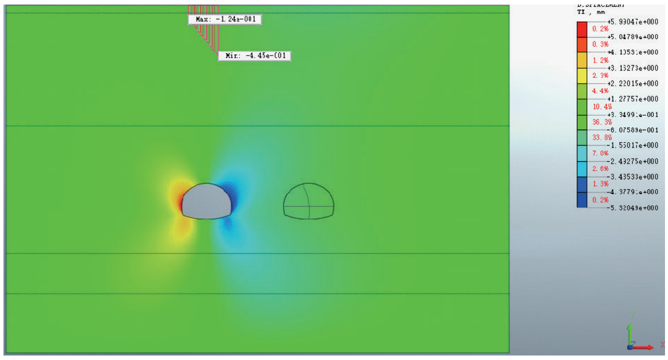
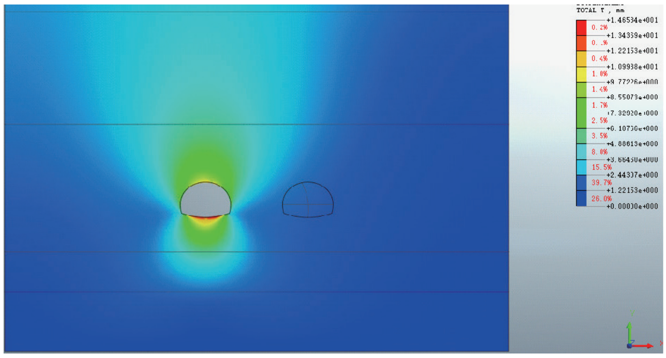


Figure 2. Diagram of Calculated Model

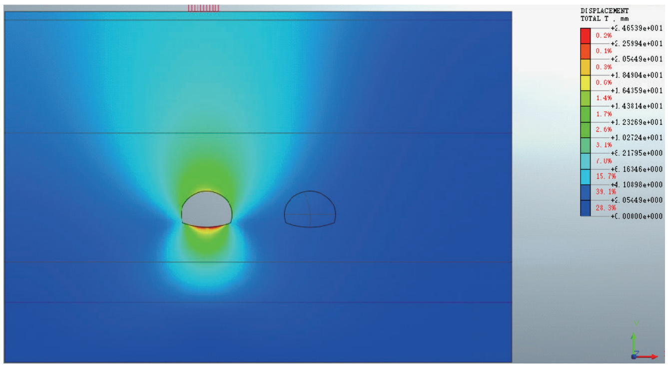
In order to compare the impact of the two construction methods on the high-voltage tower during the construction process, the surrounding rock and structural displacement of the left chamber constructed using full-section excavation and CD method are shown in Figure 3 below(Table 1).



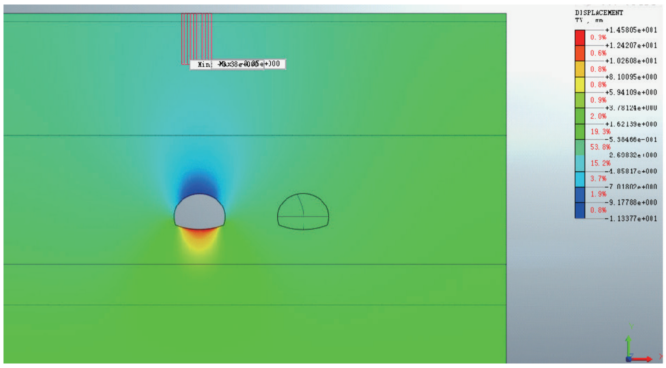
(a)Total Displacement with CD Method



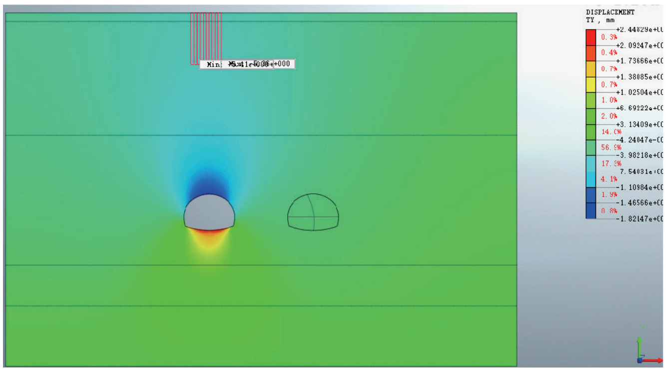
(b)Horizontal Displacement with CD Method



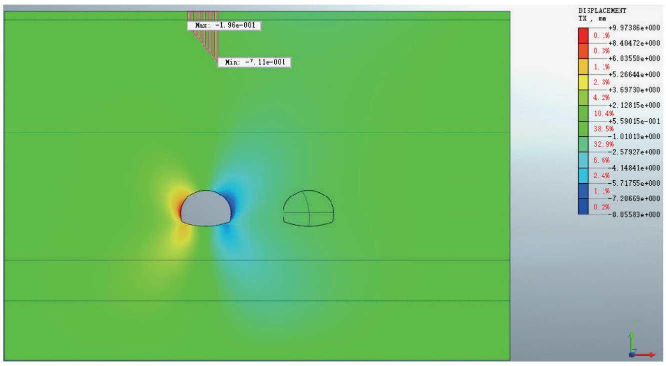
(c)Vertical Displacement with CD Method



(d)Total Displacement with Full-section Method



(e) Horizontal Displacement with Full-section Method



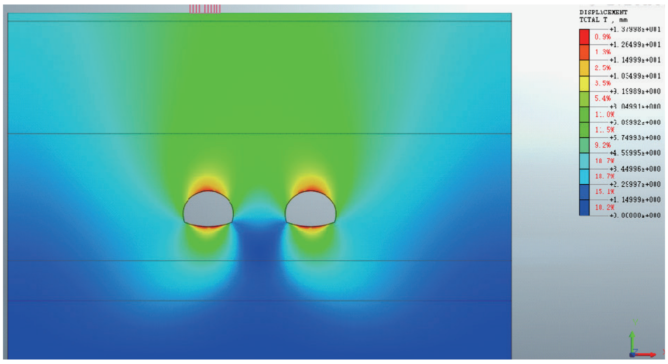
(f) Vertical Displacement with Full-section Method

Figure 3. Distribution Map of the Displacement of Surrounding Rocks

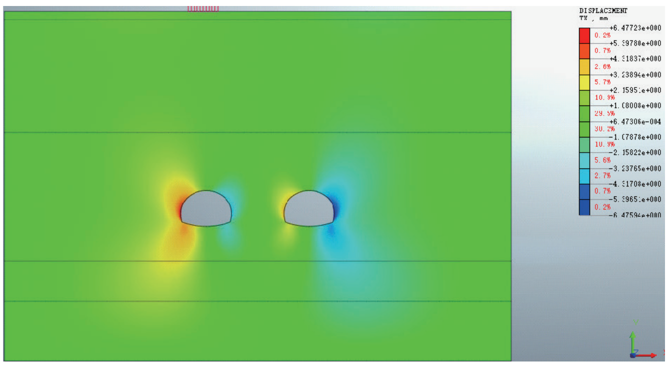
Table 1. Statistical Table of the Maximum Displacement of Key Sites

