Journal of World Architecture

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Study on Fine Management of Construction Engineering Projects Based on BIM Technology: Taking the Construction of Group C Project of Zibo Cultural Center as an Example

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Abstract: The roof steel structure of group C project of Zibo cultural center is composed of steel truss, welded H-shaped steel and large-diameter steel pipe embedded parts. The construction of embedded parts of inclined cylinder overhanging steel structure is difficult. The stair square tube ladder beam requires precise angles and radians, complex processing, and construction site setting out is difficult. A three-dimensional visual building information model has been established for this projects which includes several aspects which are as follows: the development of the post anchor construction technology of large steel sleeve embedded parts with inclined cylinders based on Building Information Modeling (BIM) technology, multi discipline synthesis and collision optimization, the net height optimization of electromechanical pipelines, fine reinforcement management, BIM virtual construction template. Through this planning, 14908 pipeline collisions, including 236 major collisions have been eliminated. BIM is used in handling and solving problems with the construction unit and the supervision company. This greatly improves the project work efficiency and saves meeting time. Through optimization of electromechanical line collision and secondary masonry layout, more than RMB 9 million has been saved in terms of personnel and materials, effectively reducing material losses, saving manpower, and significantly improving the implementation efficiency of the project. Based on the on-site simulation, the project planning scheme of the enterprise was adjusted, efficient work allocation with less idle time were ensured, and the correct utilization of project funds and time were ensured. The original extensive annual control and monthly control have been dynamically and accurately controlled to realize the dynamic understanding of the profits and losses of the project, and effectively reduce the occurrence of non-ideal situations.

Keywords: Zibo cultural center; Steel structure; Building Information Modeling; Fine control

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1. Introduction

In recent years, the construction industry at home and abroad has developed rapidly, but various problems have emerged in the development process, such as unnecessary waste of resources, improper construction organization design, engineering quality and safety accidents, etc. [1,2]. Therefore, based on BIM Technology, many scholars at home and abroad have studied how to effectively improve construction efficiency and reduce resource investment [3,4]. At the same time, in accordance with China's double carbon policy and build green buildings, many construction enterprises in China have introduced BIM Technology into the construction process of a large number of domestic construction projects, so as to improve

construction efficiency, optimize design and reduce resource waste [5]. Hence, this paper thoroughly analyzes how to realize the fine management of construction projects based on BIM technology using the C group project of Zibo cultural center as an example.

2. Project overview

The group C project of Zibo cultural industry center is located at the southeast corner of the intersection of Liantong road and Xinhuan West Road, Zhangdian District, Zibo City, with a total construction area of 76782 m^2. The ground buildings include culture and science museum, ceramic art museum. Among them, the culture and science museum cover an area of 21,503 m^2, with the height of the main building at 28.4m, and the ceramics museum covers an area of 38,539 m^2, with a building height of 46m.The project was officially commenced on May 15, 2016 and completed on April 29, 2019.

3. Engineering difficulties and characteristics

3.1. Construction of large-span and large-size roof steel truss

The steel structure of the museum roof is composed of steel truss, welded H-shaped steel and large-diameter steel pipe embedded parts. The top elevation of roof steel truss is 33.875 m, the maximum span is 70.5 m, the number of members is about 2500, and the maximum section size of steel beam is h1500 $\times$ 400 mm while the maximum weight of a single member is 11.5 t.

Tekla software is used for three-dimensional modeling, which shortens the drawing time and improves the drawing accuracy. The preliminary planning through the three-dimensional model is conducive to a more thorough analysis of components and safer, more reasonable and reliable scheme [6].

3.2. Construction of large steel sleeve with inclined cylinder

It is difficult to install the embedded parts of the inclined cylinder overhanging steel structure. The large grouting material installation hole of the inclined cylinder is mainly used for the foundation treatment of the inclined cylinder overhanging steel structure, and requires precise positioning, axis displacement, elevation, and highly accurate construction of the embedded parts. The reserved hole for steel grouting material has a large volume, high load, difficult construction quality control and inconvenient operation, and the tower crane cannot be lifted; There are many anchor bars in reserved holes, and the inclined column head reinforcement is dense, so it is difficult to install the steel sleeve embedded parts in place; The installation height of steel sleeve embedded parts is high, and high-altitude operation are dangerous.

3.3. Construction of steel structure rotating stairs

The steel structure rotating staircase is located at the entrance of the science museum hall of the project. Its horizontal projection is oval, supported by nine large-diameter circular steel columns, and its overall height reaches 19.3 m. It is directly connected to the third floor of the science museum from the commodity department on the first floor underground. The square tube ladder beam of stairs requires precise angles and radians, complex processing which is difficult to set out on site. In addition, there are also problems of large stair size and difficult indoor hoisting.

