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Original Articles

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Research and Analysis of the Causes of Train Derailment Accidents Based on ISM Explanatory Structure Model

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Abstract: Train derailment happens from time to time,every accident will cause great economic losses and serious casualties. The reasons of train derailment are complicated,which makes it difficult for relevant technicians to take effective preventive measures. This paper studies the direct and indirect causes of train derailment by using interpretive structural model and transforms them into multi-level hierarchical directed graphs. The important factors affecting train derailment accidents are found out,and countermeasures for effective prevention of train derailment accidents are put forward. It will provide references for researchers in the field of train derailment studies and promote the rapid development of railway in our country.

Keywords: Systems Engineering; Interpretive Structural Model; The Train Derailed; Cause Analysis

1. Introduction

The operation and control of trains are related to the safety of passengers' life and property. With the large-scale popularization of rail transit,railway transportation has become the first choice for many people to travel,but railway traffic accidents often occur,especially the train derailment problem has become one of the important factors affecting the long-term stability of the rail transit industry. There are many reasons affecting the occurrence of train derailment accidents,and the direct and indirect relationship between each reason can not be inferred subjectively,but must sort out its hierarchy,so as to put forward targeted solutions.

Using ISM(Interpretative Structural Modeling Method) in system engineering to explain structural models,analyze the influencing factors of train derailment accidents,establish multi-level hierarchical directed graphs,and obtain the root causes affecting train derailment accidents. At the same time,master the general direction of solving the train derailment accident,in order to get effective countermeasures to prevent the train derailment accident.

2. Basic principles and calculation procedures of ISM

ISM interpretive structure model is based on the correlation matrix principle in graph theory,which is used to analyze methods with many complex factors and explore the direct and indirect relationships between each factor in the system. Through the transformation between matrix and graph,the structure system of complex factors is obtained,which can clearly express the relationship of each factor in the system,so as to grasp the root cause of the influence of the system. The ISM interprets structural models as follows:

Step-1:Find the elements according to the specific problem and build the set S .

Step-2:The relationship between elements is analyzed and the adjacency matrix A is constructed.

Step-3:According to the Boolean logic operation,add the adjacency matrix A and the identity matrix I to get matrix $V = A + I$,and then perform matrix $V = A + I$ as A matrix power operation according to formula (1) to get the reachable matrix $(A + I)^r$,in which the direct and indirect relations between various elements can be seen.

$$A + I \neq (A + I)^2 \neq (A + I)^3 \neq \cdots \neq (A + I)^r = (A + I)^{r+1} \quad (1)$$

Step-4: Determine the level of each element,and determine the set of each element to reach all elements as reachable set $T_{(S_i)}$; Determines that the set of all elements that can reach an element is the antecedent set $Y_{(S_i)}$. Then a new set O_1 is found according to formula (2).

$$T_{(S_i)} \cap Y_{(Si)} = T_{(Si)} \quad (2)$$

The elements are divided into the first level of the digraph O_1 . At the same time,the reachable matrix $V = (A + I)^r$ strips out the rows and columns of the elements concerned,giving V' . Then,according to the above calculation method,a new set of elements is obtained,which

are divided into the second level of the digraph O_2 ,and the set O_3 , O_4 , O_5 , O_6 ,... ,and the elements are graded.

Step-5: Draw a multi-level hierarchical digraph,using directed line segments to connect elements in different levels and express the relationship between elements.

3. Application process of ISM in train derailment accident research

3.1 Summary of main factors affecting train derailment

Through the review of relevant literature[2]-[5] in this field and the reflection of train derailment accidents at home and abroad,combined with the railway operation situation,it is summarized from four categories: natural disaster,the status of relevant personnel,the status of relevant equipment and relevant management measures the 20 relevant factors are shown in Table 1.

Table 1 Summary of relevant factors.

Element category	Specific elements under this category
Natural disaster	Earthquakes(S_1),Mudslides(S_2),Collapses(S_3)
Relevant person status	Mental state(S_4), Professionalism(S_5), Driving state(S_6), Mental quality(S_7)
Related facility status	Service life(S_8),Train operating parameter(S_9),Rail health status(S_{10}), Communication network state(S_{11}),Electric driving capacity(S_{12}),Wheelset wear degree(S_{13}),Train dynamics parameter(S_{14}),Train loading degree(S_{15})
Relevant management measures	The strength of the implementation of rules and regulations(S_{16}), The judgment of train operating conditions(S_{17}), The analysis of relevant data(S_{18}), The cleaning and maintenance of the track(S_{19}), The signal management and Control of the railway(S_{20})

3.2 Construct the adjacency matrix of the problem

After comprehensive analysis of all factors, the direct influence relationship between each two factors is obtained. Meanwhile, in the process of constructing the matrix, 1 is used to indicate that the two have a direct influence relationship, and 0 is used to indicate that the two have no direct influence relationship, as shown in Table 2.

Table 2 the adjacency matrix.

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	S_{19}	S_{20}
S_1	0	1	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
S_2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S_3	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S_4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_5	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1
S_6	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	0
S_7	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_8	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0
S_9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
S_{10}	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	1
S_{11}	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1
S_{12}	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	1	0	1	1
S_{13}	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
S_{14}	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
S_{15}	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
S_{16}	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0

S_{17}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_{18}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S_{19}	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1
S_{20}	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0

3.3 Construct the reachability matrix of the problem

The adjacency matrix and the identity matrix above are added and iterated according to formula (1). The reachable matrix is obtained after five iterations, as shown in Table 3.

Table 3 the reachable matrix.

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	S_{19}	S_{20}
S_1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
S_2	0	1	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
S_3	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
S_4	0	0	0	1	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_5	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
S_6	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_7	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
S_8	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_9	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{10}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{11}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{12}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{13}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{14}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{15}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1
S_{16}	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S_{17}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S_{18}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
S_{19}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1
S_{20}	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1

3.4 Hierarchical division

According to the generated reachable matrix, the reachable set and the leading set are sorted out, and then the intersection of the reachable set and the leading set is obtained as a whole, and the hierarchical division is discussed according to formula (2). According to the calculation, it is divided into 7 layers, from top to bottom, which are the first level, the second level and the third level..... The explanatory structure model diagram is shown in Figure 1. In order to make the graph expression more clear, the strong association relationship, reflexive relationship and leap-over relationship are not considered.

Figure 1 Structural model of train derailment accident cause explanation

4. According to model analysis

According to the first-level analysis, it is clear that The judgment of train operating conditions (S_{17}) has a relatively obvious impact on the occurrence of train derailment accidents. If the relevant staff cannot accurately predict whether the train can run from the train itself, the condition of the line, weather conditions and other conditions through their professional ability, the probability of train derailment will be increased.

The factors at the second level are all influenced by the factors at the third level.The third level of factors are Driving state(S_6), Service life(S_8), Train operating parameter(S_9), Rail health status(S_{10}), Communication network state(S_{11}), Electric driving capacity(S_{12}), Wheelset wear degree(S_{13}), Train dynamics parameter(S_{14}), The cleaning and maintenance of the track(S_{19}), The signal management and control Control of the railway(S_{20}), these factors are related to the equipment related to the train derailment event, including the equipment on the train, the track, and the rail transit system related equipment, combined with the first layer of factors, need to make further analysis from the data feedback information of these devices, so as to achieve the control of the train derailment accident.

Factors at The fourth level include Mental state(S_4) and Train loading degree(S_{15}), where Train loading degree is directly affected by The strength of the implementation of rules and regulations (S_{16}). The fifth level of Mental quality(S_7)directly affects Mental state(S_4).

From the relationship between the fifth and sixth layers, Mudslides(S_2), Collapses(S_3)and Professionalism(S_5)will affect Mental quality(S_7), and then lead to operational errors resulting in irreversible losses caused by train derailment. From the relationship between the sixth

and seventh layers, Mudslides(S_2)and Collapses(S_3)are probably secondary disasters of Earthquakes(S_1), while Mental quality(S_7)is affected by The strength of the implementation of rules and regulations(S_{16}). Only by doing emergency drills for earthquakes and other disasters and formulating emergency measures can we reduce the loss caused by accidents as much as possible. At present, the railway related system is relatively complete, but the implementation needs to be improved. We can start from the aspect of improving the professional quality of employees to improve the business ability of railway staff.

5. Conclusion

This paper analyzes the occurrence of train derailment accidents through the interpretation structure model, and uses the means of hierarchical division to sort out the relationship between various factors, and finds that the deep cause is the seventh layer factor -- earthquake and the implementation of rules and regulations, which represent the emergency factor and the human factor respectively. Combining with the relationship between other levels, the protection direction of train derailment accident is put forward, which is conducive to the "long-term stability" of railway transportation.

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Evaluation of Coordinated Development of Transportation and Urban Industry

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Abstract: The development of a city is inseparable from the support of transportation and industry. Taking Changshou District of Chongqing as an example, this article explores the coordinated development of the transportation system and urban industrial system. The study collected indicator data from the region from 2017 to 2020 and constructed an evaluation index system based on the characteristics of the transportation and industrial systems. The entropy method is used for quantitative analysis to determine the weights of each indicator and calculate the comprehensive score for the coordinated development of transportation and industry in Changshou District. In conclusion, it was found that while there are differences and lags in the development of the two systems, the overall coordination is steadily increasing. Based on the economic and transportation network situation in Changshou District, development suggestions are proposed.

Keywords: Transportation System; Industry System; Entropy Method

1. Introduction

The transportation system and the economy are closely intertwined. The transportation system is an important carrier of industrial development, determining the level and speed of industrial development[1]. The pillar industries of the economy promote the formation of the surrounding transportation network, and transportation development drives the flow of economic factors. With the development of society, the concentration and distribution of economic activities will increasingly rely on the transportation system. Therefore, the evaluation of the coordinated development of transportation and the economy is of great significance for the future planning of cities. In recent years, many scholars have conducted research on the relationship between urban transportation and industry.Liu YH et al. collected data on the "Guanzhong-Tianshui Economic Zone" and found that the backward transportation system could become a hindrance to the development of the tertiary industry[2]. Shen F, Hua ML focused on the coupling coordination between transportation advantages and economic development levels[3-4]. Tang YC et al. constructed an evaluation model for transportation advantages and discovered the spatial differences in the transportation and economic development in the Yellow River Basin[5].Wang XM et al. starting from the perspective of "industry-transportation" coupling, explored the spatial development characteristics of the Beijing-Tianjin-Hebei urban agglomeration and concluded that the low degree of overlap between transportation and industry development is an important reason for the lack of regional coordination[6]. In summary, there is indeed a close connection between transportation and industry.

The geographical advantages and historical opportunities have laid the foundation for the development of Changshou District into an industrial city, and have also had an impact on the local economy, transportation, and urban layout. This article will analyze and evaluate the coordinated development of transportation and urban economy in the Changshou District in recent years from the perspectives of industry and transportation.

2. Research area and data sources

2.1 Research Area Overview

Changshou District is a bridgehead radiating to the southeast and northeast of Chongqing. In terms of economy, the district relies on support from the secondary industry, and the development of the primary and tertiary industries lags behind. In terms of transportation, it is located on the transportation corridor between Chongqing and the northeast region, serving as a crucial hub for the main urban area's external transportation links.

2.2 Data Sources and Data Analysis

The data in this article is sourced from official statistical bulletins from 2018 to 2021. The data indicates significant disparities in the output value of various industries in Changshou District, with the output value of the primary industry consistently below 50 billion yuan. The output value of the tertiary industry has shown minimal growth, while the secondary industry has the highest output value. Furthermore, the volume of road freight transportation in Changshou District has increased, while road passenger transportation has declined, and the proportion of waterway passenger and freight transportation is extremely low.

3. Selection of indicators and research methods

3.1 Selection of indicators

Following the principles of scientific rigor, comparability, and data availability, a comprehensive indicator system based on industrial and transportation systems will be constructed. This article will focus on the industrial and transportation systems, and will discuss industrial development, industrial structure, energy consumption, transportation capacity, and infrastructure as the five key aspects of the evaluation.

3.2 Research methods

The commonly used weighting methods can be divided into two major categories: objective weighting and subjective weighting. The entropy method, as an objective weighting approach, has strong operability and better avoids the controversial nature of subjective weighting. Therefore, this paper chooses the entropy method to determine the weights of the indicators.

Selecting data for n years and m indicators, X_{ij} represents the value of the j indicator in i year (i=1,2,3…,n; j=1,2,3…,m). P_{ij}represents the proportion of the j indicator in i year.