Construction ethod	Location	Horizontal Displacement (mm)	Vertical Displacement (mm)
CD Method	Surrounding Rocks	6.0	14.6
	Foundations	0.4	3.4
Full-Section Method	Surrounding Rocks	10.0	24.4
	Foundations	0.7	5.4

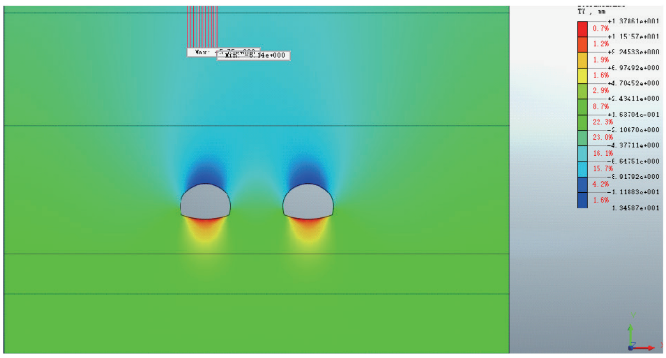
After the CD method construction of the left tunnel was completed, the maximum horizontal displacement of the rock around the cave was 6.0mm, the maximum settlement was 11.2mm, the maximum uplift was 14.6mm, the maximum horizontal displacement of the structure was 0.4mm, and the maximum foundation subsidence was 3.4mm, and the uneven subsidence was 0.03mm. During the tunnel excavation, the deformation of the foundation was small, which meets the requirements of the "Technical Regulations for the Design of Overhead Transmission Line Foundation" (DL/T 5219-2014) to control the maximum foundation inclination at 0.006. With full-face excavation, the maximum horizontal displacement of the surrounding rock was 10.0mm, the maximum settlement was 18.2mm, the maximum uplift was 24.4mm, the maximum horizontal displacement of the structure was 0.7mm, the maximum foundation subsidence was 5.41mm, and the uneven subsidence was 0.04. mm. The displacement data of full-section excavation were greater than that of the CD method construction. In order to further study the influence of the construction method on the high-voltage electric tower during the construction process, the surrounding rock and structure displacement after the excavation was completed are shown in Figure 4 below(Table 2).



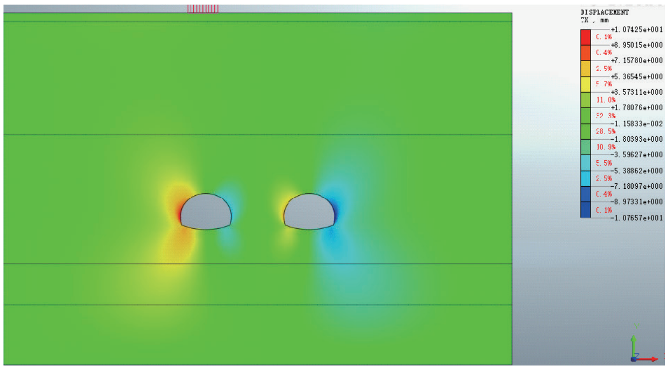
(a)Total Displacement with CD Method



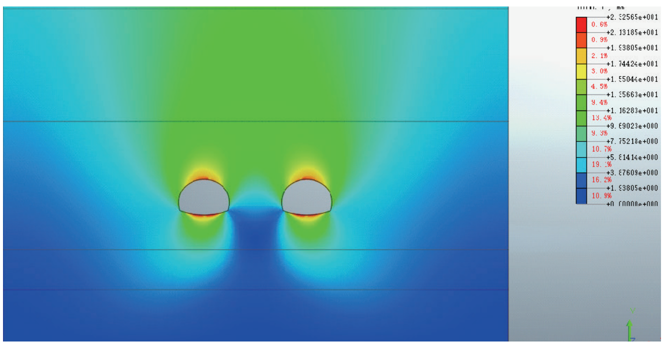
(b)Horizontal Displacement with CD Method



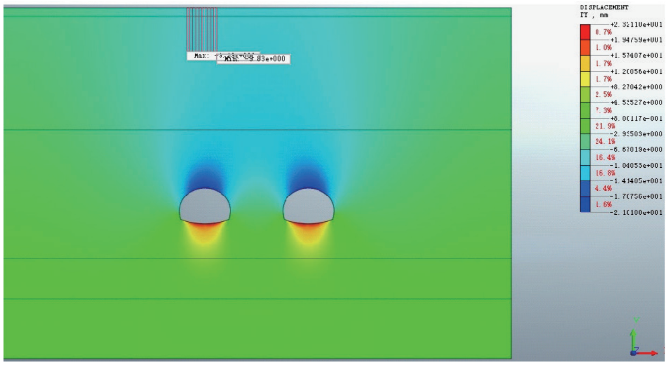
(c)Vertical Displacement with CD Method



(e) Horizontal Displacement with Full-section Method



(d)Total Displacement with Full-section Method



(f) Vertical Displacement with Full-section Method

Figure 4. Distribution Map of the Displacement of Surrounding Rocks

Table 2. Statistical Table of the Maximum Displacement of Key Sites

Construction Method	Location	Horizontal Displacement (mm)	Vertical Displacement (mm)
CD Method	Surrounding Rocks	6.5	13.8
	Foundations	1.0	6.1
Full-Section Method	Surrounding Rocks	10.8	23.2
	Foundations	1.6	9.8

After the excavation was completed, the maximum horizontal displacement of the rock around the cave was 6.5 mm, the maximum subsidence was 13.5 mm, the maximum uplift was 13.8 mm, the maximum horizontal displacement of the structure was 1.0mm, the maximum foundation subsidence was 6.1mm, the minimum foundation subsidence was 5.8mm, and the uneven subsidence was 0.39mm. During the tunnel excavation process, the foundation deformation was less, which meets the requirements of the "Technical Regulations for Basic Design of Overhead Transmission Lines" (DL/T 5219-2014) to control the maximum foundation inclination at 0.006. Although the full-section excavation also meets the specification requirements, the horizontal displacement of the surrounding rock was 4.3 mm greater than the CD method, and the vertical displacement was 10.6 mm greater. The uneven subsidence of the high-voltage electric tower foundation reached 0.64 mm, which was much greater than that of the CD method. From the perspective of the whole construction process, the CD construction method can well control the deformation of the surrounding rock and the foundation of the chamber, and reduce the impact of tunnel construction on the high-voltage electric tower.

4 Conclusions

The Hanping small-distance tunnel underpasses high-voltage line, and the construction requirements of the tunnel are extremely high. In order to ensure the safety of the 330KV high-voltage line tower above it, a series of safety assurance measures were formulated during the construction, controlling from the two aspects of the displacement of the chamber surrounding rock and the subsidence of the high-voltage tower. In order to ensure the smooth progress of the construction, the large-scale finite element program GTS was used to carry out the full-scale construction simulation of the whole process. Through simulation analysis, it was found that using the CD method for construction to control the displacement of the surrounding rock and the subsidence of the high-voltage electric tower, the displacement of the rock can be controlled within 15mm, and the maximum subsidence of the high-voltage iron tower is 6.1mm, which meets the relevant requirements of the regulation. It is recommended to use the CD method to reduce the area of a single excavation in the construction of such large-span and small-distance underpassing high-voltage tunnels. In order to further reduce the impact caused by blasting, use smooth blasting and control the single charge amount to protect the safety of the high-voltage transmission lines.