Tekla was used to draw the steel structure rotating stairs, and the details of important nodes were optimized and adjusted. Combined with the mapping function of Tekla, the plane, elevation and section drawings were exported, and the special nodes were indicated in tables to guide the later construction [7].

3.4. Professional construction of complex electromechanical installation

There are many mechanical and electrical installation disciplines in the project, and the pipeline layout is complex therefore requiring precise height. During the construction of mechanical and electrical installation

works, the coordination and management of equipment procurement, installation, commissioning, operation and other aspects are involved. There are many subcontracts which causes difficulties in coordination. Secondly, the mechanical construction requirements cover a wide range of aspects, including electrical engineering, automation, electrical engineering and other fields, which require mechanical practitioners to master all-round engineering knowledge.

4. BIM based technology application and deepening design

4.1. Joint review of drawings based on BIM

Through the three-dimensional visualization of BIM mode, the design problems in the drawings can be more directly reflected which greatly improves communication [8]. The problems reviewed were sorted out according to disciplines and regions. Then, information such as drawing problem sources, problem descriptions, pictures (modification suggestions) were provided, and the review results of the final BIM drawings were generated.

4.2. Three-dimensional planning of construction site based on BIM

BIM Technology is used to conduct scientific three-dimensional design for the construction area, including the design of residential area, office, material production and storage area, site traffic, etc., which directly expresses the construction site information [9-12]. This ensures smooth traffic on the construction site, facilitate the operation of workers, and effectively prevent secondary handling and accidents.

4.3. Post-anchor construction technology of large steel sleeve embedded parts of inclined cylinder based on BIM

The visualization of BIM technology is used to assist the project in the research of quality control (QC) results, and the post anchor construction technology of large steel sleeve embedded parts with inclined cylinders was developed in this project.

4.4. Multi-discipline synthesis and collision optimization based on BIM

BIM is used for collision test [13] in which it can detect situations that are not found in various plan views and different collision situations. Finally, 14908 collisions were found, including 236 major collisions, which minimized unnecessary material and economic losses such as rework.

4.5. Clear height optimization of electromechanical pipeline based on BIM

BIM Technology is adopted to realize the clear height control inspection [14]. By scientifically and reasonably arranging various pipelines within the limited floor height, the available space on the ground is saved to the greatest extent. Besides, the overall sense of space for construction is improved. The engineering design intention and connection with construction products are also better completed. Moreover, various pipelines are arranged in an overall and reasonable manner to well meet the engineering application function, economy and aesthetic standards. Thus, the purpose of reducing the cost or improving the appearance is realized. In the construction of this project, the net height of the basement is adjusted reasonably, and the local equipment pipelines are adjusted and optimized to meet the needs of the construction owner.

Machine room pipeline optimization - the design of the equipment room uses the early deepening technology of BIM [15]. This ensures that the facilities and pipelines can be arranged uniformly in a limited space, realizing the unified arrangement of a variety of special pipelines, making the overall design of the machine room more complete, reasonable and beautiful. Through the preliminary planning, it meets the needs of many but not miscellaneous lines, orderly arrangement, clear hierarchy, correct direction, correct

pipeline delivery position and beautiful layout.

4.6. BIM based audit meeting

In depth technical meetings are often held to discuss BIM model collision detection technology and comes out with reasonable solutions. After the meeting, the outcomes are summarized and collision inspection reports according to the main collision conditions are provided. The construction party will then adjust the BIM design scheme of the discipline according to the conditions in the collision inspection report [16].

4.7. BIM based construction drawings

Through the construction platform of smart site construction, 3D modeling and 2D computer-aided design (CAD) files can be introduced into the cloud service management system, and the site manager can query through a mobile client. Using this method, the site manager can obtain drawing data very simply and efficiently, which is convenient for site management.

4.8. BIM based integrated support design optimization

Through BIM technology, the design and installation of integrated supports and hangers are realized. Besides, the air path, water channel, fire pipeline, cable tray, etc. are reasonably planned in order to save space, facilitate maintenance, and have a beautiful and tidy environment.

5. Project fine management based on BIM

5.1. Pine management of reinforcement

Due to the large amount of reinforcement used in this project, Guanglian Dayun proofing software and reinforcement site management software are used to help project managers realize site proofing and improve efficiency by using BIM Technology in reinforcement plan management, site proofing, processing optimization, material management, etc. [17].

5.2. BIM virtual construction template

By using BIM technology, with the help of its three-dimensional and visual characteristics, the construction process can be digitized and virtualized to replace the traditional entity template, at the same time realizing the visual preview. This creates a multi angle and all-round query of model information and make the construction disclosure process more efficient and easier for the construction personnel to master. In this way, not only does it save cost, but the use of materials and the generation of construction waste is also reduced. Besides, green construction is also realized.