（1）Calculate the entropy value of indicator j.

$$e_j=-\frac{1}{\ln n}\sum_{i=1}^{n} p_{ij}\times \ln p_{ij} \quad (1)$$

（2）Calculate the weights of the indicators.

$$W_j=\frac{g_j}{\sum_{j=1}^{m} g_j}, j=1,2,3,...,m, g_j=1-e_j \quad (2)$$

（3）Calculate the comprehensive score K for each year.

$$K=\sum_{j=1}^{m} W_j\times x_{ij} \quad (3)$$

4. Weighting of indicators and analysis of results

Collect data for various indicators in Changshu district from 2017 to 2020, calculate the entropy, coefficient of variation and weights for each indicator, and derive the overall system score.

Table 1: Calculation Results of Various Indicators for Coordinated Development of the Transportation Industry

Target layer	Weighting of indicators	Indicator layer	e_j	W_j
Industrial system	Industrial development(0.2048)	Regional GDP	0.7118	0.0622
		Fixed assets	0.7140	0.0618
	Industrial structure(0.1158)	Number of large industrial enterprises	0.6258	0.0808
		Proportion of the output value of the secondary industry	0.6859	0.0678
		Proportion of the output value of the tertiary industry	0.7776	0.0480
	Energy consumption(0.1039)	Total energy consumption of large-scale industrial enterprises	0.5186	0.1039

Transportation system	Transportation capacity(0.4542)	Mileage of classified highways	0.4931	0.1094
		Road passenger traffic volume	0.7722	0.0492
		Road freight volume	0.5475	0.0977
		Waterway passenger traffic volume	0.4474	0.1193
		Waterway freight volume	0.6357	0.0786
	Infrastructure(0.1213)	Total number of motor vehicles	0.6699	0.0713
		Road density	0.7682	0.0500

Table 2: Score of Coordinated Development of Transportation and Industry

Year	2017	2018	2019	2020
Industrial System	0.2006	0.1820	0.1968	0.2065
Transportation System	0.0739	0.1409	0.3323	0.3986
Overall Score	0.2744	0.3299	0.5291	0.6051

In 2017, the score for the industrial system was higher than that of the transportation system. From 2018 to 2020, the transportation system's score surpassed that of the industrial system. From 2017 to 2020, the comprehensive score for the coordinated development of transportation and industry has been on the rise, indicating that, although there is a lag in the development of transportation and industry in Changshu, the overall development is good.

5. Conclusion

The article is based on the coordinated development of the industrial and transportation systems, constructing an evaluation index system consisting of 5 primary indicators and 13 secondary indicators. The entropy weight method was used to calculate the weights of each indicator, ultimately obtaining the comprehensive scores for the industrial-transportation system and individual systems. Through analysis, the following conclusions were reached:

(1) During the evaluation period, there is a lack of coordination and relative lag in the development of transportation and industry in Changshu, which results in mutual constraints.

(2) From the perspective of the comprehensive score of the coordination between transportation and industry, the development of transportation and industry in Changshu is in a stage of continuous improvement in coordination.

(3) Transportation and industry are closely related, and the lag in the development of the transportation system can become an important factor affecting economic and industrial development.

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Exploring the Challenges and Strategies of Sustainable Urban Renewal in Industrial Cities in Northeast China

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Abstract: Industrial cities in Northeast China were once developed areas of industry. However, with the economic restructuring and excessive resource exploitation leading to depletion, industrial cities in Northeast China face many challenges such as the difficulty of traditional industrial transformation, the decline of market economy, a large outflow of population, and difficulties in talent introduction. This article aimed to explore the challenges and strategies for sustainable urban renewal in industrial cities in Northeast China, and propose strategies and suggestions for green economy, low-carbon environmental protection, and the transformation of traditional industries into new low-carbon industries.

Keywords: Northeast China; Industrial Cities; Sustainable Urban Renewal; Challenges and Strategies; Structural Transformation

1. Introduction

The Northeast region of China has many resources and a mature foundation of heavy industry. However, with the changes in the global economic environment and the adjustment of China's economic structure, sustainable urban renewal of industrial cities in Northeast China needs to face many challenges. Some of these challenges are influenced by the overall environment of China's opening-up to the outside world, while others belong to endogenous challenges originating from industrial cities in the Northeast region. A series of problems such as environmental pollution, resource depletion, economic transformation, and population outflow have become important factors restricting the sustainable development of industrial cities in the Northeast region. Therefore, exploring the challenges and strategies for sustainable urban renewal in industrial cities in Northeast China also has significant theoretical and practical significance.

In order to address the aforementioned issues, this article proposes the following changes and transformations for sustainable urban renewal in industrial cities in Northeast China, including environmental protection, traditional industrial transformation, urban future planning, social participation, funding investment, policy support and guidance, technological innovation, and talent introduction and cultivation, so as to promote the transformation of industrial cities in Northeast China towards sustainable development. This article analyzes the existing problems of sustainable urban renewal in industrial cities in Northeast China, and then provides targeted solutions to related issues in sequence. Innovative industrial development models, innovative urban planning and design, and innovative talent policies are established to achieve sustainable urban renewal in industrial cities in Northeast China.

2. Related Work

With the transformation of economic structure and the depletion of resources, industrial cities in Northeast China are facing a common problem of difficulty in traditional industrial transformation. The economic development of industrial cities in Northeast China is overly dependent on traditional industry, which seriously hinders the sustainable urban renewal of industrial cities in Northeast China [1-2]. The transformation and upgrading of traditional industries to green and efficient new industries faces challenges such as technological development, capital introduction, market changes, economic downturn, and population outflow. Therefore, the challenges and strategies for exploring sustainable urban renewal in industrial cities in Northeast China are the focus of this article [3]. ZHU Xiaodan used CiteSpace software to conduct a systematic review of sustainable city research, analyze its evolution and research hotspots, and explore its implications for national spatial planning. He proposed a scientific evaluation index system for sustainable smart cities, attached importance to urban-rural co govern-

ance based on national conditions, and integrated these concepts into national spatial planning [4]. Wang Mou proposed based on the national conditions that sustainable urban construction under the background of ecological civilization is not simply "downscaling" the concept of sustainable development to the urban level, but endowing sustainable development with more specific, situational, and localized connotations at the urban level. It is internalizing sustainable development into various dimensions of urban construction at the special time and spatial scale of the city. Concrete, institutionalized, and sustainable urban development plans were designed as top-level urban development plans that can comprehensively cover low-carbon, ecological, industrial, spatial, and other specialized urban development plans [5]. Chen Ruishan studied the development process of the concept and indicator system of urban sustainable development evaluation, which determined the quality and progress of China's future development based on the health and sustainability of cities and urban agglomerations. He focused on examining the methods of conducting urban sustainable development evaluations based on the United Nations Sustainable Development Goals framework and proposed ways to construct sustainable development indices for cities and urban agglomerations. He proposed the idea of promoting the evaluation of urban sustainable development index and establishing a "dashboard" for urban development from the aspects of platform construction, big data foundation, tracking and publishing. He provided important support in comparing cities in different regions, identifying development goals, and identifying existing problems [6]. However, there is a lack of feasibility in addressing a series of issues such as resource depletion, economic transformation, and population outflow. This article conducted research on various aspects such as environmental protection, industrial transformation, talent introduction and training, urban planning and construction, social participation and co construction and governance. A series of problems such as resource depletion, economic transformation, and population outflow were further addressed to promote the sustainable urban renewal and development of industrial cities in Northeast China [7-8].

3. Exploring the Challenges of Sustainable Urban Renewal in Industrial Cities in Northeast China

3.1 Difficulty in Transforming Traditional Industries

With the arrival of the new era, the Chinese economy has shifted from a stage of high-speed growth to a stage of high-quality development. From the perspective of traditional industry, with the rise of costs, increasing pressure on resources and environment, and overcapacity, the growth model that relied on factor driven and low-cost competition from industrial cities in Northeast China has become increasingly difficult to sustain. These problems seriously constrain the sustainable development of cities and urgently require the transformation and development of new industrial models. However, the transformation and upgrading of traditional industries still face many difficulties and challenges [9-10].

(1) One is that the technology of traditional industry is relatively mature, the market is basically fixed; the industry is structured, and the thinking is fixed and not easy to change. Many business owners are passionate about short-term profits and are determined to make quick money, making it difficult to focus on core technologies and gradually moving away from reality to illusion. As the saying goes, there is no backward industry, only backward concepts, fixed standards, outdated technology, and cumbersome management.

(2) The second is that the transformation system of industrial development needs to be improved. For example, administrative intervention and approval have created many "policy opportunities", leading companies to profit by renting technology rather than relying on technological innovation. Enterprises use this to reduce taxes and fees, and transaction costs are also significant. Traditional industries face a "crowding out effect" in the credit market, which has led to the formation of the so-called "dual track credit system".

(3) The third issue is the insufficient supply of technology, which increasingly highlights the constraints on the transformation and upgrading of traditional industries. Many enterprises rely on purchasing equipment and introducing production capacity, or have to seek cooperation from research institutions to develop equipment in technological transformation, which requires a large amount of upfront costs. These problems seriously hinder the sustainable development of industrial cities in the Northeast region. Due to the insufficient supply of common technologies, the path of enterprise transformation and upgrading is very difficult [11-12].

(4) The fifth issue is insufficient protection of intellectual property rights. The common problem for transformation and upgrading en-

terprises is that new products are prone to counterfeiting. The cost of violating intellectual property rights is relatively low, while the cost of anti-counterfeiting and rights protection for enterprises is high, resulting in a large number of negative phenomena, which inevitably seriously undermines the enthusiasm of enterprises for innovation. Therefore, in the process of traditional industrial transformation and upgrading, the whole society's awareness of intellectual property protection and commercial secrets is also facing challenges.

3.2 Environmental Pollution and Resource Depletion in Industrial Cities

The industrial structure of industrial cities in Northeast China is mainly dominated by heavy industry, with high energy consumption and pollution emissions, as well as high environmental pressure.

(1) When the economic development of industrial cities in the Northeast region overly relies on the extraction of one or a few local natural resources, over time, such resources also inevitably deplete. Once new growth points or economic sources cannot be found, the economy of the region would also fall into a long-term stagnation or even regression, unable to achieve the goal of sustainable development and renewal [13].

(2) As a non renewable resource, the total amount of natural resources is limited, and after being exploited to a certain extent, they may become depleted. Generally speaking, if the collection reaches more than 70% of the original measured total amount, or if the current technological level and mining capacity can only sustain mining for 5 years, the city would be called a resource depleted city, which is difficult to form an industrial city for sustainable development .

(3) Environmental pressure: From the perspective of the overall international development trend, China is facing environmental pressure in the process of rapid development. China is also changing its economic development model and proposing the concept of green GDP, with sustainable development at its core. This is both a challenge and an opportunity for sustainable cities in industrial cities in the Northeast region.

3.3 Population Outflow from Industrial Cities

(1) From an economic perspective, workers seek to maximize economic benefits in order to better meet their own needs. Therefore, generally speaking, excluding other factors, as workers, they tend to prefer industries with higher incomes and choose regions with higher incomes. If the economic pressure that workers need to bear is significant, this trend is more pronounced, which poses certain obstacles to the sustainable urban renewal of industrial cities in the Northeast region. As a gathering area of large state-owned enterprises, the Northeast region has implemented its family planning policy well under the organizational form of the unit system, resulting in a large number of only children. After marriage, only children face a "four two one" family structure, and the pressure of raising offspring and supporting the elderly is very great for only children. They usually need more economic income to maintain family operation. Therefore, how to improve the local economic belt would be an important factor in the sustainable urban renewal of industrial cities in the Northeast region.

4. Explore Strategies for Sustainable Urban Renewal in Industrial Cities in Northeast China

4.1 Adjusting Industrial Structure and Developing New Industries

(1) The orientation and overall strategy of overcapacity governance policies is optimized and adjusted, and an effective market mechanism is established to resolve overcapacity through fair competition and survival of the fittest. There is a need to relax and gradually eliminate unnecessary investment and access controls; it is necessary to clean up and standardize the preferential policies of local governments for specific enterprises, such as subsidies and tax reductions; it is necessary to actively promote the reform of the environmental protection system and strengthen environmental supervision; it is necessary to strengthen the supervision of product quality and the enforcement of anti unfair competition laws; it is necessary to do a good job in providing social support and properly resettle unemployed workers in the process of reducing production capacity.

(2) The transformation and upgrading of traditional industries have been promoted, and the transformation of people's concepts has

been actively promoted, making efficiency and quality a common belief of the whole society, forming a social atmosphere that advocates efficiency and quality. The market system and environment have been improved, and the role of market mechanisms has been fully utilized. The construction and improvement of the market legal system have been accelerated, the intellectual property and related legal system and enforcement mechanisms have been improved. Market reform has been accelerated, and the consumer rights protection system has been improved. The evaluation system for industrial cities in Northeast China has been constructed, and the Management Consulting Association for Large and Small Enterprises has been established to assist small and medium-sized enterprises in improving their management level, thereby promoting the strategy of sustainable urban renewal in industrial cities in Northeast China.