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Journal of World Architecture

Research Article

Rethinking of Construction Robot in the Whole Project Life Cycle

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Abstract: Assistive technology and evaluation system are expected to effectively solve the challenges of using robots in construction activities and improve the efficiency and building performance. Still, challenges are still need to be addressed before using robots for construction on a large scale. This Studies were corresponded to the identified areas for further critical review, and the development of research and application in each area was systematically analyzed to identify future directions for both the academia and the industry. More specifically, this review focus on determining the requirement of technology and application profile for robots, and based on the above analysis, a complete set of construction framework for robot was proposed, which integrates robots and activities with the various modular systems and digital technology to get global optimum solution.

Keywords: Assistive technology; Evaluation system; Artificial intelligence

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1 Introduction

1.1 Computer vision system

Important precondition of the practical application of robot is to have the technology of perceiving the external environment. With the approaches like machine learning(MI) (Lawaniya 2020), artificial intelligence(AI), approximate nearest neighbors (ANN) (Wahrmann 2019), pre-assumption, computer vision system could assist robot to achieve navigation (Feng 2019), identification and modeling in completely unknown environments. Yet, there are some challenges such as object recognition. Until now, only a few of object which have a proper scale could be well recognized, other objects may have the following identification errors such as low-accuracy (i.e., deformation, fuzziness etc.) and drifting effects (i.e., scale variation, warp etc.), which will reduce the efficiency of recognition in robot vision.

1.2 Communication technology

The timeliness, nondestructive and efficiency of information flow exchange in human-robot interaction and it play an important role in the development of robot technology, and significance are continuously deepened. However, the current communication signal on the site attenuates seriously in the process of transmission, so the communication speed is slow and the cost is high. For the complexity, variability, and abundance of information at the scene, thus it is critical to create communication network between the site work status and the project network and establish information integration management standards, so as to solve interoperability and cloud computing problems to ensure the seamless exchange of information flows.

1.3 Intelligent system

With robots failing to comprehend actual situation on expectations, the use of construction robots has been planned at three different levels of abstraction. At the bottom signal, the data and corresponding actions are mapped at physical level; the middle layer and language layer reflect the robot's reading of external information in the form of symbols. The automation system developed to realize above function based on the development of intelligent system. One key advance in this domain process sensor data and drive robot hardware, allowing system interfaces to access various databases and hardware control systems (Zekavat 2014; Kangari 1988)

1.4 Control technology

Vigorous development of control technology enable the robot to complete the scheduled task in contexts that either structured/unstructured environment. For example, remote control technology further illuminate not only the capability to construction robots or mechanical equipment to reach extreme environments that are difficult to reach or unsuitable for human beings, but also the construction costs were effectively reduced and efficiency were improved (Hainsworth 1993.). Research crux in this domain highlights not only restricted to provide the robot with tools to sense the dynamic environment and make corresponding decisions and instructions, and arguably deserves more attention, how to achieve reliable environmental identification, effective motion control and real-time acquisition of location sensor data (Fong and Thorpe 2001). The author's table reports the existing control system has certain limitations which make robot having a higher error rate when completing tasks required high accuracy.

1.5 Simulation technology

Management could be uniform and effective, with the integrated modeling and simulation environment, for various resources involved in the simulation. Going beyond above content, the simulation of robot in different scenarios can provide empirical evidence and quantitative analysis for production activities, identifying the optimal resource allocation level and operation mode, the integration of economic indicators into the simulation operation can also reduce the cost budget to a certain extent. Yet, the technology has little considered in the actual production environment of prefabricated and modular structural design, with only around 13% (Abbasian-Hosseini, Nikakhtar, and Ghoddousi 2014) of the studies combining the actual production with robot simulation.

1.6 Positioning technology

In addition to the technologies mentioned above, improving the positioning accuracy of robot is also a key issue in robot research (Yu 2019). The use of multi-sensor fusion has become a spotlight in recent years. Besides, interactive execution demonstration based on model and visual simulation in advance, and the attitude control of the robot was integrated with the external environment to ensure robot operation accurately also become a trend. The strategies pose a significant challenge to robot application, because even with the most advanced localization technology or sensory, the needed accuracy is still difficult to achieve at a large environment.

2 Description of problems in construction whole-life cycle management

2.1 Planning and Design Phrase

2.1.1 Adaptive design

With building system and economy level became more complex and higher, a novel challenge in automatic construction research was emerged. How to ensure the success and smoothness of the construction process while various factors existed which affecting the construction quality and machine performance (Goessens, Mueller, and Latteur 2018) has important practical significance in the new era. Although variety of auto-adapted design approaches were applied during Planning and design phase, there still face many challenges. For example, it is difficult to form a complete design and construction mechanism.

2.1.2 Structural architecture

The components involved in the construction process were defined as the specific products from combinations of common elements, could be distinguished as multi-unit or single-unit modules. Traditional construction methods cannot flexibly combine components according to the functional requirements of the building, blind use will only increase construction costs, leading to a reduction in economic benefits. At present, intelligent and distributed control strategies are adopted to co-design construction structures, materials and robots, based on a variety of existing tools, such as Rhinoceros 3D, Grasshopper and Robot structure Analysis, can maximize the flexibility of the construction component to some extent. Yet, those methods always apply only to the design phase and does not take into account the uncertainties associated with subsequent related operations.

2.1.3 Robot oriented design

The selection and scheduling of construction equipment is also a task to be considered in the design and planning phase. Due to, existing machine or robot usually unable to meet the needs of construction automation, thus, how to combine the architecture design, construction process and mechanisms to design the construction robot mechanism and volume, as to achieve robustness and adaptability of robot in construction site, which became an urgent problem in application.

2.2 Construction Phrase

2.2.1 Industrial flow operation

Construction systems can be classified according to the types of equipment involved, building materials or operating environments, etc. Currently, most construction operations use distributed robot group cooperation to operate the pre-processed building components respectively. The more common way of definition is to define the streamline construction in the construction process from the aspects of numerical control program and path attitude. Although the former method clearly demonstrates the arrangement and design of the robot in accordance with the construction process, it does not consider the robot's adaptability to the inherent irregular terrain and environment of the site.

2.2.2 Construction man-machine management

Effective man-machine management can help the managers to gain more effective control over the flow of work at the operational level when the production blocks are issued to the unit of work according to the construction plan. At present, new information and communication technologies are widely used in on-site management of construction, effectively helping managers save materials, improve productivity and speed of information dissemination, but it cannot simplify the flow of information. The man-machine cooperation mode of construction site also brings new challenges and dangers to site management. To mitigate these hazards, operators need to have a rich understanding of the building and robot operation characteristics.

2.3 Maintenance Phrase

2.3.1 Evaluation and monitoring stage

Quality assessment and testing is an indispensable process in the whole construction activity, and continuous testing of building performance after construction is completed is necessary (Ghaffarianhoseini et al. 2017). Accordingly, the researchers designed and developed various mechanical equipment capable of quality inspection, evaluation and monitoring, and equipped the equipment with multiple sensors related to the developed fusion algorithm. Yet, for the existing equipment, the error of position estimation is large, and the efficiency, availability and repetition are also unsatisfactory, which means higher requirements for perceptive hardware system.