5.3. Visual technical disclosure

In this project, the direct insert plate pin type formwork support will be used, which is a new type of formwork support. Compared with the traditional fastener type steel pipe scaffold, this formwork support has no zero parts, avoiding the loss and waste of zero parts. At the same time, this formwork support is convenient to set up, quick to construct and is efficient. It speeds up the construction process, and reduces labor intensity and the rental cost of reusable materials.

5.4. Application of two-dimensional code in measured real quantity

The two-dimensional code technology is effectively used in the actual measurement work. The staff can see the actual measurement results of various places anytime and anywhere, grasp the existing problems in the early construction process, and summarize the parts under construction, thus further improving the quality of project construction. On one hand, the problems existing in the previous construction process can

be understood; on the other hand, post skills can be improved by learning the measured results.

5.5. Construction progress management

The presentation method of virtual construction through construction simulation based on NavisWorks is an evolution of construction simulation in BIM technology. Applying it to the construction process of the project can effectively realize the early guidance of construction, process control implementation, and finally check the construction, so as to achieve the fine control of the project.

5.6. Construction quality management

Project quality control is performed using the “intelligent construction integrated management platform”. The site manager directly takes photos of the project quality problems on the mobile terminal at the construction site, and uploads the pictures to the platform. The system identifies the area where the project quality problems occur, defines the person in charge of rectification, the rectification time, etc., and sends the rectification results to the person in charge's personal mobile terminal. After the person in charge completes the rectification, the system determines the end. This is therefore in accordance to the “Plan Do Check Act” (PDCA) principle. At the same time, the problem record is linked to the BIM model. If the problem is not solved, it will always be nailed to the corresponding position on the BIM model. If the problem is not solved within the time limit, it will automatically remind relevant personnel. This allows the informatization and intelligence in quality management.

5.7. Construction safety management

It is necessary to use big data cloud processing platform, combined with the labor real name system management system, process the information of construction personnel in a timely and provide feedback in a timely manner, and conduct real-time supervision on site staff. It is necessary to monitor the construction site in real time and give early warning of unsafe construction behaviors in advance.

5.8. BIM + VR application

By introducing the VR experience safety education system developed by Ruigezhi Network Technology Co., Ltd. and restoring the safety accidents in the production process of the actual building, educated and experienced personnel can achieve better understanding of the causes of accidents, experience the process of accidents, and better understand the production technology and safety precautions.

5.9. BIM + UAV Technology

By introducing the BIM based UAV shooting method, the project sets the UAV flight photography route and scenic spots, and grasps the layout and image progress of personnel, materials, machines and tools at each time, so as to help control and adjust the construction deployment of the project, and finally master the construction image resources of the complete project.

6. Refined management effect based on BIM technology

Work efficiency: There are a total of 14908 pipeline collisions in this project, including 236 major collisions. The BIM model is used to with and solve problems for construction units, supervision units, engineering design units, etc. in a timely manner. This in turn greatly improves work coordination effect and saves meeting time.

Design advantages: BIM Technology is adopted to realize design advantages. According to the design of electromechanical line collision and secondary masonry layout, the cost department has saved about RMB 9 million according to the comprehensive calculation of labor and capital, effectively reducing

material economic losses, saving labor costs, and significantly improving the implementation efficiency of the project [18-20].

Construction organization optimization: Through building simulation, the construction organization planning of the enterprise is further optimized. Four large peaks and one large trough are combined with the actual construction, and finally optimized into a reasonable peak to reduce unnecessary idling. This is to ensure the rational planning and use of resources and time.

Contract control: The original extensive annual control and monthly control are dynamically and accurately controlled to dynamically understand the profit and loss and excess savings of the project, so as to effectively prevent the occurrence of unreasonable situations.

7. Summary and prospect

With the continuous development of BIM technology and information technology, more and more construction projects will phase out the original rough construction management mode and carry out fine management based on BIM technology. This requires future construction units to continuously cultivate a new generation of construction technicians, integrate construction technology and BIM technology, and build high-quality construction projects according to the national double carbon policy.

Disclosure statement

The author declares no conflict of interest.

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Study on the Operation Mechanism and Effect of the Yellow River Water and Sediment Regulation System

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Abstract: In order to scientifically deal with the problems of less water and more sediment in the Yellow River and the uncoordinated relationship between water and sediment, it is necessary to establish a perfect water and sediment regulation system. Through the calculation of the sediment transport capacity of the Yellow River and the application of the water and sediment regulation system, it is found that the sediment transport efficiency of the Yellow River will increase with the increase of water flow, and there will be an obvious inflection point near the flat discharge. The joint regulation of the backbone reservoir group can discharge the large discharge close to the minimum flat discharge of the downstream river, which improves the sediment transport capacity of the river and alleviates the problem of sediment deposition. In this paper, through the introduction of the Yellow River water and sediment regulation project system, regulation indicators and mechanisms, the author discusses in detail the Yellow River water and sediment regulation scheme and its operation effect, hoping to provide help promote the improvement of the Yellow River governance effect.