4.2 Energy Achievements of Sustainable Urban Renewal in Industrial Cities in Northeast China

According to the governance policies of optimizing and adjusting overcapacity, the new industries, new forms, and new models of sustainable urban renewal in industrial cities in Northeast China are growing rapidly. In recent years, high-tech manufacturing has increased significantly in industries above designated size. The following is a comparison chart of energy and traditional heavy industry in industrial cities in Northeast China.

4.3 Optimizing Export Structure and Strengthening Talent Development

(1) In recent years, the export scale of industrial cities in Northeast China has gradually expanded, but the export structure is single, and the export scale of primary materials such as steel and aluminum, as well as low value-added products, is relatively large. Therefore, it is necessary to guide enterprises in the Northeast region to actively adjust their export product structure, increase investment in science and technology, research and development of new products, improve their technological innovation capabilities, enhance the added value and technological content of products, in order to achieve the goal of optimizing the export product structure and promote the strategy of sustainable urban renewal in industrial cities in the Northeast region.

(2) The application and promotion of science and technology in industrialization are vigorously promoted, and policy support is applied to improve management and technology. By extending the industrial chain, the added value of products is increased; the construction of commodity export bases is given priority support, and a number of demonstration bases for foreign trade transformation and upgrading with strong export driving effects, obvious industrial advantages, and distinctive regional characteristics are cultivated.

(3) The revitalization of Northeast China cannot be achieved without the support of technological innovation and mid to high end talents. To provide talent guarantee for the construction of an open economy, on the one hand, efforts should be made to introduce a group of technology leading talents and senior management talents, and targeted introduction of professional talents in logistics, finance, and service fields, comprehensively improving the internationalization level of talents; on the other hand, efforts should be made to increase the cultivation and training of local talents in Northeast China, focusing on cultivating a large number of versatile talents, focusing on developing a group of high-quality investment and international trade talents, accelerating the cultivation of a group of high-quality entrepreneurs with international vision, etc., in order to accelerate the process of promoting sustainable urban renewal in industrial cities in Northeast China.

4.4 Leveraging the Advantages of Industrial Cities in Northeast China

(1) The Northeast region has vast natural ecological resources, which can leverage the advantages of ecological environment protection, develop ecotourism and green industry, attract more investment and tourists, promote a win-win development of economic growth and ecological environment protection, and realize a virtuous cycle of economic growth and ecological environment protection.

(2) The industrial cities in Northeast China are located in the transportation hub of Northeast Asia, which can leverage their geographical advantages, strengthen economic cooperation with neighboring countries such as Russia and North Korea, and expand international markets.

(3) Releasing the advantages of traditional industry and promoting digital transformation and upgrading are key measures for the revitalization of Northeast China. Northeast China has a strong industrial foundation, a complete manufacturing system, and a complete industri-

al chain.

(4) The traditional heavy industry foundation of industrial cities in the Northeast region is utilized to promote industrial upgrading and transformation, develop emerging industries such as high-tech industry, equipment manufacturing industry, and biomedicine, and improve industrial added value and competitiveness.

In summary, industrial cities in Northeast China can promote sustainable development and sustainable urban renewal by fully leveraging their geographical advantages, strengthening regional cooperation, resource development and utilization, ecological environment protection, and population advantages. At the same time, it is necessary for the government, enterprises, and all sectors of society to work together to form a joint force and promote the development of industrial cities in the Northeast region.

4.5 Solutions to Environmental Pollution and Resource Depletion

(1) The single structure has been changed, and industry has been diversified. Due to the large number of traditional industrial facilities such as factories and coal mines in industrial cities in Northeast China, the environment is facing serious pollution. In addition, with a single economic structure, outdated production capacity is gradually phased out, and support for emerging industries such as high-tech industries and cultural and creative industries is increased, guiding enterprises to transform and upgrade towards high value-added, green and environmentally friendly industries. Capital are actively introduced to promote industrial structure upgrading, while emerging industries and high-tech enterprises are introduced to promote diversified industrial development. According to the actual situation and resource endowment of the city, the industrial layout is reasonably planned to leverage their respective advantages and form a diversified development pattern of industry. Industrial cities in the Northeast region can gradually change their single structure, achieve diversified industrial development, enhance the economic vitality and competitiveness of cities, and promote sustainable economic development, as shown in Figure 1.

(a) Before the industrial transformation in Northeast China

(b) After the industrial transformation in Northeast China

Figure 1. Scenery before and after industrial transformation in Northeast China

(2) It is necessary to focus on people's livelihood issues, pay attention to ecological governance, increase environmental governance efforts, reduce pollution emissions, improve air quality and water sources, ensure a healthy living environment for residents, strengthen environmental awareness, promote green energy, clean production, environmental technology and other green industrial development. As shown in Table 1, the environmental governance status can be seen. At the same time, it also improves the quality of life for residents. During governance, efforts should also be made to strengthen the protection of the ecological environment, protect natural ecosystems such as wetlands, water resources, and forests, improve the quality of urban ecological environment, and provide residents with a better living environment. It is necessary to encourage residents to participate in ecological environment governance and urban construction, enhance their awareness and sense of responsibility for environmental protection, and jointly maintain the ecological environment of the city.

Table 1. Air quality in Northeast China from 2014 to 2022

Year	Average air quality index	Quality grade	PM2.5	PM10	SO_2	CO	NO_2	O_3
2014	183	Heavy pollution	170	194	75	2.9383	121	205
2015	176	Heavy pollution	159	178	54	2.5830	97	195
2016	167	Heavy pollution	139	187	53	2.0378	98	187
2017	149	Mild pollution	105	155	32	1.7863	73	178

2018	143	Mild pollution	76	132	22	1.4232	75	142
2019	135	Mild pollution	73	120	20	0.9273	45	157
2020	127	Mild pollution	54	121	23	0.8231	54	135
2021	99	Good	34	78	9	0.9234	29	97
2022	93	Good	23	40	11	0.7456	14	93

(3) The partial achievement of the goal still requires support from multiple parties, and it is necessary to attract more funds to invest in the diversified development of industry, including government guided funds, bank credit, venture capital and other channels of financial support. It is necessary to provide technological innovation support, including establishing technology research and development platforms, providing professional technical training, etc., to help enterprises improve their technological level and innovation capabilities. It is necessary to establish a good social atmosphere, encourage entrepreneurial innovation, and provide good social support and environmental protection. It is necessary to expand the market, expand sales channels, enhance product competitiveness, and provide broader development space for enterprises. The sustainable urban renewal of industrial cities in the Northeast region requires support and cooperation from various aspects such as government, enterprises, financial institutions, research institutes, and social organizations to achieve diversified industrial development, forming a joint force and jointly promoting the realization of diversified industrial development.

4.6 Low Carbon and Green Development Achievements of Sustainable Urban Renewal in Industrial Cities in Northeast China

As a pilot project for the “Electricity Auxiliary Service Market” special reform of the national power system reform, the sustainable urban renewal of industrial cities in Northeast China continuously adapts to the new situation of power development in Northeast China, actively establishes a regional circulation system for power consumption, and promotes the construction of a new development pattern for electricity. Figures 2 show the green and low-carbon energy structure in the Northeast region.

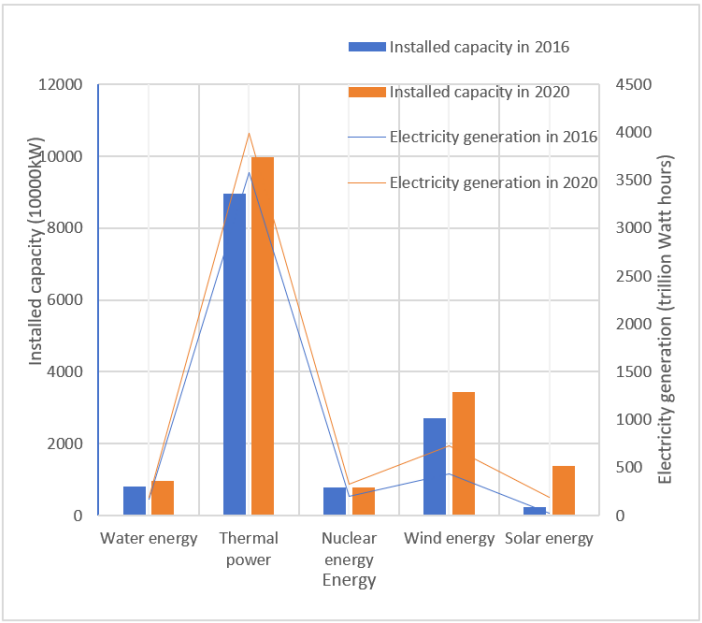

Figure 2. Power generation and installed capacity in Northeast China

4.7 Results of Low Carbon and Green Development for Sustainable Urban Renewal in Industrial Cities in Northeast China

From Figure 2, it can be seen that the development of new energy in 2016 and 2020 is compared, and it can be found that industrial cities in Northeast China are moving towards the path of sustainable urban renewal. Especially for new energy sources, solar energy has increased from 20 trillion watt hours of electricity generation to 187 trillion watt hours in 2020, and wind energy has increased from 437

trillion watt hours to 727 trillion watt hours in 2020. By promoting green energy, clean production, environmental protection technology and other green industrial development, it has become the cornerstone of sustainable urban renewal in industrial cities in Northeast China.

5. Conclusion

Although the sustainable urban renewal of industrial cities in Northeast China faces many challenges, it is still necessary to firmly adhere to sustainable development, take corresponding measures to address the challenges, seek the benefits of economic globalization, promote reform and development through openness, the rise of the Central Plains, benefit the Central Plains, and assist in the realization of the Chinese Dream, in order to achieve sustainable urban renewal of industrial cities in Northeast China. Taking into account multiple factors such as environment, industry, talent, and urban renewal, comprehensive policies and measures have been adopted to form a joint force and jointly promote the sustainable urban renewal and development of industrial cities in Northeast China.

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Suggestions on Green Transformation of OCT Creative Park South Area based on Industrial Sites

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Abstract: This paper aims to put forward the scheme and strategy of green reconstruction of the south district of OCT Creative Park based on industrial sites. Through the analysis of the planning, landscape, function, architecture and management of the industrial site in the south area of OCT Creative Park, the paper puts forward the innovative design scheme, the improvement of green design and the introduction of environmental protection industry and innovative technology and other green transformation schemes. Through the literature review and research methods, these schemes are discussed and analyzed, and the final conclusion is drawn.

Keywords: OCT Creative Park; Industrial Site; Green Transformation; Innovative Design

1. Analysis of industrial sites in the south district of OCT Creative Park

1.1 Planning

(1) Positioning and location: The south area of octa Creative Industry Park is reasonably positioned, and the construction status is consistent with the positioning during the planning period. It is located in a location with convenient transportation, strong accessibility, numerous surrounding residents and large flow of people.

(2) Resources: There are enough merchants in the park. Except for 3 stores under renovation and 1 vacant store, other areas are occupied by normal business entities.

(3) Space and function: Rich types of space, sufficient underforest space, sufficient open space, green coverage in line with user needs. Various functional Spaces are well distinguished, with

ample rest space and access space effectively separated by height difference. Open space has wide vision and good ventilation. The restaurants and other consumption shops are well scattered, and the environment is well maintained, which brings a good sense of experience to people in outdoor space activities.

1.2 Landscape

● The overall greening is relatively insufficient

The coverage rate of green space is 33.69%, lower than the average of 43% in Shenzhen. From the data, the green space rate of South Creative Park is relatively insufficient. Through our analysis and interviews with site management personnel, we know that the reason is that the buildings in the park occupy a large area, but most of the buildings have tiled roofs, and the roof green space is few, so the greening rate of the whole park is lower. However, if the buildings occupy a large area, the greening rate of the creative park will become considerable.

● The rate of shade is low

The plants in the park are mostly native tree species such as palm trees and pollowi trees. Although planting and maintenance are relatively easy, the canopy of these books is small, resulting in low shade rate, and it is hot to walk on the main road in sunny days.

1.3 Function

(1) Some infrastructure service functions need to be improved

The following results can be obtained through questionnaires and field investigations: The waste disposal in the park is relatively proper, and the respondents (74.47%) generally believe that the rest facilities are sufficient and comfortable, but the park needs improvement

in the setting of the sign system, toilet and air problems (for the questionnaire of the park's sign system, the respondents scored 4, the toilet scored 2, and the air problems were field research).

Specifically, the accessibility of toilets is not strong or the number is not reasonable enough, the signage system is not easy to identify and use, there is no smoking area, and the passageway has the problem of oil smoke collusion. In the future, the park should strengthen the construction of these aspects to ensure the basic needs of users.