3 Research related to construction robot

3.1 Planning and design phase

As a new construction element, the robot has a certain impact on the original construction method. Based on the demands of all parties, the robot-oriented construction method leads to more complex construction systems due to its multi-faceted products, life cycle with complicated and long-lasting characteristics, multiple and critical dimensions, as well as the fixed construction site. Hence it is absolutely vital to use a comprehensive modular construction design method (Bock and Thomas 2015) to add the robot as a new element to the original building system while meeting the functional requirements and construction specifications. How to reduce the factors affecting construction quality and the performance of robot by appropriate combinations while ensuring the proper construction of the robot has important practical significance in the new era (Goessens, Mueller, and Latteur 2018) , have important realistic significance in the new period.

In order to better adapt to the characteristics of construction activities, the modular design of the robot itself is also a major focus of research. The process can be generated through the use of Automated Construction System and Integrated Information Management System, but the implementation of the process confronts various challenges which depends largely on how the operator transforms a particular building form (Mammen, Jacob, and Kokai 2005; Werfel, Petersen, and Nagpal 2014) into a construction activity performed by robots. High-efficient auto-control system and perception also needs to be added in robot itself , tightly integrated structuring , construction, mechanism and control to achieve scalability and adaptability (Petersen et al. 2019) for a particular job or top-down bottom-up collaborative integrated hardware and software systems, adjusting traditional construction processes and improve the role of the construction party, eventually generate the viewpoint of technological innovation in the building environment guided by the whole life cycle (Bock and Thomas 2015).

What's more, single robot always inability to meet the demands of actual application during construction process. Therefore, multi-robot system is often be considered to systematically accomplish the tasks of automatic acquisition, transmission and accurate matching of components in construction tasks. The strategy gets closer to real scene of construction of the object, so that the robot can reach to more coverage and more powerful work and adaptive capacity.

3.2 Construction phase

The more common robot strategy at this stage is to define the application of the construction robot from the NC program and the attitude path, employing computer-control system to realize the autonomous construction of different types of robots on the physical plane based on the mathematical model and coordination algorithm. Although the above clearly illustrates the mechanism of the robot for the construction process, few considerations have been given to the robot's adaptive capacity for the inherent irregular terrain and construction environment of the site. To make up for the above-mentioned shortcomings, distributed multi-robot architectures and visualization began to be considered by researchers in construction site.

Distributed multi-robot architectures are often used in irregular terrain to complete tasks such as component identification, transportation, and exact matches between different locations by heterogeneous robot groups (Parker 1994; Rus D 1995; Wawerla, Sukhatme, and Mataric 2002). During construction while avoiding collision or interference ensure better efficiency collective robot construction, with a visual or communication technology (Balch and Arkin 1998; Carpin and Parker 2002; Desai, Kumar, and Ostrowski 2002) precise positioning is necessary. However, the application of the collective robot is limited to the height of the feature processing rules in a structured environment for construction work at present. It is necessary to develop the ability of collective robot to recognize the structures with obstacles and mobilization of mechanical resources on the scene can be improved by extending the model and algorithm, while the robot is not constrained by irregular terrain.

Visualization is one of the basic elements of a robot construction-management system. Robots at the construction site must move through an unstructured environment to perform tasks (Liang et al. 2019), and the robot and operator also need to maintain real-time perceptual interactions. With the sensors and vision systems we may monitor the attitude in real time and strengthen the locale information by Augmented Reality, providing real-time information necessary for the workers and the operator (Lundeen et al. 2016; Azar and Mccabe 2012; Soltani, Zhu, and Hammad 2018; Vahdatikhaki, Hammad, and Siddiqui 2015).

3.3 Detection and recovery phase

Quality assessment and inspection act as an indispensable process in the event overall, with the emphasis on the continuous inspection of building performance after construction (Ghaffarianhoseini et al. 2017). Accordingly, researchers devised the robot with quality inspection, evaluation and inspection capabilities, and equipped the robots with multiple sensors related to the fusion algorithm, making robots perform non-contact detection in certain areas to improve efficiency. The real trick is to establish a larger computer vision database identifying more types of nonconforming components in conditions, providing information for quality control and updating architectural models.

The combination of computer vision technology and full coverage path planning algorithm to complete the recycling of construction waste can effectively solve the inefficiency and high cost of traditional methods. The second way is to use neural network technology to attract the robot to the unscanned area and produce the effect of repelling the robot's obstacles (Batsaikhan, Janchiv, and Lee 2013; Khan et al. 2017; Caihong et al. 2015; Freeman and Shapira 1975), typical algorithms including full coverage path planning algorithms.

4 Shortcomings and Challenges of robot in construction

The robot in construction is often regarded to be non-obvious in improving Construction benefits due to the challenges in Section 4. As diverse innovative technologies and application range continue to develop, researchers and engineers are increasingly aware that innovative technologies and application can be an effective solution to inefficiency of robots. In the period of rapid development of automation and information, a large body of research have just tried to apply robots to particular construction activities without determine: (1) Adaptability to the dynamically changing built environment; (2) Whether the accuracy required by the building can be reached; (3) The contribution of robots on construction. Then, we will discuss the challenges of applying robots to construction application and technical challenges. The details are as follows.

4.1 Technical challenges

Having a complete system of robotics of multiple categories to enhance the applicability of robotics to single or multiple construction tasks is the critical factor to future research. simplifying and controlling the construction site or process by determining the duplicated degrees and regularity of structural configuration and material repetition, while increasing the complexity of operation and production to develop new technologies of high effectiveness. However, the construction operations involve many characteristics like complexity, long life cycle, dimensional diversity and physicality, and the unique nature of fixed location (Diaz, Doostan, and Hampton 2017) that stymies the use of technology for construction of robots.

To make the feasibility of robots at the activity level, the gap between product design and mechanical devices must be narrowed (Gambao, Balaguer, and Gebhart 2000), the crux of research is the evolution of CAD that we can give the robot the ability to design and control which are beneficial to make up of the interaction and interconnection. Thus, there is a new system for collecting, processing, analyzing, exchanging and implementing construction information to integrate the design of Processes and products and manufacture on the premise of improving communication technology. The establishment of some kind of self-positioning access implementation "sense-act" (Linner and Thomas 2013) Operation, combining the robot's position and posture more accurately, and finally forming an optimal path.

Due to the drastically different between simulation modeling examples and the actual robot construction process, researches have had to spend so much time and energy undertaking their experimental works to ascertainment error. The key to the problem is to re-analyze and plan the nature and implementation of the construction operation, an effective method is to explore the potential use of mechanized or automated methods to change the design or equipment. To increase the degree of mechanization and automation of construction under the inherently rigorous and chaotic background, the priority is to develop hardware equipment with high universality and accuracy to cover the single type device to improve the automation of machinery to meet the requirement of precision and efficiency of robot programming control in remote or off-line state.

While simulation software is capable of Predicting the effect, it is essential to recognize that large deviations between the path or attitude of the robot construction and the theoretical design model due to environmental factors or the robot itself. Thus, we should analyze the intelligence control research (Ma and Liu 2018) to make intelligent robots constantly report site geography, project progress and location information to central computer and so on (Omar and Nehdi 2016).

4.2 Deficiencies of the application

As mentioned above, there has been a guarantee for robot activities to ensure its maturity and usability to rely on the complete standard system with sufficient operating efficiency and comparatively high operational suitability of robot. By means of different standards for various construction activities are classified in terms of the basis of the sufficient research about materials, categories of robotics, construction procedure, etc. and in combination with robot standard operating system, evaluation method of digital technology and sustainability performance evaluation index building a robot construction standards to determine the relationship between the different factors of production in new construction mode.