Keywords: Yellow River; Water and sediment regulation; Regulatory indicators; Regulatory mechanism; Operation effect

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1. Introduction

The Yellow River is the mother river of China. It has watered the vast central plains, raised the Chinese people, cultivated the great Chinese national spirit, and created a splendid Chinese culture. Therefore, paying attention to the ecological protection of the Yellow River basin, strengthening the regulation of reservoirs, coordinating the water sediment relationship of the Yellow River, and ensuring the flood control safety and water supply safety of the Yellow River have always been issues of widespread concern to the people of the whole Yellow River Basin. For a long time, the problems of less water and more sediment and the uncoordinated relationship between water and sediment have been the main problems restricting the economic development of the Yellow River basin. In order to thoroughly improve this situation, we must build a perfect water and sediment regulation system and operation mechanism of the Yellow River, reduce the risk of bank breach caused by river sediment deposition by increasing water, reducing sediment, and regulating water and sediment, so as to ensure the long-term stability of the Yellow River, ensure the safety of production and life of the people downstream, and promote the high-quality development of the whole basin. In the early 1980s, in combination with the Xiaolangdi water control project, theoretical research on the variation law of water and sediment and the regulation of water and sediment in the Yellow

River were carried out, and demonstrated the key technologies such as the initial operating water level, regulating flow and regulating storage capacity of the Xiaolangdi reservoir. However, the research results show that this water and sediment control system cannot achieve the ideal goal of coordinating the water and sediment relationship. Therefore, in the context of the development of the new era, the Yellow River water and sediment control work should be combined with the operation indicators of reservoirs, through the accurate analysis of the operation mechanism of the water and sediment control system and the impact of the coordination degree of the Yellow River water and sediment relationship on the Yellow River trough section and reservoirs, so as to build a more perfect Yellow River water and sediment control system and operation mechanism, to ensure the best scouring and silting effect of the Yellow River reservoir and river channel, and to effectively promote the high quality of the Yellow River basin.

2. Water and sediment regulation engineering system of the Yellow River

The Yellow River water and sediment regulation project system is mainly built around Longyangxia, Liujiaxia, Heishanxia, Qikou, Guxian, Sanmenxia, Xiaolangdi and other key water conservancy hubs, and Luhun, Guxian, Hekou village, Dongzhuang reservoirs in the main stream and the tributaries of Haibowan and Wanjiazhai reservoirs. The project system is shown in **Figure 1**.

Figure 1. Water and sediment regulation engineering system of the Yellow River

The water and sediment regulation engineering system of the Yellow River mainly includes two key parts: the upstream regulation subsystem and the midstream regulation subsystem. Among them, the upstream regulation subsystem includes Longyangxia, Liujiaxia, Heishanxia reservoir, and so on. The main regulation indicators are to regulate water volume and optimize the regulation of water resources, so as to meet the requirements of upstream ice cream prevention, flood control and silt reduction to the greatest extent. In the whole Yellow River water differential regulation subsystem, Qikou, Guxian, Sanmenxia and Xiaolangdi reservoirs are the main bodies, which plays a decisive role in improving flood, sediment control, water diversion, coordinating the relationship between water and sediment and optimizing the water resources of the Yellow River. Among the key projects to be inspected, Dongzhuang water control project is the most important, which is expected to be completed in 2025; Guxian Water Control Project has passed the review and is planned to start construction in 2030; Heishan Gorge and Qikou are currently in the preliminary demonstration stage of the project.

3. Water and sediment regulation index and mechanism of the Yellow River

3.1. Control indicators

The regulation of water and sediment in the Yellow River mainly includes the function index of sediment transport and flood discharge in the river, the safety index of flood control and ice prevention in the Yellow River, and the index of optimal allocation of water resources. It is the basic parameter to ensure the stable operation of the regulation system of water and sediment in the Yellow River. China has a long history of research on the water and sand control of the Yellow River, especially in the research on reducing the siltation of the river. Scholars An Guihua, Lu Jun et al. [1], based on the analysis of flood data measured in the Ningjiang-Mongolia Reach, concluded that the basic regulated flow rate for maintaining and restoring the middle water channel in the Ningjiang-Mongolia Reach was 2.5×10^3–$3.0 \times 10^3 m^3/s$, and the corresponding regulated water amount was 3.2 -3.9 billion m^3.Scholars Hu Chunhong, Liu Jixiang et al. [2,3] analyzed the flood data measured in the lower Reaches of the Yellow River, and pointed out that the effectively regulated flow should be more than $2.6\times10^3 m^3/s$ for sediment transport and water restoration and maintenance in the lower Reaches of the Yellow River. Among them, when the scour efficiency is the highest, the regulated flow is 3.0×10^3- $4.0\times10^3 m^3/s$, and the corresponding regulated water is 1.5–1.7 billion m^3.