(2) There are differences in the evaluation of art, culture and business climate

On the one hand, through communication with practitioners in the art field of the park, the construction of the park is convenient for art exchange, inspiration stimulation and various creative activities, which is reflected in the large gathering of practitioners in the field of art, creativity and design in the park, and the park has many art galleries and other Spaces, which the respondents are satisfied with. In terms of creating a business atmosphere, 84% of respondents believe that the green transformation of the park has "increased a lot" or "increased a little" on the attraction of the park and the image and competitiveness of the merchants in the park. Meanwhile, the service personnel of the catering industry of the Park believe that the park is a good choice for business operation, which is reflected in the large radiation range of the park and the large flow of people. Moreover,the management of the park is also conducive to business operation.

On the other hand, however, another respondent said that she felt sorry for visiting the park and hoped that the park would add or create some landmark region-specific check-in points to enhance the park's appeal. Moreover, according to the field research conducted by the members of the group, compared with the North district, the southern district has less artistic atmosphere and more commercial and working atmosphere. In terms of business atmosphere, a waiter from the catering industry said that the park has been lonely a lot in recent years, and the passenger flow is less than before.

1.4 Architecture

● Poor use of roof space

According to the satellite map, part of the roof of the OCT Creative Park is made of slanted tiles, while the rest is made of flat roof. However, no roof greening is used or implemented, which greatly wastes the roof space.

● The entrance of the building makes people uncomfortable

According to the analysis of the questionnaire results, more than half of the respondents of the randomly selected architectural entrances think that they are depressing, especially the entrances, which make people feel uncomfortable. As a friendly creative park, we should pay attention to the visitors' feelings in this respect.

1.5 Management

(1) Insufficient investment in cultural construction

Through interviews with the site management staff, we learned that the new development of the park in the future will be more inclined to artistic creation and cultural inheritance. Due to the nature of an emerging city in Shenzhen, as well as being a super first-tier city, Shenzhen has a relatively young urban style, so correspondingly, it lacks a relatively thick and precipitated cultural heritage. The same goes for this site, which has advanced technological and artistic flavor but lacks depth and thickness. Therefore, it is more necessary to increase its cultural heritage and confidence.

(2) Green facility management needs to be improved

The overall green coverage rate of the park site is very high. During the research process, we often saw the park staff taking care of the green plants. We also learned from the interview that the park regularly trims these green plants and regularly kills mosquitoes.However, the effect is very small. According to our own experience of the use of the plants in the process of research and the experience of other users in the interview, the mosquito phenomenon in the park is still serious even with the regular elimination work. Due to climatic and geographical factors, this problem exists almost all year round,so the management of this area needs to be improved and enhanced.

2. Green transformation plan and strategy of the South District of OCT Creative Park based on industrial sites

2.1 Innovative design scheme

(1) Protection and restoration measures of industrial sites

In the scheme and strategy of green transformation of OCT Creative Park South, the protection and restoration of industrial sites is an important consideration. Through the protection of industrial sites, the historical and cultural heritage can be preserved and the basis for the green transformation can be provided. In terms of restoration measures, a combination of protective restoration and functional restoration can be adopted, which not only protects the original appearance and historical value of industrial sites, but also enables them to adapt to the needs of modernization.

(2) The introduction and cultivation of creative industries. As a creative park, the green transformation of OCT South needs to pay attention to the introduction and cultivation of creative industries. By introducing creative and innovative enterprises and projects, the creative atmosphere and competitiveness of the park can be enhanced. At the same time, it is also necessary to attract more excellent creative enterprises and projects to the park by nurturing creative talents and providing an innovative and entrepreneurial environment for creative industries.

(3) Integration of cultural and artistic elements. In the green transformation, emphasis should be placed on integrating cultural and artistic elements to enhance the artistic atmosphere and cultural connotation of the park. The park can be built into a landmark with cultural and artistic value through art installations, sculptures and other means. At the same time, various cultural activities can be held to attract more people's participation and attention, and enhance the visibility and influence of the park.

(4) Integration of industry and city with community sharing. Green transformation requires the integration of industry and city to create a comprehensive park suitable for both work and life. In the green transformation of the south district of the OCT Creative Park, multifunctional public Spaces can be built to provide various convenience facilities and services to meet people's diverse needs. At the same time, community participation can also be encouraged to jointly build the park and realize resource sharing and common development of the community.

(5) Smart parks and technological innovation. In the plan and strategy of green transformation, the concept of smart park can be introduced, and advanced scientific and technological means and technologies can be used to improve the management and service level of the park. Through intelligent facilities and systems, the efficient utilization and management of various resources in the park can be realized. At the same time, it can also encourage scientific and technological innovation, promote the integration of creative industries and technology, and enhance the innovation ability and competitiveness of the park.

(6) Pay attention to the protection and inheritance of cultural heritage. In the transformation of industrial sites, it is also very important to pay attention to the protection and inheritance of cultural heritage. The historical culture of industrial sites can be passed on through the establishment of cultural museums, cultural blocks and other means, while attracting more tourists to visit them.

(7) Carry out creative cultural activities and exhibitions. In the operation of the park, it is also very helpful to carry out creative cultural activities and exhibitions. Activities such as creative and cultural festivals, art exhibitions and design competitions can be held to attract more young people and entrepreneurs to the park to start their own businesses, while also injecting new cultural elements into the park to enhance its cultural charm and brand influence.

2.2 Improve the green design

The plan and strategy of green transformation in the south area of OCT Creative Park aims to improve the environmental quality of industrial sites and create a pleasant and livable creative park. To this end, our primary consideration is to improve the green design, and one of the important strategies is to add tall courtyard shade trees. By planting these tall trees, we can effectively provide more shade and shade space for the park, and create a comfortable environment for people to rest and work. Introduce diverse plant landscapes and landscaped wa-

ter bodies. By introducing diverse plant landscapes and landscape water bodies, a richer and more diverse natural atmosphere can be brought to the south area of OCT Creative Park. The types of plant landscapes can include different kinds of flowers, shrubs and lawns, as well as various forms of landscaped water bodies, such as fountains and artificial lakes. The integrated use of these landscape elements will add a unique charm to the park and attract more people to visit and work there.

Ecological wetlands and rainwater collection systems will be built. Toimprove the sustainability of OCT Creative Park South, we also plan to build an ecological wetland and rainwater collection system. Eco- wetlands can effectively purify wastewater and provide ecosystem services, such as water purification and biodiversity conservation. At the same time, rainwater harvesting systems can collect rainwater and store it for irrigation and landscape use within the park. The implementation of these measures will help reduce dependence on external water resources and achieve sustainable development of the park.

2.3 The introduction of environmental protection industries and innovative technologies

(1) Restoration and protection of the ecological environment. In order to realize the green transformation, it is necessary to restore and protect the ecological environment in the south area of OCT Creative Park. By planting vegetation and ecological restoration, the green area can be increased, and the air quality and ecological environment of the park can be improved. At the same time, strengthening the management and protection of water resources and building rainwater collection systems and sewage treatment facilities can effectively reduce the waste and pollution of water resources. Through the restoration and protection of the ecological environment, a healthy and comfortable ecological environment can be created for the south district of the OCT Creative Park.

(2) The construction and promotion of circular economy. In order to realize the green transformation, it is necessary to build and promote the circular economy model. Through the construction of waste resource utilization facilities and recycling systems, the generation of waste and environmental pollution can be reduced. At the same time, promoting sustainable production and consumption patterns and encouraging enterprises and residents to adopt measures of energy conservation and emission reduction can realize the effective use of resources and environmental protection. Through the construction and promotion of circular economy, double benefits of economy and environment can be provided for the green transformation of the south district of OCT Creative Park.

(3) Social participation and shared development. In order to achieve green transformation, social participation and shared development need to be strengthened. Promoting public awareness and participation in environmental protection through environmental education and publicity activities can promote the popularization and promotion of green concepts. At the same time, encouraging enterprises and social organizations to participate in the construction and management of green projects can achieve resource sharing and complementary advantages. Through social participation and shared development, broad support and cooperation can be provided for the green transformation of the south district of the OCT Creative Park.

Conclusion

Through the analysis and research of industrial sites in the south district of OCT Creative Park, this paper puts forward a series of green transformation schemes and strategies based on industrial sites. These schemes include innovative design scheme, perfecting greening design and introducing environmental protection industry and innovative technology. The implementation of these plans can improve the environmental quality of OCT Creative Park South, enhance its image and functions, and promote its sustainable development.

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Practice Analysis of Metal Wear Self-Repair Technology in Automobile Engine Maintenance

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Abstract: With the high temperature and high speed of the automobile engine working environment, metal wear has become the main factor of engine failure. This paper explores the application of metal wear self-repair technology. Through nanomaterials addition, chemical reaction repair and other methods, tiny cracks are filled, protective film is formed, and self-repair of metal is realized. This study provides innovative solutions for engine maintenance and provides an important reference for automobile maintenance engineering.

Keywords: Automobile Engine; Metal Wear; Self-Repair Technology; Practical Analysis

Introduction

In the automobile industry, the long running of the engine inevitably causes metal wear. In order to solve this problem, the metal wear self-repair technology has emerged. Its application in the field of automotive engine maintenance has become a cutting-edge solution to improve the life of parts and reduce maintenance costs.

1. Failure causes of automobile engine and the application principle of metal wear self-repair technology

1.1 Cause of automobile engine failure

1.1.1 Frictional wear

Friction wear refers to the engine operation, internal parts such as piston ring, crankshaft, connecting rod gradually lose surface material due to long time high speed friction and extreme high temperature environment, forming wear. This stems from the constant friction of the piston ring and the cylinder, crankshaft and connecting rod, which bears the huge friction and high temperature pressure in the engine work. The surface of the piston ring, crankshaft and connecting rod gradually wear, affecting the engine performance.

1.1.2 Metal fatigue

Metal fatigue refers to the phenomenon of gradual damage and final failure of metal materials under frequent stress changes. In automotive engines, parts experience constant stress changes in tens of thousands of reciprocating movements, leading to small stress concentration of metal materials and fatigue cracks. Especially under high load, high speed, such as crankshaft, connecting rod and other core components to bear greater pressure and vibration, accelerate the formation of fatigue crack. These cracks may eventually lead to component failure, so the monitoring and prevention of fatigue cracks is critical.

1.1.3 Particulate matter erosion

Particulate erosion refers to the engine internal combustion process, small particles in the air enter the engine with the intake air, causing small and frequent impact and friction on the surface of key components. This tiny particle erosion occurs on rapidly rotating components, such as cylinder walls, pistons, crankshaft, etc. In a high temperature and high pressure environment, these particles cause local wear on the surface and accumulate into tiny wear areas over time. Especially in the combustion environment, particles interact with lubricating oil and combustion products to produce acidic or corrosive substances, aggravate surface erosion.

1.2 Application principle of metal wear self-repair technology

1.2.1 The nanomaterial addition

Nanomaterials addition is an advanced engine maintenance technology that introduces nanoscale materials such as nanoparticles and

nanolubricants into engine oil to cope with wear and tiny cracks in parts. These nanomaterials have an extremely small particle size and a high specific surface area, allowing them to go deep into the microscopic wear areas during the engine work. Once added to the engine oil, these nanomaterials form a uniform and wear-resistant protective film on the wear surface. This nanoprotective film acts like a microscopic layer of a shield, which can fill and cover tiny cracks, wear areas and uneven surface, slowing or even preventing further wear processes. These nanomaterials also exhibit excellent lubrication properties, helping to reduce friction between parts and reduce heat and energy losses.

1.2.2 Chemical reaction for repair

Chemical reaction repair technology is an innovative engine repair method to deal with the wear of parts by introducing special chemicals. When the engine parts wear, these special chemicals act on the damaged surface and achieve the effect of automatic repair by chemical reaction with the surface metal. These chemicals often contain components such as organic synthetic materials, surfactants, and metal ions[1]. When the engine runs, these substances will form a solid layer of repair on the damaged surface. The formation process of this repair layer involves various chemical reactions, which may include reaction mechanisms such as ion exchange, deposition, and chemical bonding. These reactions allow the originally damaged metal surface to be repaired, enhancing the surface hardness, and also improving the smoothness of the surface.

1.2.3 Magnetic field-assisted repair

Magnetic field-assisted repair technology is an innovative engine repair method that uses magnetic field technology to repair metal wear surfaces. By introducing a magnetic field in the engine, the distribution of metal particles on the wear surface can form an orderly wear repair structure. Under the action of the magnetic field, the metal particles in the engine are guided by the magnetic force to form an orderly arranged structure on the worn surface. This ordered metal particle structure not only fills tiny areas of wear, but also can form a uniform wear repair layer. The effect of magnetic field regulation improves the adhesion of metal particles on the wear surface, and then enhances the adhesion and stability of the repair layer[2]. Magnetic field-assisted repair technology also has the characteristics of regulating the morphology of the wear surface, which helps to improve the flatness of the surface and slow down the development of further wear.