Relatively little economic data has been produced on robots due to the lack of experience of robots in the construction industry. Thus need to build a comprehensive evaluation index system to describe the robot activity and form a model of it and the common steps and economic evaluation system of the robot on the civil engineering, which can forecast a wide range of common economic activities and allocate resources timely(Moselhi and Hason 1989).

5 Solution and further research

5.1 Combining robotics & basic technologies in key research area

Compared with actual requirements, the production efficiency for robotics was lower. Current robotics technology will inability to complete a series of activities smoothly with the increasing complexity of the construction and the closer links with multi-modules. The technology will not be of utility value if it cannot be improved to adapt to changing construction specifications and provide real-time feedback on a dynamic environment.

5.2 Ensuring the man-machine interoperability & exchange of information flows

Research on construction robots is a multidisciplinary field (Cai et al. 2019), the improvement of robot level relies on the robot positioning accuracy. We suggest that robot should use the computer-based image processing for architectural design visualization and simulation models interact to perform demonstration. The robot posture control with the external environment is integrated that shows states, sequence, and information stream between them to improve the robot level of the building will be an important topic. With this in mind, the integration of BIM and IOT should be developed that addresses two issues: (1) ensure unhindered man-machine interoperability; (2) extend data manipulation capabilities with minimal cost and speed by cloud computing; (3) the real-time exchange of information stream.

5.3 Auto-create robotic "sense-act" framework

The automated system developed for the autonomous construction of robots relies greatly on the Artificial Intelligence, transfers design information to databases supported by robots. Thus, we attach that there is a critical point to develop an intelligent control system for processing the sensor data on the control signal and the driving of the robot hardware. In doing this, this system would able to allow system interfaces to access various databases and hardware control systems (Zekavat 2014; Kangari 1988), thus controlling the robot to reach extreme environments (Hainsworth 1993.). Thus, 'perceived data - response' data can be stored in the system internally, which can be trained and iterated continuously in real-time. By this means, new-type of correspondence will be able to be forecasted, with poor feedback or handling being able to be improved(Fong and Thorpe 2001).

5.4 Virtualization with simulation platform, mode-lling software and BIM

Virtual simulation technology has been frequently applied while Implement the construction activities, quantitatively analyzed and improved the robot situ-model involved with various resources. Through using this technique, it is sufficiently feasible to establish systems that can develop, design and plan in order to:

•Visual architectural management during the design and construction process.

•Identify optimal resource allocation levels and practices.

•Obtain real-time model information that represent the entire implementation.

The advantages of using BIM over the whole life cycle (Davtalab and Omid 2017; Becerikgerber and Rice 2012) are explicit that beyond the reach of the degree of participation and implementation details in various stages of robot. The lack of data interoperability between the BIM platform and robot system currently makes it impractical to use algorithmic approach to automatically generate a database of automated operating locations. There is a need to customize and expand the BIM platform by inheriting the virtual reality interface, and attach information related to automation to fully take advantage of the new opportunities provided by robotic systems (Davtalab, Kazemian, and Khoshnevis 2018).

5.5 Applying robots in practice

5.5.1 Establish comprehensive system of technical standards

Robot has generally been applied in construction within an explicit benefit goal where the high adaptability application condition is defined, so it is necessary to establish a complete set of technical standards system to evaluate research conducted by independent research institutions, using various indicators to detect the efficiency of construction of robots as well its operational reliability and running efficiency. Classify various construction activities by different criteria, combining with the standard system for robot operations, evaluation method of digital construction technology and sustainability performance evaluation index based on the sufficiently study of mechanical equipment, the categories of technologies, scope of application, conditions on the spot, resource allocation, economic benefits and energy consumption, etc. building a standard system and eventually confirming the new fabrication approach of the relationships between various factors of production.

Simultaneous, factor of influencing the performance of technology in context to sustainable development including robustness, adaptability, and accessibility should also be evaluated:

•Detailed techniques need to be evaluated according to its popularity, and reliability at operation process would be considered synchronously during runtime.

• Robot should be able to complete construction activities in the uncharted and highly dynamic changing environment, and maintain higher adaptability.

• The accessibility of technology would be evaluated by the technology provider and machine component performance.

5.5.2 Define the evaluation system between economic benefit and social performance

It is predictable that robots can directly use, supplement or substitute human activities to brings the direct benefit of decreased cost of production and elevated productivity. Here, the social benefits evaluation research has three approaches:

Adopt the thought of systems engineering to establish a project-oriented evaluation system which including five major indicators: 1) construction site; 2) mission objectives; 3) related agency; 4) resource allocation; 5) other. Evaluation system integrate five indicators aim to overcome the drawback of incompleteness of individual ones.

The improvement of building quality by robots, the government's encouragement of innovative technologies and the new impact of applying robot to the construction environment are taken into account in terms of economic benefits, and the effect of increase and decrease of related benefits by automation to varying degrees are considered.

With the growth of robotics, the corresponding social benefit evaluation research will achieve rapid development, such as carbon emission statistics, analysis of resource and energy consumption, cost estimation, etc, forming a virtuous circle related to the development of robotics, which in turn will promote the iteration of the technology itself. Ultimately, it helps us assess the potential benefits of each level of complexity in the robot construction process.

6 Conclusions

Assistive technology and evaluation system are expected to effectively solve the challenges of using robots in construction activities and improve the efficiency and building performance. Still, challenges are still need to be addressed before using robots for construction on a large scale. This Studies were corresponded to the identified areas for further critical review, and the development of research and application in each area was systematically analyzed to identify future directions for both the academia and the industry. More specifically, this review focus on determining the requirement of technology and application profile for robots, and based on the above analysis, a complete set of construction framework for robot was proposed, which integrates robots and activities with the various modular systems and digital technology to get global optimum solution. As the improvement of information and automation technology, modular design and digital technology will be gradually introduced into the construction site, robot framework proposed by this review will act as a powerful tool to improve the efficiency of robot construction and lay the foundation for the industrialization of construction.

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Journal of World Architecture

Research Article

Optimization of Maintenance in Civil Aviation Aircraft Equipments

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Abstract: As the economic level rising, the function and stability of civil aircraft have been greatly improved. However, with the development of science and technology in modern civil aviation transportation, the frequent occurrence of flight accidents has threatened people's safety. The main reason is the internal failure of the engine body or the daily maintenance management is incomplete. Therefore, the relevant maintenance management departments should attach great importance to the first core research and management of civil aircraft stability and safety. In view of various equipment problems existing in the operation of civil aircraft, the practical application of data collection mode and maintenance information disclosure mode of modern aircraft maintenance equipment is analyzed. This paper describes some characteristics of aircraft maintenance work, and combined with the main factors affecting the risk of civil aircraft maintenance, giving countermeasures and suggestions to effectively improve the level of civil aircraft maintenance risk management.