In this study, the reasonable regulation index of river sediment transport and flood discharge is obtained through the calculation of river sediment transport capacity formula (formula 1).The average depth of riverbed is closely related to water flow. Taking $h = \alpha Q^{\beta}$ and $U = \frac{1}{n} h^{\frac{2}{3}} J^{\frac{1}{2}}$ into the sediment carrying capacity formula of water flow $S^* = K (\frac{U^3}{gh\omega})^m$, the formula of river sediment carrying capacity can be obtained:

$$S^* = K \alpha^m Q^{\beta m} (\frac{J^{3/2}}{g\omega n^3})^m \quad (1)$$

Where,
H–average water depth of river channel (m);
Q–flow (m^3/s);
U–average flow velocity of section (m/s);
S–flow sediment transport capacity (kg/m3);
N–roughness;
J–hydraulic gradient;
G–gravitational acceleration (m/s^2）;
Ω–average sedimentation velocity of sediment, (m/s);
K. M–sediment carrying capacity coefficient and index;
α, β–Coefficient

When water flows through the main channel of the lower reaches of the Yellow River, the sediment transport capacity of the rive– will increase with the increase of water flow; When water flows through the floodplain, due to the high roughness of the floodplain, the flow radius of the river section decreases, and the sediment transport capacity of the river channel also decreases. Therefore, there is often an obvious inflection point in the sediment transport capacity of the river channel in the flat area [4]. In the whole water

and sediment regulation system of the Yellow River, the minimum flat discharge of the river is located in the Gaocun Aishan river section. Therefore, in order to effectively improve the sediment transport capacity into the sea and reduce the risk of river siltation during the operation of the water and sediment regulation system, it is necessary to create the flow passage conditions closest to the flat discharge on the premise of fully considering the flood control requirements of the region [5].

3.2. Regulation mechanism

Because of the great difference between topographic and climatic conditions in the whole Yellow River basin, the Yellow River presents the characteristics of different sources of water and sediment and great interannual variation of water and sediment.The water volume of the Yellow River mainly comes from the upper Hekou Town, and the sediment source of the Yellow River is concentrated in the Hekou town Longmen interval and Longmen Sanmenxia interval. Therefore, the regulation subsystem of the upper reaches of the Yellow River should mainly regulate the water volume; the Yellow River red oil regulation subsystem should focus on flood and sediment regulation, and build a mutual cooperation mechanism between the middle and upper reaches of the regulation subsystem, which can achieve the goal of coordinated regulation of the Yellow River water sediment relationship [6].

(1) Upstream regulation mechanism

The total drainage area above Hekou town is $3.8 \times 105km^2$ is the main source of the water volume of the Yellow River, accounting for 65% of the total water volume of the whole basin. Therefore, the regulation objectives of the basins above Hekou town have been water volume regulation, mainly to supplement the dry season with abundant water, improve the supply capacity of water resources and the production efficiency of cascade hydropower stations.

Since the South-to-North Water Transfer Project was put into operation, the inflow of water from the west line into the Yellow River has become the main way of water regulation in the upper reaches of the Yellow River. The completion and operation of Heishanxia reservoir has played an anti-regulating role in the discharge flow under the upstream cascade hydropower stations. Therefore, in the operation process of the water and sediment regulation system, the non-flood season water volume should be adjusted to the flood season in combination with ice control scheduling, creating a 2.5×10^3–3×10^3 m^3/s flood discharge, in order to minimize the adverse impact of the large storage volume of Longyangxia and Liujiaxia Reservoirs on the Ningmeng river section in the flood season realize the scientific coordination of the water sediment relationship in the Ningmeng river section, and curb the occurrence of suspended rivers in the Ningmeng river section [7].

(2) Midstream regulation mechanism

The flood and sediment entering the lower reaches of the Yellow River mainly come from Hekou town-Sanmenxia section in the middle reaches of the Yellow River, and the annual water volume accounts for only 35.6% of the total water volume of the whole basin, while the annual sediment volume accounts for nearly 90% [8]. Therefore, the work of water and sediment regulation in the middle reaches of the Yellow River should focus on reducing peak discharge, combined sediment detention and water and sediment regulation. This operating mechanism can not only reduce the risk of river siltation, but also moderately restore the flood and sediment transport capacity of the river channel.