2. The application importance and specific application methods of metal wear self-repair technology

2.1 The application importance of metal wear self-repair technology

The application of metal wear self-repair technology in automotive engineering is of significant importance in improving vehicle performance, reducing maintenance cost and enhancing maintainability. By effectively filling tiny cracks and wear areas, metal wear self-repair technology is expected to significantly extend the service life of engine parts. This repair mechanism can not only prevent further wear, but also repair the already damaged surface, thus improving the reliability of the vehicle. Extending the life of parts not only meets the economic benefits, but also improves the long-term stability of vehicles and reduces the potential faults caused by the aging of parts. In terms of maintenance, the metal wear self-repair technology has obvious cost advantages over the traditional methods of replacing parts. By realizing automatic repair, the replacement frequency of expensive parts can be reduced, effectively saving the maintenance cost of car owners. This provides car owners with an economical and efficient maintenance option, but also helps to promote the automotive maintenance industry to a more sustainable direction. Self-repair technology helps to improve the engine's maintainability. By reducing the possibility of sudden failure, car owners can more easily perform regular maintenance, reducing maintenance time and costs. This not only improves the maintainability of the vehicle, but also increases the owners' confidence in the performance of the vehicle, bringing a better user experience for the entire vehicle operation cycle.

2.2 Specific application methods of metal wear self-repair technology

Using advanced technologies such as nanomaterials addition, chemical reaction repair, magnetic field assisted repair, intelligent monitoring system and regular maintenance and detection, metal wear self-repair technology has shown multi-level and all-round application in

engine maintenance.

First, By adding nanomaterials such as nanoparticles and nano-lubricants to the engine oil, the system can form a protective film to fill the tiny wear area, thus achieving the self-repair of the metal. The added nanomaterials have excellent filling and lubrication properties, effectively preventing further wear and improving the overall performance of the engine parts.

Second, the use of chemical reaction repair technology, by introducing special chemical substances, make the chemical reaction with the damaged surface, forming a solid repair layer, restore the surface hardness and smoothness of the parts. At the micro level, the automatic repair of the metal is realized, providing a more lasting and more comprehensive protection for the engine.

Third, the magnetic field assisted repair technology through the application of magnetic field to regulate the distribution of metal particles on the wear surface, form an orderly wear repair structure, improve the adhesion of metal particles on the surface, and realize the self-repair of wear. It makes the repair effect more orderly and stable, and improves the adhesion and persistence of the repair layer.

Fourth, the introduction of intelligent monitoring system enables the system to monitor the operating state of the engine in real time, and obtain the actual wear situation through the sensor, so as to dynamically adjust the self-repair strategy[3]. It is helpful to achieve the best repair effect under different working conditions, and improve the intelligence and adaptability of the whole system.

Fifth, the implementation of regular maintenance and testing procedures is an important link to ensure the reliability of self-repair technology. Through regular maintenance and testing, the effects of self-repair technology can be monitored, and potential problems can be found and solved in time to ensure that the system can maintain efficient self-repair effect in long-term operation. The comprehensive application means provide a comprehensive support for the successful application of metal wear self-repair technology.

3. Conclusion

Metal wear self-repair technology has shown great potential in automobile engine maintenance. In the future, with the progress of science and technology, combined with intelligent monitoring system and more advanced repair methods, a more efficient and intelligent self-repair system will be realized, improve engine reliability, and promote automotive engineering to a more sustainable future.

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Explore the Maintenance Measures and Methods of Computer Software Engineering

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Abstract: With the continuous development of computer software engineering, maintenance has become a key challenge. This paper takes the software maintainability as the background, takes the actual case as an example, analyzes the maintenance measures and methods, and puts forward the targeted solutions. The findings aim to provide software engineers with practical guidelines to optimize maintenance processes and improve software quality and long-term usability.

Keywords: Computer Software Engineering; Maintenance Measures; Maintenance Methods; Software Maintainability

Introduction

In the field of computer software engineering, as software systems continue to evolve, maintenance becomes a key challenge in ensuring system reliability and continuous innovation. In order to solve the increasingly complex maintenance needs, this paper deeply explores the maintenance measures and methods of computer software engineering, aiming to deal with the changing application background and improve the maintainability and long-term performance of the software system.

1. Significance of computer software engineering maintenance

1.1 Continue the software life cycle

Upgrades and changes in hardware platforms are inevitable, and such changes can have an impact on the performance and compatibility of software systems. Therefore, software maintenance needs to constantly pay attention to the development trend of hardware technology, the necessary adjustment and optimization of the software, to ensure that it can maintain efficient and stable operation on the new hardware platform. This also includes the elimination of old technologies and the introduction of new technologies to keep the software systems advanced and available. The update and evolution of operating systems are also considerations. As the OS versions are updated, the software systems may face compatibility challenges. Software maintenance requires timely applies to the new operating system environment and repairs problems that may be caused by operating system changes to ensure the normal operation and safety of the software. Changes in business requirements are one of the most common challenges in software maintenance. As the business environment changes, the user needs may change, and new functional requirements may emerge. One of the goals of software maintenance is to enable the software system to adapt to these changes through flexible design and modifications. This may include optimization of existing features, development of new features, and adjustments to the entire system architecture. Maintenance also includes updates and additions to existing documents to maintain consistency with the actual code. This is essential for the understanding and work efficiency of the subsequent maintenance personnel.

1.2 Improve and optimize the software quality

Error repair includes not only solving known problems, but also actively responding to user feedback and real-time monitoring of system performance, as well as quickly locating and fixing potential problems by means such as logging. Performance optimization is another key aspect. Regular performance testing and analysis can identify performance bottlenecks and bottleneck causes in the software system. Optimizing algorithms, improving database queries, and reducing resource consumption can all be used to improve the response speed and overall performance of the software. Performance optimization not only improves the user experience, but also helps to improve the scalability of software systems and adapt to the growth of user scale. Introducing new technologies and functions is also an important task of software maintenance. Continuous advances in technology and changes in business requirements may require software systems to adopt new technol-

ogy stacks or add new functional modules. By introducing advanced technology, the software can better adapt to the new environment and needs and remain competitive. At the same time, adding new features can also improve the market value of the software to meet the evolving needs of users. Software maintenance should also focus on code maintainability. By reconstructing and optimizing the code, we can eliminate the redundancy and complexity, and make the code more clear and concise. This not only helps to reduce the difficulty of future maintenance, but also improves the efficiency of team members to understand and modify the code.

2. Computer software engineering maintenance measures

2.1 Establish a sound document system

Requirements documentation is the cornerstone of software development. Detailed and accurate requirements documentation ensures a consistent understanding of the business requirements by the team, providing a clear direction for subsequent design and development work. The architecture design document focuses on the overall system structure, including the system module division, the interaction between modules, etc., which helps the team to understand the overall blueprint of the system. The detailed design document is more specific, covering the detailed design of each module, including data structure, algorithm selection, etc. Database design documents focus on data storage and management to ensure that the structure of the database meets the system requirements and ensure the integrity and consistency of data. The software installation and deployment document is a key link to ensure the successful operation of the software. It describes the installation steps and configuration requirements of the software in detail, and provides convenience for the deployment personnel. The user manual is a guide to end-users, detailing the software's functions, operating methods, and solutions to common problems, enabling the user to quickly learn and take full advantage of the software's capabilities. To ensure the effectiveness of these documents, regular updates and maintenance are essential[1]. As the project progresses, requirements may change, and system design may need to be adjusted, and timely updated documentation enables consistent understanding across the entire team and avoid lag and inconsistency of information.

2.2 Modular design to reduce the coupling

Modular design is a key software design concept, designed to achieve the design goal of high cohesion and low coupling by dividing the software system into logically independent and functional self-contained modules. The high cohesin modules are closely related and perform a single responsibility, while the low coupling emphasizes the independence between modules and interact through simple and clear interfaces to reduce the dependence between each other. Within the module, the strong correlation and tight combination of functions enable each module to perform specific tasks independently, which helps to improve the maintainability and reusability of the module. With loose functions between modules and simple data exchange, this design makes the system more flexible and easy to adapt to changes. This also means that when new functions need to be added, new modules can be added without affecting the rest of the system, limiting the diffusion range of changes and improving the maintainability of the system. However, caution is needed in the process of module separation, and too meticulous separation may lead to increased complexity of the system, making collaboration and communication between modules difficult[2]. Therefore, selecting the appropriate module granularity is crucial. Reasonable module granularity should not only ensure that a complete business model can be established within the module, but also ensure that the coupling degree between the modules is minimized to form the best mode of cohesion and coupling.

2.3 Adopt the code specification to improve the readability

Naming specification is one of the cornerstones of a programming specification. The naming rules of class names, method names and variable names should be concise and descriptive, avoiding using abbreviation and single character naming to improve the self-interpretability of the code. A clear and consistent naming style helps reduce the code to read, making it easier for developers to understand the code. Format specification is another important aspect. When formulating specifications, we need to pay attention to code indentation, function physique, annotation specification, etc. Consistent indentation and formats can clarify the code structure, reduce ambiguity, and improve

readability. The annotation specification should include interpretation of critical business logic, algorithms, and recording of code changes to make it easier for team members to understand the design and use of the code. The implementation of the code specification is not only the responsibility of an individual developer, but also the responsibility of the whole team. By promoting and training the code specifications on the team, a team culture is formed by ensuring that developers jointly follow the specifications when writing the code. Code review can also be more convenient and quick because the entire team follows the same specifications, making it easier for team members to understand and evaluate each other's code. During the software maintenance phase, using consistent code specifications can significantly improve efficiency.

2.4 Build an automatic test system

The foundation of the automated test system is the perfect test cases. These test cases should cover all aspects of the software, including functionality, performance, security, etc. Test cases are designed to fully consider the integrity of the code coverage to ensure that as many code paths are covered as possible, thus improving the comprehensiveness and depth of the test. The choice of an automated framework is crucial. A powerful automation framework can improve the maintainability and scalability of the test code. With an automated framework, the test cases can be run continuously, and the results can be checked in a timely manner. This not only provides timely feedback for every modification of the software, but also provides a stable testing base for the development team. The automated testing system should also support continuous integration, meaning that testing can be seamlessly integrated with other stages of the development process[3]. By automatically triggering the test process, the regression test of the software can be made more easily and more efficient. This automated integration approach helps to identify potential problems early, thus reducing the cost of fixing problems later in the software development cycle. The operation of large-scale automated test cases not only helps to verify the correctness of the software modifications, but also releases the energy of the testing team. By automatically running routine tests, test teams can focus on developing more complex and innovative new test cases.

Conclusion

The in-depth study in the computer software engineering maintenance has laid a foundation for improving the reliability of the software system. In the future, with the continuous evolution of technology, we will continue to explore more advanced maintenance measures and methods to adapt to the increasingly complex software environment. It is expected that these efforts will provide more innovative and efficient solutions in the field of software engineering and promote the sustainable development of software systems.

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The Characteristics, Advantages and Development Trends of Mechanical Design, Manufacture and Automation

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Abstract: Mechanical design and manufacturing and its automation is one of the key fields in the field of modern manufacturing. Its characteristics and advantages are directly related to the competitiveness and sustainable development of the manufacturing industry. In this paper on the characteristics of mechanical design and manufacturing and automation in-depth analysis, advantages and development trend, discusses the role in promoting technology innovation, improve production efficiency, reduce costs, and in the digital, intelligent, green manufacturing in the direction of development prospects, for the field of research and practice provides a reference.

Keywords: Mechanical Design and Manufacturing; Automation; Characteristics and Advantages; Development Trend

Introduction

With the continuous development of science and technology, the position of mechanical design and automation in manufacturing industry is increasingly prominent. In the context of global economic integration, the manufacturing industry has an increasingly urgent demand for technological innovation, production efficiency improvement and cost reduction. Mechanical design and manufacturing and its automation emerge with its unique characteristics and advantages, and become the key force to promote the upgrading of manufacturing industry.

1. Characteristics of mechanical design and automation

Mechanical design and manufacturing requires the knowledge of mechanical engineering, electrical engineering, computer science and other disciplines, and the whole process of its design and manufacturing needs the cooperation of multiple disciplines to form a closely interwoven knowledge network. With the rapid development of computer technology, mechanical design and manufacturing has changed from the traditional hand drawing to the era of digital model. Using computer aided design (CAD) and other tools, can more intuitive, accurately complete product design, improve the design efficiency. Machinery manufacturing industry is more and more inclined to the industrial Internet, through the Internet of things technology to achieve the information and intelligence of the production process. The connection of the production equipment and sensors with the cloud computing platform provides the possibility for the monitoring and optimization of the production process.