Keywords: Civil aircraft; Equipment; Maintenance; Optimization

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1 Introduction

With the development of society and the progress of science and technology, people have developed from ground transportation to air transportation. The appearance of aircraft has become one of the symbolic characteristics of civilization progress. Nowadays, aircraft has become an indispensable means of transportation in people's daily life. From a professional point of view, the structure and technology of aircraft are very sophisticated, and the equipment and instruments sizes are also very large. If equipment failure occurs, it will seriously affect the flight and operation of civil aviation aircraft, seriously threaten the safety of nation's life, and it is not conducive to the development of aviation industry. From the perspective of civil aviation transportation, safety has always been the core issue and also the basic requirement for land, sea, air transportation industry. Among them, civil aviation equipment, as an important equipment of air transportation, must strictly abide by national standards and requirements, do a good job in the maintenance of civil aviation equipment, ensure the reasonable implementation of various safety regulations and maintenance procedures, ensure the sustainable development of China's aviation industry. At the same time, reducing the aircraft failure rate is also an important work which beneficial to nation. Relevant aircraft maintenance risk management departments should also carry out scientific management, attach importance to aircraft maintenance management, and ensure the safety of aircraft operation. In recent years, the incidence of aircraft accidents is rising. Due to various reasons, aircraft maintenance risk management also needs careful inspection, scientific maintenance, reasonable improvement and appropriate management. In modern aircraft maintenance, through continuous experience summary and equipment update, civil aircraft on-board maintenance system gradually forming a system[1].

2 Risk characteristics of civil aviation aircraft maintenance

2.1 Necessity and complementarity

Currently, the maintenance management of civil aircraft has not been fully automated and intelligent, and it is still depending on manual maintenance. In the process of maintenance, due to the human's subjective judgment, some maintenance errors might inevitably occur. In addition, the accuracy of aircraft determines the complexity of the system, so it becomes an inevitable feature of civil aircraft maintenance management. However, from the accuracy of maintenance, these errors can be solved. After maintenance, through equipment inspection, troubleshooting and obstacle avoidance can be succeeded[2].

2.2 Randomness and concealment

The structure and accuracy of the aircraft are very high. In order to maintain the efficiency and quality of aircraft maintenance, we must be much careful. In the whole process of aircraft maintenance, due to the complexity, there will be inevitably some small factors and also randomness which causing aircraft failure. Many obstacles cannot be simply detected. The hidden feature of aircraft maintenance is that only when all aircraft working normally, the maintenance task can then only be said completed[3].

2.3 Cumulative

Due to the hidden danger of civil aircraft maintenance, many aircraft cannot find and judge the existence and faulty part in time. Therefore, it is necessary to make a suspicious judgment according to the actual and careful inspection, remove the specific faulty parts and complete the aircraft maintenance work. It is often affected by some factors in the whole process. In addition, other parts of the aircraft and subsequent maintenance work will also affect the operation, which shows the characteristics of continuous accumulation to a certain extent[4].

2.4 Hysteresis

Currently, the maintenance technology of civil aircraft cannot catch up with the advanced level of aircraft equipment. Due to the high complexity of aircraft maintenance, aircraft maintenance workers need to have a high degree of professional skills and professionalism. Currently, the aircraft operation system is updated very quickly, and the whole system is very related. If some of them are exposed to the risk of failure, they may directly spread to the whole system operation. The technical level of machinists is an important dependence to solve the problem of aircraft. Therefore, the technical level of civil aviation machinists is very important. If the technical level cannot keep up with the progress of aircraft system, the maintenance quality of civil aviation aircraft will be seriously affected[5].

3 Problems in maintenance of civil aviation aircraft

3.1 Business process delay

Currently, most of the civil aviation maintenance tools management system is in the post-processing or manual processing stage. For example, carry out rectification according to the temporary requirements of the purchasing department, or only repair and recycle the civil aircraft when obvious fault problems occurred. It can be said that the pre control work has not been effectively implemented, which cannot fundamentally avoid the danger of civil aircraft equipment. For business processes, maintenance technician need to go through multiple business processes to formally perform maintenance tasks. As a result, once the aircraft has serious problems, it is difficult to repair them in time, and the hidden danger problems becoming more serious. In view of this, the business process of civil aircraft equipment maintenance should be reasonably improved and optimized according to the actual situation.

3.2 The quality of maintenance technician needs to be improved

To a certain extent, civil aircraft equipment maintenance technician are selected from different levels before taking up their posts, most of the theoretical knowledge is strong, but actually relatively weak. The most important thing is that most of the maintenance technician in the long-term work process of the existence of fluke gradually increased, some hidden problems were not dealt in time. Due to this part of hidden problems that cannot be repaired in time, makes the normal operation of civil aircraft difficult to be effectively guaranteed. Therefore, it can be said that currently, the quality of maintenance technician needs to be improved, which must be strengthened in time to ensure the safety of aircraft equipment.

3.3 Maintenance means lack of rationality

The maintenance management of civil aircraft equipment is mainly administrative management means. However, administrative means often include complex and changeable working procedures. In addition, there are also blind spots in equipment maintenance means and related management. For example, the lack of reasonable storage methods will affect the inspection efficiency of subsequent tools and equipment, and seriously limited the maintenance efficiency.

4 Suggestions for civil aviation aircraft maintenance management

4.1 Improve the problems solving ability

The maintenance process of civil aircraft is also the process of problems solving. In addition to quickly solve problems, it is also necessary to prevent failures. Therefore, in order to improve the effect of civil aircraft maintenance risk management, one of the effective methods is to record the civil aircraft failure and processing in detail, establish a perfect database, and improve the risk of subsequent failure maintenance in the management work. When similar fault occurs, the fault can be handled quickly and the effect of aircraft maintenance risk management can be improved.

4.2 Improve maintenance management standard requirements

Reasonable maintenance management standard is a necessary condition to ensure the safe operation of civil aircraft. In the past, civil aviation managers paid more attention to the maintenance management of aircraft faulty problems but ignored the maintenance management of aircraft maintenance equipment. Often lack of strength in the performance of maintenance management responsibility, or some content is difficult to effectively perform. In order to further improve the safety and rationality of civil aircraft maintenance, maintenance managers should further refine the management content and technical content in combination with the relevant content of equipment management, in order to fundamentally guarantee the scientific rationality of civil aircraft maintenance equipment. Therefore, maintenance managers must be clear about the importance of equipment maintenance management and the important content of maintenance technology to ensure the maintenance effect of equipment. Therefore, managers should strengthen equipment maintenance standards, pay attention to equipment technical data and technical standards, and strive to optimize the maintenance process. In the specific implementation, the administrator can start according to the order of equipment maintenance. The management can communicate with the factory deeply, and the manufacturer must provide feasible maintenance management manual and relevant parts standards. In this process, managers should do a good job in data collection of maintenance equipment. According to the actual situation, it is better to set up a reference room, which is in the charge of experts and uniformly deployed and managed. Combining computer technology with information technology, establish the maintenance management database of maintenance equipment. The information content of the database can include the technical parameters, number and price of the equipment, reasonably record the state of the equipment after scrapping, and provide scientific guidance for the follow-up maintenance and management. It is worth noting that the management should optimize the maintenance management process and effectively deal with the safety risk of civil aircraft in combination with the actual situation[6].

4.3 Strengthen management work

Currently, civil aviation maintenance technician do not pay enough attention to maintenance rules and regulations, and airlines must fundamentally solve this problem. The aircraft equipment repair department of airlines can effectively strengthen the daily management of equipment, including focusing on the problems or failures in the daily maintenance management, and effectively recording various problems on the aircraft, in order to provide reference and maintenance in case of the second failure of the aircraft. In this process, maintenance technician should strengthen the integration of various technical resources, and effectively optimize the technical equipment and technical means which suitable for the maintenance equipment. It must be rectified in accordance with the current national standards and requirements. If necessary, an inter departmental professional team can be established to solve the problem of equipment operation failure and ensure the maintenance effect of civil aircraft. Among them, the equipment management team established between departments can incorporate equipment maintenance into the internal management system of the organization, and assign professional and technical technician to solve common failures or other difficult problems of civil aircraft equipment. Do a good job in daily supervision and management to ensure the safety of civil aircraft operation to the maximum extent.