At present, in the regulation and control of water and sediment in the middle reaches of the Yellow River, water and sediment regulation is mainly carried out around Xiaolangdi reservoir, and the discharge capacity of the main channel of the river is improved under the timely operation of Wanjiazhai, Sanmenxia Reservoir and their tributary reservoirs, so as to ensure that the disharmony between water and sediment in the downstream river is effectively improved [9].

(3) Joint application mechanism of middle and upper reaches

Based on the analysis of the characteristics of the water and sediment heterogenesis of the Yellow River, the water and sediment regulation work of the Yellow River should be combined with the application of the upstream regulation system and the midstream regulation system. In the process of upstream regulation and control, it is necessary to focus on the regulation and control of water discharge in flood season, so as to provide sufficient hydraulic conditions for the coordination of water sediment relations in the middle reaches; The regulation and control of the middle reaches should focus on shaping the sediment transport volume of the flat beach, so as to minimize the siltation of the flat beach out of the riverbed.

During the specific application of the joint mechanism of the middle and upper reaches, the pre-discharge of Xiaolangdi reservoir is often carried out in combination with the flood evolution, so as to reserve enough storage capacity for the flood season, and ensure the over capacity of the reservoir in case of severe rainstorm. At the same time, by docking with the discharge flow of the upper reaches, it provides sufficient power for the water and sediment regulation of the middle and lower reaches of the reservoir, so as to achieve the best dredging effect of the reservoir and the river [10].

4. Scheme and effect of water and sediment regulation in the Yellow River

4.1. Water and sediment conditions

Relevant research results show that there are two main reasons for the great changes in moderate runoff and sediment volume, one is the influence of natural climate factors, and the other is the influence of human activities. This paper analyzes the effect of water and sediment regulation based on the sediment inflow of 800 million tons in the middle reaches of the Yellow River. Based on the calculation of the annual average water and sediment yield during the period of 1988−1997 + (1959-2008) × 3, the accurate results of the annual average water and sediment yield of 27.08 billion m³, 796 million t and 29.4kg/m³ were obtained.

4.2. Calculation method

The actual operation effect of the water and sediment regulation system of the Yellow River can be clarified through the analysis of the siltation amount and the coordination degree of water and sediment relationship in the lower reaches of the Yellow River. Among them, for the calculation of the expected volume of the lower Yellow River, the joint regulation model of reservoir and river sediment is used, and the coordination of water sediment relationship is queried through the coordination degree table of water sediment relationship [11].

(1) Combined regulation model of reservoir and river sediment

The joint mediation model of reservoir and river sediment mainly includes reservoir regulation and sediment scouring and silting module. The main function of the reservoir regulation module is to generate reservoir regulation instructions in combination with the different sediment scouring and silting states of the reservoir and the downstream channel, which in turn provides the boundary conditions for flow calculation for the sediment scouring and silting module [12].The sediment scouring and silting module is mainly composed of two parts: reservoir sediment scouring and silting and river sediment scouring and silting, both of which are calculated by one-dimensional hydrodynamic models (flow continuity equation and flow motion equation), which is shown below:

$$B\frac{\partial z}{\partial t}+\frac{\partial Q}{\partial x}=qt \tag{2}$$

$$\frac{\partial Z}{\partial t}+2\frac{Q}{A}\frac{\partial Q}{\partial x}-\frac{BQ^2}{A^2}\frac{\partial z}{\partial x}-\frac{Q^2}{A^2}\frac{\partial A}{\partial x}\Big|_Z=-gA\frac{\partial z}{\partial x}-\frac{gn^2|Q|Q}{A(\frac{A}{B})^{\frac{4}{3}}} \tag{3}$$

The suspended sediment is divided into M groups, and the sediment concentration of K groups is expressed by Sk. The unbalanced sediment transport equation and riverbed deformation equation can be obtained through equations (4) and (5):

$$\frac{\partial\ (AS_k)}{\partial t}+\frac{\partial QS_k}{\partial x}=-\alpha\ \omega_k B(S_k-S_{*k}) \tag{4}$$

$$\gamma'\frac{\partial A}{\partial t}=\sum_{k=1}^{M}\alpha\omega_k B(S_k-S_{*k}) \tag{5}$$

Where,

X−coordinate along the flow direction, m;

T−time, s;

z− water level height, m;

A − cross section water passing area, m²;

B−river width, m;

QL−inflow (outflow) flow per unit time and river length, m²/ s;

A−recovery saturation coefficient;

ω_K−settling velocity of sediment particles in Group K, m/s;

S_k−sediment carrying capacity of Group K, kg/m^3;

γ'−dry bulk density of sediment, kg/m^3.