2. Advantages of mechanical design and manufacturing and its automation

2.1 Improve production efficiency

Through the introduction of advanced automatic production line, enterprises can achieve 24 hours of continuous production, effectively reduce the waste of human operation time, so as to significantly improve the overall production efficiency. This automated system can efficiently perform repetitive work, maintain a high degree of stability and accuracy, and greatly improve the operation efficiency of the production line. At the same time, automated production can also reduce the labor cost, so that enterprises in a long time to maintain a high level of production state, better meet the market demand, improve competitiveness[1].

2.2 Reduce production costs

By reducing the reliance on manpower, enterprises can effectively reduce labor costs and make the production process more economical and efficient. At the same time, due to the improvement of production efficiency, the production cost of unit product is relatively reduced, so that enterprises can better grasp the initiative of cost control. This not only improves the profit space of the enterprise, but also makes it more competitive in the market competition, and can more flexibly to deal with market fluctuations. By reducing production costs, enterprises

can not only improve their own profit level, but also to provide consumers with more competitive products, achieving a win-win situation.

2.3 Improve product quality

The automation system of mechanical design and manufacturing plays a key role in improving the quality of products. Its high precision and high stability ensure the precision control of the production process and effectively reduce the error in product manufacturing. Through the advanced sensing technology, intelligent control system and strict production standards, the automation system can realize the accurate monitoring and adjustment of each production link, to ensure the consistency and quality stability of the products in the whole production process. This precision control not only improves the overall quality level of the product, but also reduces the defect rate in the manufacturing, and wins a higher reputation and market competitiveness for the enterprise. By improving product quality, enterprises can not only meet customers' demand for high-quality products, but also build a reliable brand image and achieve sustainable business success[2].

2.4 Promote technological innovation

By introducing advanced manufacturing technologies, automated systems can continuously optimize the production process, improve manufacturing efficiency, and achieve more complex and sophisticated product manufacturing. The continuous improvement of automation systems, including the introduction of intelligent control, Internet of Things applications and other technologies, provides enterprises with more efficient and flexible means of production. This not only enables enterprises to better adapt to the changes in the market, but also encourages the enthusiasm of employees in technological innovation. By promoting technological innovation, companies can stand out in the highly competitive market and maintain a leading position in the industry.

3. The development trend of mechanical design and automation

3.1 Digital manufacturing

Digital manufacturing is one of the future development trends of mechanical design and manufacturing and its automation, and its importance is increasingly prominent. Through digital modeling, virtual design, digital simulation and other technical means, the manufacturing industry can digitize the whole process of product design and production, and realize the whole process visualization and real-time monitoring of information. This enables companies to develop and produce products more accurately, reducing the cost of trial and error in traditional manufacturing. Digital manufacturing not only improves production efficiency, but also promotes collaborative work and the efficient use of resources. At the same time, through digital data analysis, enterprises can better understand the key factors in the production process, and achieve lean production and continuous improvement. The introduction of digital manufacturing has brought a more flexible, efficient and intelligent production mode to the manufacturing industry, and is a key driving force for the manufacturing industry forward.

3.2 Intelligent manufacturing

Intelligent manufacturing is an important development trend in the field of mechanical design and manufacturing, injecting new vitality into the manufacturing industry. Through the introduction of artificial intelligence, machine learning and other high and new technologies, the mechanical system gradually has the ability of self-learning and self-optimization. This enables the intelligent manufacturing system to adjust intelligently according to the real-time changes in the production environment, and improve the flexibility and adaptability of production. Intelligent manufacturing can not only predict and respond to changes in production, but also actively conduct fault diagnosis and repair, minimizing downtime. Through real-time data collection and analysis, the system can optimize the production process and improve the production efficiency. This intelligent manufacturing mode will provide more decision support and strategic advantages for enterprises, and promote the development of the manufacturing industry in a more intelligent and efficient direction[3].

3.3 Green manufacturing

As environmental problems become more prominent, enterprises are paying more and more attention to sustainable and eco-friendly production methods. Green manufacturing is environmentally friendly by improving manufacturing processes, using environmentally friend-

ly materials, reducing energy consumption and reducing waste emissions. This environmental protection concept not only meets the society's expectations for sustainable development, but also helps enterprises to establish a good brand image. Green manufacturing is not only the corporate social responsibility, but also an effective way to improve the overall competitiveness of enterprises. By focusing on environmental protection in the manufacturing process, companies can gain more recognition from consumers in the market and push the entire industry into a more sustainable future.

3.4 Man-machine collaborative manufacturing

The concept of human-machine collaborative manufacturing emphasizes the close collaboration between the human and the machine, aiming to achieve the combination of intelligent human guidance and precision execution of the machine in the manufacturing process. By integrating human creative thinking and the efficient execution ability of machines, human-machine collaborative manufacturing can improve the overall manufacturing efficiency. The development of technologies such as artificial intelligence and machine learning has enabled machines to better understand and respond to human guidance, while humans can accomplish complex tasks more effectively with their precision and speed. This collaborative approach can not only reduce the human burden, but also exert human creativity and flexibility. Human-machine collaborative manufacturing will bring a more efficient, more flexible and more innovative production mode to the manufacturing industry, and promote the development of the whole manufacturing field to the direction of intelligent and humanized nature[4].

Conclusion

Mechanical design, manufacturing and automation play a vital role in today's manufacturing industry. Its characteristics and advantages not only improve production efficiency and reduce costs, but also promote the improvement of technological innovation and product quality. In the future, digital manufacturing, intelligent manufacturing, green manufacturing and other trends will lead the development of the mechanical design and manufacturing field, and open up a broader space for the sustainable development of the manufacturing industry. The development of mechanical design and manufacturing and its automation is not only related to the competitiveness of the manufacturing industry, but also a key link to promote the improvement of the economic strength of the whole country. By continuously introducing advanced technologies and strengthening research and development and innovation, we can better cope with the challenges of the global manufacturing industry and maintain a leading position. At the same time, the future trend of mechanical design and manufacturing should also pay more attention to the sustainability and environmental protection, so that the manufacturing industry can pay more attention to the ecological balance while efficient development. In the development process of mechanical design and manufacturing and its automation, the government, enterprises and research institutions should work together to increase the support and investment in related fields. Only through cooperation and innovation, can we better promote the mechanical design and manufacturing and its automation to a higher level, and contribute more to the sustainable development of social economy.

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Application of Advanced Long Pipe Shed Construction Technology in Drift-Rock Mound Tunnel

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Abstract: Floating rock pile belongs to a special geological type, body stability of tunnel hole had a serious impact, based on the tunnel, drift rock pile in high altitude cold and arid regions of engineering characteristics were analyzed, and put forward using advanced and long pipe roof construction technology to carry on the preliminary support, introduces its construction process, to ensure the safety of the floating pile rock tunnel construction, to provide technical reference for tunnel construction problems of the same type.

Keywords: Tunnel Engineering; Boulders; Lead Long Pipe Shed

Introduction

In the process of highway tunnel construction, due to the complex geological environment of the tunnel construction area, the tunnel excavation and support process often encounter rock fracture area, loose weak surrounding rock, shallow bias and other adverse geological conditions. During excavation, it is easy to be damaged and disturbed, thus affecting the stability of surrounding rock, so different construction methods should be selected for different geological conditions in the construction of tunnel engineering [1,2]。

Due to the obvious heterogeneity and anisotropy of boulders, the construction of tunnels will be seriously affected. In view of the construction problems caused by boulder talus geology, a large number of scholars have carried out relevant research.Liu Guoqing [3] This paper introduces the application of the long pipe shed construction method in the complex geological environment, which can ensure the smooth construction. At the same time, highway tunnel construction often encounters weak surrounding rock, and the use of advanced long pipe shed support construction technology can effectively guarantee the construction quality of tunnel engineering[4-5]. Wang Kai introduces the application of the advance support technology of the long pipe shed under the unfavorable geological condition. Liu Hesong introduces the problems such as construction disjunction and pipe roof intrusion in the construction process of advanced long pipe, which will cause potential safety hazards to the tunnel. Huang Yongsheng In the introduction of its construction technology, its application scope and application are supplemented.

At the same time, the construction process of advanced long pipe shed technology is complex, including too many processes. Under complex geological conditions, if one of the steps has problems, it will affect the guidance of pipe shed, resulting in grouting can not be guaranteed, and ultimately affect the construction quality. At present, there is a lack of research on the advanced long pipe roof technology in the complex geological environment of boulder rock pile, so this paper proposes to apply the advanced long pipe roof technology in the construction of boulder rock pile tunnel, and introduces the key points of operation in its construction process to ensure the smooth progress of tunnel construction.

1. Project overview

The tunnel is located in Qinghai Province, which is a mountainous and hilly area with an elevation of 3000 m to 3500 m. The total length of the route is 8.12 km. The tunnel is a separated tunnel. Due to the influence of the terrain, the elevation difference between the two places is large, so the spiral tunnel is used now. The total angle of the tunnel is nearly 220 °, the minimum radius of the curve is 700 m, the slope is concentrated, the elevation difference of the entrance and exit is 58 m, the starting and ending pile number of the right line is K6 + 008-K8 + 562.63, the length is 2554.63 m, and the longitudinal slope is 2.3% one-way slope; The starting and ending chainage of the left line is ZK6 + 062-ZK8 + 688, with a length of 2626 m. The longitudinal slope is a one-way slope of + 2.2%, and the entrance and exit portals are end-wall portals. The underlying bedrock of the tunnel site is mainly boulder talus, and unfavorable geological structures such as fracture

zone are found in the tunnel site.

The Project is located in the marginal transition zone of the Qinghai-Tibet Plateau, where the stratum distribution is complex and scattered, the geological structure is developed, and the unfavorable geology along the line is as shown in Fig. 1.

Fig. 1 Tectonically denuded alpine landform

2. Engineering characteristics of boulder heap

2.1 Formation mechanism of boulder talus

The boulder talus is located in the staggered position of the tectonic zone under different geological conditions. Due to the crustal movement, a large number of folds are formed. Under the action of extrusion and stacking, the rock strata have relatively developed joints and fissures, forming irregular square bodies. Under the action of weathering and exfoliation, they are gathered at the foot of the mountain to form talus.In addition, the formation of boulder talus is mainly due to the fragmentation and uneven weathering of argillaceous, schist, slate and other rock masses, and some of them form steep slopes with weak lithology and weak weathering resistance. During weathering, the slope surface is stepped or jagged. Due to the transportation and scouring of geological activities, the spatial distribution of boulders is random, and the talus is easy to accumulate at the slope angle. As shown in Figure 2, the boulder is prone to uneven settlement in the stratum. Its appearance is generally round and oval. When it is distributed in the stratum, it is usually inclined. When it is subjected to external force, the stress in the middle is large, the stress area on both sides is small, and the stress on both sides is greater than that in the middle. It will rotate and the pores between soil will change. The movement of water and fine sand in the pores also leads to the change of soil structure.

Due to the low strength and irregularity of boulder talus, it will bring some potential safety hazards to tunnel construction, so it is necessary to take appropriate measures to increase the intensity of support.

Fig.2 Exterior view of boulder rock pile

2.2 Influence of Boulders on Tunnel construction

The distribution of boulders is random, with obvious heterogeneity and anisotropy, which often brings potential safety hazards to tun-

nels. The adverse effects of its characteristics on tunnel construction are reflected in the following aspects:

(1)Insufficient anchoring force, drill sticking and hole collapse. Due to the randomness of the spatial distribution of boulders, the phenomenon of drill jamming and hole collapse often occurs when drilling, and it can not provide a good force foundation for the anchor rod, resulting in low anchorage capacity, which greatly affects the construction rate of shotcrete and anchor support;

(2)Collapse phenomenon. Because the boulder rock pile is soft and loose and deforms rapidly, large vault subsidence and clearance displacement often occur during construction, which easily leads to collapse;

(3)Water gushing and quicksand. The boulder rock pile has strong water permeability, and there are often aquifers in the soil. Under the action of dynamic water and water pressure, it affects the effect of grouting and drilling, and even leads to collapse, instability of the first support and other accidents;

(4)Dynamic load and bias problems. The boulders are very sensitive to the dynamic load, sometimes there is partial bias, and the tunnel is prone to lateral displacement and distortion.

3. Construction technology of advanced long pipe shed

The basic construction process of the advanced long pipe shed is to determine the excavation sideline of the side and front slope according to the construction design drawing, and to protect the side slope by shotcrete. Then the guide wall is applied to guide and fix the construction of the pipe shed. Set up the drilling platform and install the drilling rig to drill, and clean the inner rod, withdraw the inner rod and withdraw the pipe sleeve. Then install the pipe shed, and finally grout.