4.4 Improve the professionalism of maintenance technician

The professional level and responsibility awareness of civil aircraft maintenance technician are related to the efficiency and quality of maintenance risk management of the whole civil aircraft. It is also an important means of aircraft maintenance risk management. Its ability and quality are important factors to determine the effect of aircraft maintenance. Therefore, civil aviation enterprises should actively strengthen the training, improvement of professional knowledge and technical ability of aircraft maintenance technician to ensure the effective development of aircraft maintenance management and improve the effectiveness. In order to further ensure the safety operation of civil aviation aircraft, leaders of civil aviation enterprises should carry out regular training for aircraft equipment maintenance technician and strengthen the professional quality of maintenance technician. In the specific strengthening process, we can start from the aspects of working ability, employment qualification and operation ability to comprehensively improve the professionalism of maintenance technician, avoiding the situation of previous low-quality technician. In addition, civil aviation enterprises can make up for the deficiencies existing in China's maintenance and repair management, comprehensively improve the maintenance level of civil aviation aircraft equipment according to the appropriate overseas advanced repair and maintenance experience for maintenance and repair technician. It is believed that through the unremitting efforts of all technician, the maintenance level of civil aircraft equipment will be further improved.

5 Conclusion

The good operation of civil aviation aircraft is related to the safety of the people. At the same time, it is necessary to ensure the effective implementation of various safety regulations and maintenance contents, to fundamentally improve the operational safety of civil aviation aircraft.

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Journal of World Architecture

Research Article

Construction Technology of Large-deformation High Geostress Soft Rock Tunnel

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Abstract: In the process of tunnel construction, if large-deformation occurs in high geostress soft rock, it will likely cause geological disasters. This situation will not only seriously affect the smooth progress of tunnel construction, but also cause serious safety threat to the construction personnel. Therefore, with the continuous growth in the number and scale of tunnel construction in recent years, the construction technology for high geostress soft rock with large-deformation has begun to receive more and more attention from the society. Based on this, this paper takes an actual project as an example to analyze the specific application of the technology in order to improve the construction effect and avoid the damage caused by the large-deformation of the high geostress soft rock.

Keywords: Tunnel construction; High geostress soft rock; Large-deformation; Construction technology

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1 Introduction

The total length of a certain tunnel is 3127 m. In this tunnel, the design end at 1863m is in the Class V soft rock geology. At the position where the tunnel body passes through, the rock mass in the geological layer has obvious fragmentation, and has the characteristics of high porosity, prone to weathering, etc., and the whole geological body is very unstable. From the perspective of overall plate structure, because each plate will be squeezed by many surrounding plates, a large principal stress is formed. This condition will bring many difficulties to the construction of underground tunnel projects, and there are also big problems in construction safety. Therefore, in the specific construction, the construction team needs to use corresponding technology to prevent the adverse effects of large-deformation in high geostress soft rock, and to ensure the construction progress, construction quality and safety.

2 Analysis on the Deformation Characteristics of High Geostress Soft Rock in Tunnel

In the construction of the tunnel studied this time, the main deformation characteristics of the high geostress soft rock include the following aspects: The first is greater deformation strength and faster deformation speed. In this area, the total dome subsidence can reach about 0.5m, and the maximum convergence can reach about 0.11 m. The horizontal convergence is much larger than the dome subsidence, which shows its strong squeezing characteristics. The gastritis has a very large deformation rate in the initial stage, which shows that the compression is very serious, and the soft rock in the tunnel is very weak, prone to breaking, and poor stability. The second is a longer deformation time. Under the action of high geostress and construction, the soft rock in the tunnel will show a trend of continuous deformation, which will cause serious obstacles to the construction process and construction safety, and even damage the initial support. The third is the uneven spatial distribution of the deformation. In the tunnel area, the soft rock deformation is mainly characterized by asymmetry and unevenness between left and right. After the initial support was completed, there will still be deformation on left and right sides of the tunnel, and the difference in deformation amplitude on the same level is very significant. The fourth is the phasal sudden change. During the excavation process, the steps up and down often sink suddenly, which will cause serious adverse effects on the construction. Fifth, sudden changes are likely to occur under construction interference. After excavation and support of the rock mass, the deformation speed of soft rock will gradually increase due to disturbances from the processes, especially after blasting and other processes, the deformation will become more severe. It can be seen that during the construction of this soft rock geological tunnel, the construction team should take reasonable technical measures to control the soft rock deformation to avoid large deformation of the soft rock caused by high geostress, and to ensure the safety of the construction.

3 Analysis of the Control Technology for Large-deformation High Geostress Soft Rock in Tunnel

3.1 Pay Attention to Advance Geological Forecast

During the specific construction of a high-geostress soft rock tunnel, it is necessary to use advanced geological forecast to make timely judgments of the geological conditions that props up ahead, and determine a reasonable control plan based on construction experience[1]. In this construction, the TSP203 advanced geological forecasting system was mainly used to obtain advanced geological forecasts, and to achieve organic integration with the advanced geological drilling on the working surface. In this way, the actual geological deformation and its development trend before the tunnel excavation construction can be predicted in time, so that effective countermeasures can be adopted in time.

3.2 Modify the Shape of the Tunnel from Straight Wall to Curved Wall

In this project, most of the tunnel shapes are side-walls. Due to the high geostress during construction, the tunnel wall has a rapid and large-scale deformation. Observation of the deformation inside the tunnel found that the concrete cracking at the deformed sites was very obvious, and there were distortions and cracks in the inner drum of the support and the arch, which seriously affected the construction safety. Through the study of its force action principle, it was found that in the process of excavating the inclined shaft section, the circular excavation can effectively prevent the concrete cracking, and then play a role in dispersing the force, thereby reducing the concentration of forces; and with the help of a closed-form of round and curved sections, high geostress can be slowly released. In this way, large deformation of soft rock caused by high geostress can be effectively avoided, effectively guaranteeing construction progress, construction quality and construction safety.

3.3 The Application of 'Soft First Followed by Steel' and 'Release before Resistance' Control Technologies

The 'soft first followed by steel' refers to the setting of a flexible supporting structure first and the setting of secondary lining as a rigid structure. In this construction, the main components of the flexible supporting structure included steel frame, concrete and steel mesh. The secondary lining structure was constructed by filling concrete with a rigid mould, and its bearing capacity should be consistent with the design requirements of the actual project. The so-called 'release before resistance' refers to that a certain level of deformation can be allowed after the completion of the initial support construction as long as the deformation is controlled within the preset range[2]. Then, on this basis, the lining construction in the form of two-mould injection concrete was carried out.