The governing equation of the mathematical model is discretized by finite volume method, and the coupling relationship between flow and water level is processed by simple algorithm based on staggered grid. The model has been tested by many measured data of the Xiaobei main stream of the Yellow River, Sanmenxia reservoir, Xiaolangdi reservoir, the lower reaches of the Yellow River and the estuary of the Yellow River, and can accurately reflect the characteristics of water and sediment transport and sediment erosion in the study area.

(2) Coordination degree of water sediment relationship

The lower reaches of the Yellow River have the lowest slope and the most serious sediment deposition.Relevant scholars have proposed that the long-term non silt or silt deposition process in the main channel of the lower Yellow River is the basis for maintaining the harmonious relationship between water and sediment of the Yellow River, and defined the coordination degree of water and sediment relationship [13].The calculation formula of water sediment coordination relationship is shown in equation (6):

$$Cun(i)=\frac{\xi_i}{\xi_T} \tag{6}$$

Where,

Cun(i) − coordination degree of water sediment relationship;

i − sediment inflow coefficient of different water and sediment source areas of the Yellow River;

ξ_T − critical sediment inflow coefficient of non-siltation or slight siltation in the lower reaches of the Yellow River.

According to formula (1), divide the calculated sediment transport efficiency by the flow velocity, that is, the ratio of critical sediment concentration to flow velocity. If the sediment inflow coefficient is greater than the critical sediment inflow coefficient, that is, Cun(i) > 1, it indicates that the river channel is in a siltation state and the water sediment relationship is not harmonious. If the coefficient is less than the critical cement sand coefficient, that is, Cun(i) < 1, the river channel is in a scouring state, and the water sediment relationship is coordinated. The smaller the Cun(i) is, the higher the coordination degree of water sediment relationship is [14].

4.3. Regulation scheme

In order to study the operation effect of the Yellow River water and sediment regulation system, the five schemes in **Table 1** are combined according to the time when the backbone projects are put into operation.

Table 1. Application scheme of Yellow River water and sediment regulation system project

Working condition	Programme	Combined application scheme
1	Xiaolangdi Project	Longyangxia + Liujiaxia + Haibowan + Wanjiazhai + Sanmenxia + Xiaolangdi + Luhun + Guxian + Hekou Village
2	Xiaolangdi + Guxian (2030) + Dongzhuang (2025)	Longyangxia + Liujiaxia + Haibowan + Wanjiazhai + Guxian + Sanmenxia + Xiaolangdi + Luhun + Guxian County + Hekou village + Dongzhuang
3	Xiaolangdi + Guxian + Dongzhuang + Heishanxia (2035)	Longyangxia + Liujiaxia + Heishanxia + Haibowan + Wanjiazhai + Guxian + Sanmenxia + Xiaolangdi + Luhun + Guxian County + Hekou village + Dongzhuang
4	Xiaolangdi + Guxian + Dongzhuang + Heishanxia + Qikou (2035)	Longyangxia + Liujiaxia + Heishanxia + Haibowan + Wanjiazhai + Guxian + Qikou + Sanmenxia + Xiaolangdi + Luhun + Guxian County + Hekou village + Dongzhuang
5	Xiaolangdi + Guxian + Dongzhuang + Heishanxia + Qikou + West Line Phase I Project (2035)	Longyangxia + West Line Phase I + Liujiaxia + Heishan Gorge + Haibowan + Wanjiazhai + Guxian + Qikou + Sanmenxia + Xiaolangdi + Luhun + Guxian County + Hekou village + Dongzhuang

4.4. Regulation effect

The numerical model is used to calculate the scouring and silting changes of the downstream channel of different engineering application schemes under the condition of 800million tons of sediment coming from the Yellow River in the future. Equation (6) is used to calculate the coordination degree of water sediment relationship [15]. The starting year is 2020, and the calculation results are shown in **Table 2**.

Table 2. Regulation effect of key water and sediment regulation projects of the Yellow River on water and sediment entering the downstream (calculation period: 160 years)

Working condition	Programme	Water volume entering downstream / 100 million M ³		Sediment entering downstream / 100 million T		Coordination degree of water sediment relationship			Annual average sediment reduction of downstream channel after sediment detention period / 100 million t
		Flood season	Year	Flood season	Year	During sediment detention period	Normal operation period	Multi-year average	
1	Xiaolangdi Project	143.5	277.3	6.9	6.9	0.9	1.4	1.3	-
2	Xiaolangdi + Guxian + Dongzhuang	129.9	264.7	5.8	5.9	0.8	1.3	1.1	0.5
3	Xiaolangdi + Guxian + Dongzhuang + Heishanxia	154.1	262.6	5.7	5.8	0.7	1.2	1.1	0.8
4	Xiaolangdi + Guxian + Dongzhuang + Heishanxia + Qikou	155.7	262.6	4.9	5.0	0.7	1.2	1.0	1.3
5	Xiaolangdi + Guxian + Dongzhuang + Heishanxia + Qikou + West Line Phase I Project	167.3	279.4	5.1	5.2	0.7	1.2	0.9	1.5

5. Conclusion

In conclusion, the governance of the Yellow River Basin still faces great challenges, and the protection of ecological environment and economic development need to be coordinated and followed up. Only by analyzing the disharmonious relationship between water and sediment in the Yellow River Basin at this stage, and constantly improving the basin planning, basin protection, basin governance and other aspects, can we better make fruitful contributions to the high-quality development of the basin economy and help realize the dream of China's rejuvenation.