3.1 Drilling construction

φ140mm seamless steel pipe is used as the guide pipe for this drilling, with a circumferential spacing of 40cm. The drill pipe length of the hydraulic trolley is 4.3m and 5.5m.

When drilling a deep hole, the connection between the drill pipes shall be connected by the drill pipe connecting sleeve, and the material shall be the same as that of the drill pipe, and the overall strength after connection shall be ensured. See Fig. 3 for drill pipe connecting sleeve.

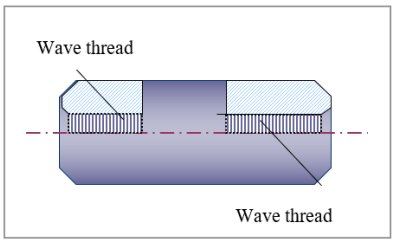

Fig. 3 Schematic Diagram of Drill Pipe Connecting Sleeve

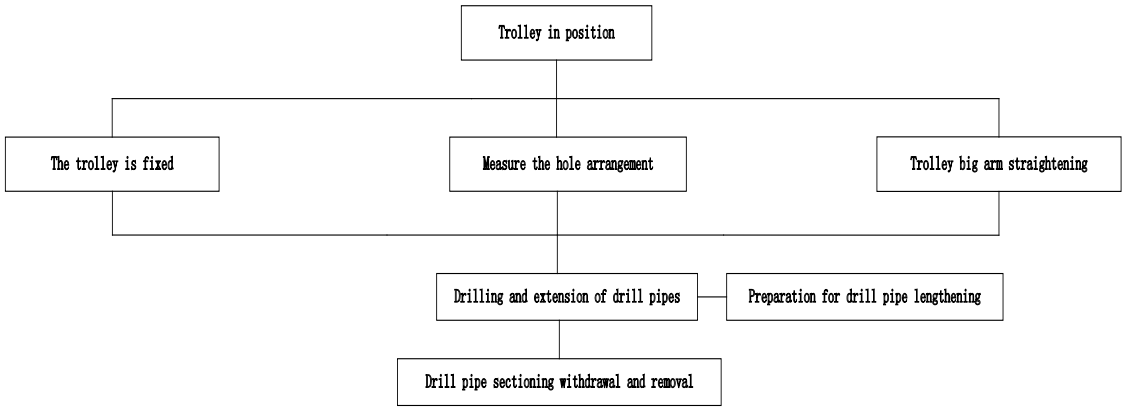

Fig. 4 Process Flow of Deep Hole Drilling

The operation of drilling deep holes has the following key points:

(1) Before drilling, it is necessary to drive the trolley to the tunnel face for positioning, and the surveyor stands on the basket of the trolley arm to determine the specific position of the drilling hole. In order to prevent vibration from affecting the accuracy of construction, the bogie arm must be pressed against the tunnel face during drilling.

(2) When the drilling machine starts to work, the speed of the drilling machine should not be too fast. When the drilling depth is about 20cm, it should be controlled at the normal speed. After the first section of drill pipe is drilled into the rock formation, stop drilling when there is about 25 cm left at the tail, and manually install the second section of drill pipe with the coupling sleeve installed into the drill rig, and connect the second section of drill rod with the tail of the first section as a whole.

(3) During the drilling process, the drill pipe may be damaged and cannot be used, so the overall structure of the drill pipe must be checked in time during the construction process to see whether there is obvious bending and damage and whether the central water hole is unblocked. When the above situation occurs, it needs to be replaced immediately.

(4) The diameter of the drilling guide hole shall be 15 ~ 20 mm larger than the outer diameter of the shed pipe, and the hole depth shall be more than 0.5m longer than the pipe length.

3.2 Process flow of pipe jacking

The combined process of large hole guide and shed pipe drilling is adopted, and the impact and thrust of the drilling machine are used to push the shed pipe with the working pipe head along the guide hole, and the shed pipe is extended section by section to the bottom of the hole. The process flow is shown in Figure 5.

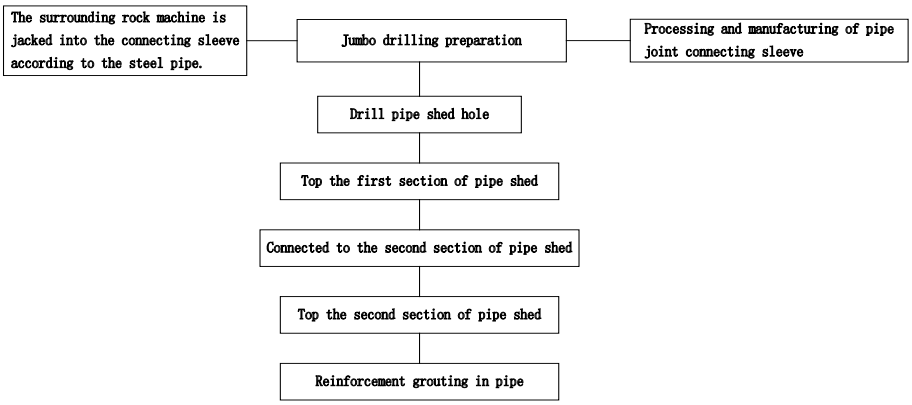

Figure 5 Process Flow of Pipe Jacking Construction

The key points of pipe jacking process and operation are as follows:

(1)Fabrication of pipe fittings: Φ108 and 6mm hot-rolled seamless steel pipes are used, with pipe sections of 3m and 6m in length. The left and right tunnels at the inlet and outlet ends of a tunnel are both 30m in length, so the pipe sections shall be lengthened. When lengthening the pipe fittings, the joints of the connected pipe sections must be staggered back and forth to make their structure stable.

Double-arm hydraulic drilling jumbo is used for the construction of the long and large pipe shed. One of the big arms is used to drill the pilot hole with a Φ120mm percussion drill, as shown in Fig. 6. The other big arm is used to Jack the Φ108mm shed pipe. A steel pipe jacking connecting sleeve (as shown in Fig. 7) corresponding to the diameter of the pipe shed must be installed on the rock drill of the pipe jacking boom, and a special steel pipe straightener (as shown in Fig. 7) must be replaced on the boom. After the pilot hole is drilled, use the pipe jacking boom for jacking operation.

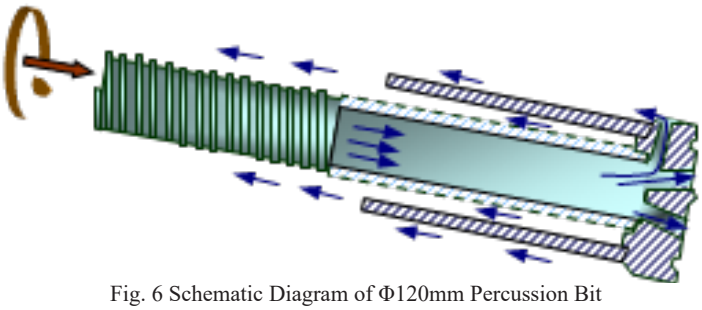

Fig. 6 Schematic Diagram of Φ120mm Percussion Bit

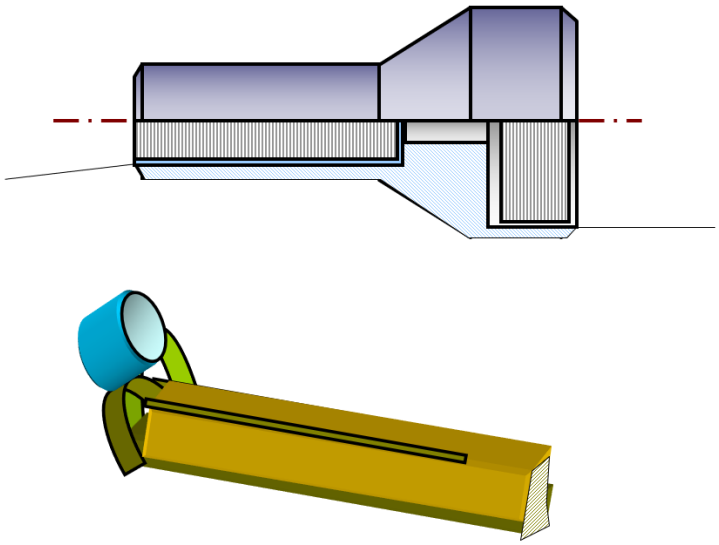

Fig. 7 Schematic Diagram of Pipe Roof Jacking Connecting Sleeve and Trolley Arm Straightener

(2) Pipe jacking operation: the other big arm of the double-arm hydraulic drilling jumbo is used to Jack the steel pipe. During operation, the steel pipe shall be pushed at a low speed. During jacking, the pressure shall be controlled at about 1.9 Mpa, and the pushing pressure shall be controlled at about 5Mpa.

(3) Connecting pipe: when the first steel pipe is about 30cm left, the big arm jacking connecting sleeve needs to be separated from the steel pipe, the rock drill is reversed, the steel pipe is connected manually, and the two steel pipes are connected into a whole at the connecting sleeve. The big arm prepares the steel pipe again, and the rock drill pushes the steel pipe in at a low speed.

(4) Grouting and consolidation: try to prevent the occurrence of grouting, and stop immediately if it occurs. At the same time, to ensure uniform grouting, a hammer can be used to knock the steel pipe. If there is a clear sound, it means that there is a vacancy and the steel pipe is not filled.

(5) Reinforcement of pipe shed: pigging shall be carried out before reinforcement, so as to strengthen the rigidity and strength of pipe shed. Reinforcing method: cement concrete is injected into the steel pipe to form the cement concrete steel pipe under common environment. In case of collapse and destruction of surrounding rock, Φ20mm reinforcement cage shall be placed in the steel pipe first, and then grout shall be injected into the steel pipe to form a concrete steel pipe.

4. Conclusion

(1) The distribution of boulders and rock piles is random. Under the action of external force, the force at different positions cannot be balanced, which often causes construction problems such as drill jamming, hole collapse, insufficient anchoring force and water gushing and quicksand.

(2) The advanced long pipe shed support plays a positive role in the construction of boulder rock accumulation tunnel project, which can effectively prevent the collapse of tunnel face excavation and form a stable composite consolidation body after grouting.

(3) The advanced long pipe shed does not require particularly large construction machinery and equipment, has good technical and economic performance and good stability, and can effectively guarantee the construction safety.

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Key Technologies for In-Situ Conservation of Sites in Site Display Projects

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Abstract: The protection and display of ruins has received more and more attention and importance due to its inheritance, education and economy. This paper relies on the DeShouGong site protection and display project to carry out research on the key technology of earth site protection under the humid environment in the south, and integrates and applies the protection technology of the Southern Song Palace site to provide a reference sample for the protection of the same type of site in the humid area in the south.

Keywords: Site Protection; Humid Environment; Large-Span Steel Structure; De Shou Palace

1. Introductory

Site display is an effective way to protect and sustainably display and utilize archaeological sites, and its construction and development can effectively protect and pass on cultural heritage resources, improve the public's knowledge and understanding of history and culture, and promote cultural tourism and social and economic development [1]. The protection of cultural heritage, together with that of natural heritage, has attracted the attention of all mankind, and China has been paying more and more attention to the protection of heritage [2, 3]. Earthen sites, as a type of natural heritage, are characterized by the nature of the earth, which results in lower strength and poorer water stability performance of the site itself. In arid and semi-arid regions, the conservation techniques for earthen sites are relatively mature and successful, but there are fewer relevant studies on the conservation of earthen sites in humid environments [4]. Conservation of earth sites in humid environments is a highly targeted and complex task, affected by many factors such as the geographical environment and the structural characteristics of the sites, and there is no set of mature and standardized conservation techniques and reinforcement materials. At the same time, the earth site generally covers a large area and is directly connected to the ground, how to carry out the site display protection, has important theoretical significance and practical value.

Based on this, this study relies on the Deshou Palace site protection and display project to study how to carry out the protection of earth sites under humid environments, and to integrate and apply the relevant technologies for the protection of the Southern Song Dynasty palace sites, which will not only provide sufficient technical support for the relevant projects in the future, but also enhance the domestic technical strength in the protection of the sites of the Southern Song Dynasty, and provide samples for the restoration and protection of the same type of sites in the humid areas of the South.

2. Project Overview

The site of Deshou Palace is an outstanding representative of the palace architecture and royal gardens of the Southern Song Dynasty, with important historical value, artistic value, scientific value and social value. The De Shou Gong site display project is located in Shangcheng District, Hangzhou City, Zhejiang Province, China, and the project is divided into two parts, the center and the west, as shown in Fig. 1. The project focuses on the protection and display of the ruins, and takes into account the functions of recreation, education, culture, and so on. Sites in the construction area are divided into two categories: those that have been archaeologically excavated and are proposed to be exposed for display; and those that have been archaeologically excavated and are proposed to be scientifically backfilled.