3.4 Application of Multiple Support Reinforcement Control Technology

In this tunnel construction, it was decided to carry out the initial support reinforcement construction in the form of double-layer steel-frame net shotcrete based on the previous construction experience and the actual deformation characteristics of the soft rock. In the process of the first layer support construction, I-shaped steel-frame was mainly used. This kind of steel-frame is very rigid and can effectively reduce the deformation speed of the soft rock. Then the second layer support construction was carried out. The main construction purpose of the supporting layer is to prevent the further expansion of soft rock deformation, avoid damage to the overall supporting system, or minimize the degree of damage to ensure the supporting effect. The following are the main technical parameters of multi-layer support reinforcement to control large deformation of high geostress soft rock in this tunnel construction:

Table 1. The Main Technical Parameters of the Multi-layer Support Reinforcement to Control Large-deformation of High Geostress Soft Rock in this Tunnel Construction

Serial No.	Item	Parameter
1	Reinforcement frame model of the first layer supporting arch wall	H175
2	Concrete spray thickness of the first layer supporting arch wall	30cm
3	Reinforcement frame model of the second layer supporting arch wall	116
4	Concrete spraying thickness of second layer supporting arch wall	20cm

In specific construction, the construction of the second layer of supporting arch wall should be carried out 6 days after the completion of the first layer of construction or when the support deformation reaches 70%.

3.5 Reasonably Increase the Reserved Deformation

In the specific construction process, the increase of the reserved deformation can effectively prevent the intrusion of the clearance part of the secondary support after the spray layer is deformed. According to the different requirements of different sections in this construction, the amount of deformation reserved is also very different. For example, during the construction of the high geostress soft rock section of the main tunnel, it is necessary to reserve a deformation of 25cm on the left and right sides to reserve enough space for the subsequent construction of the secondary supporting arch wall[3].

3.6 Reinforcement Treatment for Bottom and Surrounding Rock

When constructing tunnels under high geostress soft rock conditions, strengthening the bottom treatment can effectively prevent the soft rock from uplifting, and strengthening the surrounding rock can effectively avoid soft rock deformation. Therefore, in this construction, these two treatment methods were specially applied reasonably to meet the actual needs of this project for supporting strength. In the construction section with large deformation strength, the supporting construction was mainly carried out in the form of a full-ring steel-frame, and the concrete thickness is 42cm. After the initial reinforcement of the surrounding rock, it was found that the deformation of the soft rock was effectively prevented, but this effect was only generated in the surrounding rock part, and there would still be serious deformation at the bottom, which brought a great degree of adverse effects to the tunnel construction. Based on this, the tunnel bottom was specially strengthened in this construction to effectively avoid the adverse effects of soft rock deformation on the overall construction effect and safety, so that the construction can be carried out in a safe and orderly manner.

4 Conclusions

In summary, in the process of tunnel construction, soft rock geology is the construction condition that is most prone to safety incidents, especially under the action of high geostress. Once the surrounding rock of the tunnel undergoes large deformation, the safety progress and quality control of the overall construction will be seriously threatened and even cause major construction safety incidents. Therefore, in the specific construction, the construction team must comprehensively analyze the specific characteristics of the soft rock geological conditions, and make a construction plan based on the actual engineering requirements, then control through reasonable technical measures based on it. Only in this way can the construction quality be effectively guaranteed, the construction safety can be ensured, and a better safety guarantee can be provided for the later application of the tunnel project.

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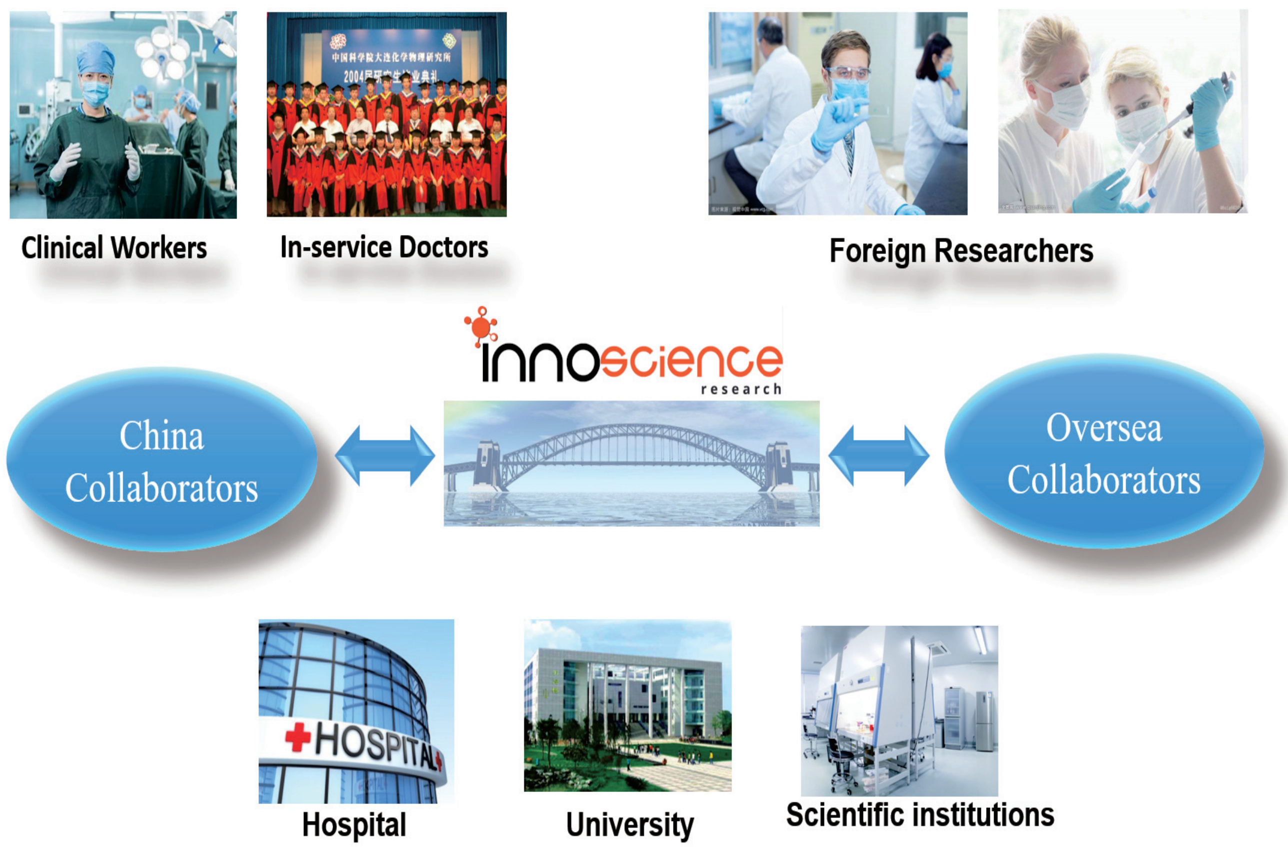

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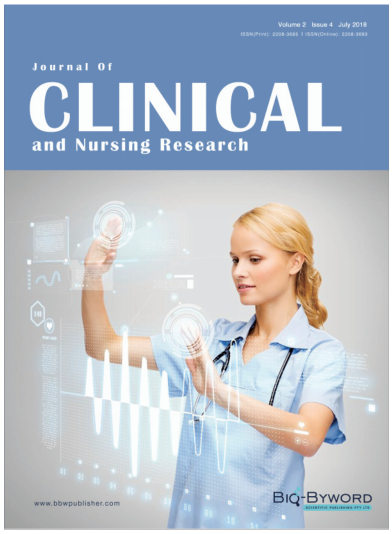

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