Figure 1:DeShouGong Ruins Museum

3. Difficulties in site protection

Deshou Palace site is located in Shangcheng District, Hangzhou, belongs to the typical subtropical monsoon climate, the average annual temperature is 17.8 ℃, the average relative humidity is 70.3%, the annual precipitation is 1,454 mm, the water table and the air humidity is high. Groundwater level changes dynamically with seasons and climate, during the survey period, the water level of all the boreholes in the site is buried between 2.10 m and 2.50 m, and the annual variation of the general groundwater level is around 1.00 m. Water damage to sites is the most serious public nuisance, and therefore, control of the water environment is a major focus and challenge for the conservation of earthen sites in wet environments.

In order to maximize the protection of the site, this project was designed to use a large-span steel structure as the main body of the site protection shed, as shown in Figure 2. Some of the regional steel trusses have a mass of about 65 t per truss and a span of 43.16 m. The steel trusses have a mass of about 1.5 t per truss and a span of about 2.5 m. Simultaneously, the project is located in the city center, and the transportation of large materials is impractical, necessitating disassembly prior to entry for on-site assembly. Construction is constrained by a limited working space, exacerbated by the challenging requirement for elevated loads in the designated archaeological site area, where the underground consists entirely of preserved relics. Furthermore, any mechanical equipment is strictly prohibited from entering the archaeological exhibition zone, adding a significant layer of complexity to the construction process.

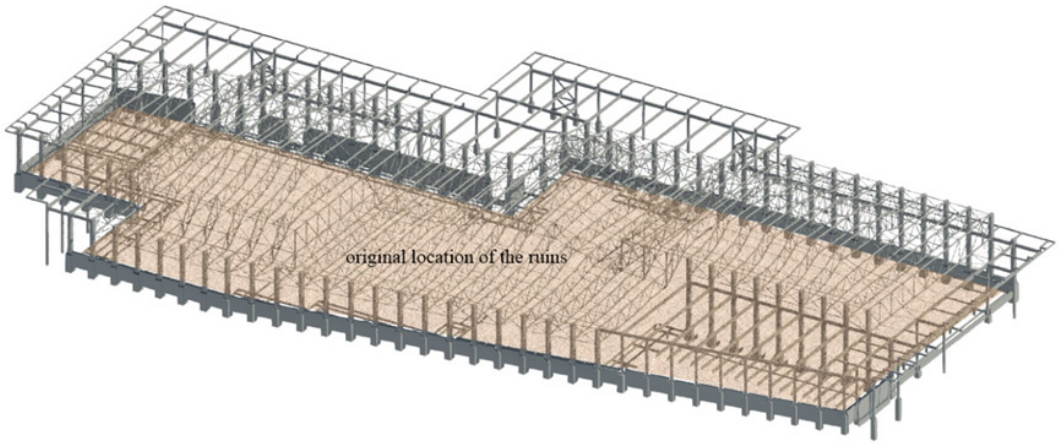

Figure 2:Steel Structure Protection Shelter in the West Area of Deshou Palace Ruins

4. Key technologies for in-situ conservation of sites

4.1 Technologies for controlling the water environment at the site

The conservation and excavation of cultural relics are intricately linked to the aquatic environment, a relationship characterized by its close and complex nature. The three states of water and the transitions between them can significantly impact the deterioration of cultural heritage materials [5]. If the Deshou Palace site is subjected to water damage, an analysis of water sources reveals three main aspects: atmospheric precipitation from above, lateral groundwater seepage along the sidewalls, and capillary rise of groundwater from below. Based on the origin of water, a combined approach involving water insulation, water diversion, and water-resistant measures is employed as a comprehensive treatment strategy.

Water insulation measures: The combination of the TRD (cement-stabilized soil continuous wall) water-stop curtain with the impermeable wall of prefabricated panel walls, along with the glass canopy situated on the walls, serves to obstruct external groundwater supply to the archaeological pit. This approach aims to reduce soil moisture content and control water levels within the pit. Considering the geographical location of the site, historical relics, soil conditions, and surrounding environment, the project adopts the TAD construction method for channel-type cut-and-assemble underground continuous walls supported by piles. Reinforcement at corners is achieved through a comprehensive approach involving full-circumference high-pressure jetting method piles (MJS). The TAD construction method involves inserting rectangular concrete prefabricated panels measuring 1000 mm*400 mm into the channel-type cut-and-assemble cement soil continuous wall (TRD), creating a reinforced concrete underground continuous wall that integrates soil retention and water-stopping functions. This design effectively intercepts the infiltration path of excessively high groundwater from the sidewalls into the archaeological exhibition area, thereby mitigating damage caused by lateral groundwater seepage to the archaeological site. Moreover, relevant studies indicate that the TRD construction method minimizes disturbances to the surrounding environment and reduces the construction's impact on the archaeological site [6, 7].

Figure 3: TAD Method Pile Construction

In addition, a protective glass canopy is installed to shield the archaeological site from atmospheric precipitation, aiming to maintain internal humidity conditions. In accordance with preservation requirements and variations in meteorological conditions, a comprehensive approach involving natural ventilation, mechanical ventilation, and a full-air HVAC system is employed to provide cooling and heating to the protected area of the archaeological site, ensuring the preservation of humidity.

Water diversion measures: Based on the general soil bearing capacity and elevated groundwater levels in the burial area of the archaeological site, flood-cutting trenches are strategically established around the distribution area of the site. This is aimed at preventing inundation and internal flooding of the site caused by the rising groundwater levels in surrounding rivers and channels during the rainy season. The wa-

terproof isolation strip measures 1 m to 1.2 m in width and 1 m to 1.5 m in depth.

Waterproofing measures: In light of the specific circumstances uncovered following the excavation of the Deshou Palace archaeological site, reinforcement measures are implemented on the site's surface by means such as spraying, watering, or pressure injection of strengthening materials to prevent the site from collapsing or weathering due to water infiltration. Simultaneously, protective measures are taken, including appropriate backfilling protection, surface cleaning, microbiological treatment, application of desalination patches, adhesive reinforcement, grouting reinforcement, and pedestal restoration. These protective measures ensure the timely cleaning of cultural relics, restoring them to their original appearance, and providing suitable protection to prevent further deterioration of cultural heritage due to viral invasion.

Figure 4:Spraying reinforcing materials and surface tamping

4.2 Large steel structure lifting technology

In order to minimize the impact of construction on the original site of the archaeological remains and ensure the safety of construction hoisting, a feasibility analysis for the lifting of large-scale steel structures was conducted prior to construction. The engineering calculations in this study utilized the finite element analysis software Midas Gen v8.21. The load considered only self-weight, with a dynamic load factor of 1.4. It was found that the maximum stress in the structural members during the construction process was 25.3 N/mm², the maximum structural displacement was 9.8 mm, and the deflection-to-span ratio was 1/2876. These results indicate that the construction requirements are met.

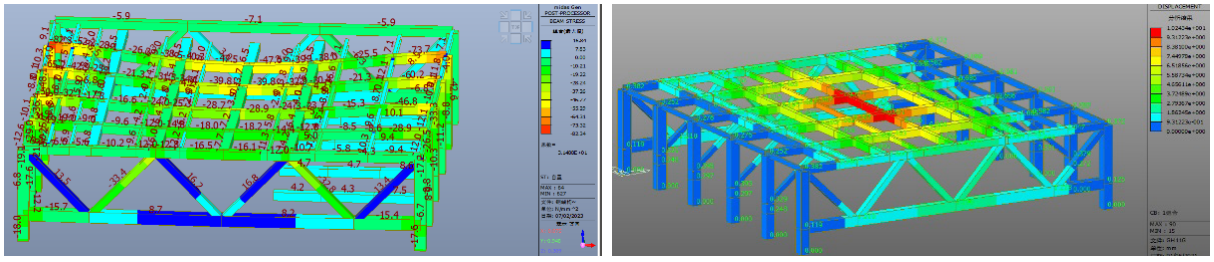

Figure 5:Finite element analysis

The main machinery employed in this project includes crawler cranes with capacities of 150 t and 400 t. Given the substantial mechanical loads involved, foundational load unloading measures are necessary. The 400 t crawler crane utilizes a hardened road surface, with steel plates laid under the tracks during construction. Similarly, for the 150 t crawler crane, steel plates are placed under the tracks during construction. Lift load verifications are conducted for both cranes to ensure the effectiveness of the foundational load unloading measures without impacting the archaeological site. For the 400 t crawler crane verification: The total weight of the crawler crane is 355 t, with an additional counterweight of 150 t, and the lifted component weighs approximately 65 t. The most critical load is determined when the lifting boom and the body form a 60° angle, and utilizing the moment distribution method, the maximum lifting ground load is calculated to be 5700 kN. During crane operation, the construction load on the floor surface is 17.8 kPa. The archaeological layer is approximately 4.0 m below the ground surface. According to the principle of additional stress, the maximum additional stress occurs at the center of the hardened floor during crane operation. Considering a stress coefficient of 0.5 for the archaeological site, the calculated additional stress at the center of the hardened floor

is 16.7 kPa, meeting the requirements. The same method is applied to calculate the 150 t crawler crane, and the results meet the specified criteria. The lifting construction involves the determination of crane parking locations, material storage yards, and pre-assembly sites. The precise calculation of site area and load values must be established and discussed by all parties before construction can proceed. Prior to lifting, foundational treatments are necessary to ensure that the foundation meets the required load values for lifting. Slopes affected by construction operations should be addressed and protected in advance, and the construction boundaries need to be clearly defined. Before lifting steel components, appropriate lifting points should be selected and verified. For components with low lateral stiffness and a large width-to-thickness ratio of the web, measures should be taken to prevent distortion, damage, and local deformation of the components. In areas where archaeological sites have been discovered, a specialized plan for cultural relic protection should be prepared in advance during the construction process. This is to prevent damage to the archaeological site, such as crushing of sites and slope displacement, caused by lifting operations.

4.3 Welded reinforcement of steel structures on the site display area

In the vicinity of the archaeological site exhibition area, a ring of steel columns has been installed, while no steel columns are positioned within the site. Above the archaeological site at an elevation of 5.05 m, there exists a single-story steel structure floor beam. Due to the large span of the steel platform beam, significant deflection is observed after lifting, and the steel beam, yet to undergo reinforcement, exhibits notable flexural deformation. Complicating matters further, no scaffolding or supports are permitted above the archaeological site. Consequently, during the construction process, welding reinforcement to the steel beam poses considerable challenges, given the necessity to ensure that the deformation of the steel beam conforms to specified requirements.

After thorough research and discussion, it has been decided to employ a non-ground-supported steel structural reinforcement system. Steel pipe supports are positioned at the ends of the reinforced steel platform beams, and diagonal steel pipe braces are installed at one-quarter of the beam length from the platform beam's ends. This structural system is employed to reduce the span of the steel beams, minimizing construction deformations. Subsequently, after adjusting the elevation of the steel beams to the design height through two sets of supports, welding reinforcement is applied to the beams. Once the steel beams are securely fixed, the two sets of supports are removed.

Figure 6:Non-ground-supported steel structural reinforcement system

4.4 Mobile platform construction techniques over the site

The elevation of the ceiling of the archaeological protection hall is 11.6 m, while the average elevation of the archaeological site surface is 6.58 m. A glass platform is situated above the archaeological site (ground level of the first floor), with an elevation of 8.1 m. In the middle, there is a void exposing the archaeological site for transparent exhibition. During the construction of pipelines, equipment, and other installations on the upper portion, the lower archaeological site surface has been exposed, and no additional construction loads are allowed on the archaeological site surface. Therefore, a construction mobile platform has been designed to provide a working surface, primarily utilizing the steel frame of the on-site constructed glass platform as a base and incorporating tracks. The main framework employs hollow steel square pipes welded with rollers, facilitating horizontal movement above the archaeological site.

Figure 7:Movable platform

5. Summary

During the archaeological site protection phase of the Deshou Palace project, excellent impermeability results were achieved without compromising the integrity of the architectural relics using the TAD method piles and MJS method piles. The project employed advanced techniques such as large-span steel structure lifting for site protection and welding reinforcement for the steel structure in the exhibition area, ensuring construction safety through condition simulation, stress calculations, and the implementation of non-ground-supported diagonal bracing. This approach minimized the impact of construction on the archaeological site and enhanced the final product quality. Simultaneously, the construction technique of an overhead movable platform above the archaeological site was employed to ensure the completion of the glass platform construction without direct contact with the archaeological area. The comprehensive archaeological site protection technologies mentioned above demonstrated favorable results in practical engineering applications, providing valuable insights for similar projects focused on the protection and exhibition of soil archaeological sites.

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