Disclosure statement

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Research on Urban Transportation Planning Strategies in China Under the "New Normal"

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Abstract: In order to explore the development direction and strategy of China's urban transportation planning, drive the development of urban transportation and urban economic progress, as well as respond to the changing trends and challenges of the market under the "new normal," this paper first analyzes the current situation of China's transportation industry under the "new normal," investigates the relationship between transportation and urban planning, and then proposes strategies for China's urban transportation development and planning as reference.

Keywords: New normal; Urban traffic; Transportation planning

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1. Introduction

Transportation is the pillar of China's economic development, and it is also the guide of future economic development in many aspects. The main contradiction in the society is now the contradiction between the yearning for a better life and the disproportionate and insufficient development. Transportation is an important measure to improve the disproportionate development. In the new era, building an efficient transportation system is conducive to the development of all walks of life [1-6]. The concept of innovation is the impetus for development. Combining innovation with transportation planning not only improves the quality and efficiency of transportation, but also promotes the development of all levels. Therefore, the innovative development of transportation planning is crucial for China. The significance of the future development of the country lies in improving the national transportation system and the operation efficiency of urban transportation.

2. Current situation of China's urban transportation industry under the "new normal"

As shown in **Figure 1**, the market scale of China's transportation industry from 2019 to 2021 is basically stable. China's transportation industry has been affected by the overall environment to a certain extent. Over the past three years, the market scale has remained the same, with 436 million yuan in 2019, 394 million yuan in 2020, and 441 million yuan in 2021.

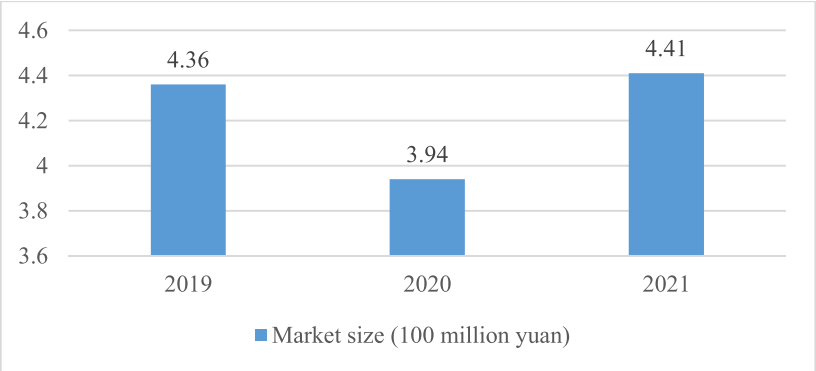

Figure 1. Market scale of China's transportation industry from 2019 to 2021

3. Relationship between urban transportation and urban planning

3.1. Brings better traffic conditions to the city

In the future, urban development will advocate smart transportation, improve traffic conditions and people's travel efficiency through the interconnection between urban planning and transportation, increase the efficiency of traffic collection and distribution on the basis of normal traffic operation, as well as promote the development and economic prosperity of the city by developing and improving the surrounding environment [7]. The next phase of urban planning will focus more on transportation planning, promoting the development of intelligent and convenient transportation, as well as the development of various industries, realizing the integration of urban planning and transportation, and strengthening the connection between roads. Likewise, the network and transportation mode of urban traffic development are being optimized. Traffic has injected new vitality into urban development and brought changes to traffic movement. The optimization of urban planning also ensures the rationalization of traffic planning.

3.2. Promoting the development of other industries

Transportation is the pioneer of urban development planning. The development of the transportation sector has the potential to shape urban industrial patterns, maximize the benefits of urban locations, and spur economic development [8]. In transportation planning, the industrial layout must be considered, while grasping the transportation dependence of the industry, emphasizing the regional value through reasonable layout, and maximizing industrial advantages, such as the integrated development of the tourism industry. The improvement and promotion of the transportation system as well as the increased efficiency of the operation will promote transportation economy, which will drive the improvement and development of the industrial chain of urban enterprises and eventually the prosperity of urban economy.

3.3. Promoting the development of transportation economy

Urban transportation presents a diversified trend. Flexibility and convenience are the definite traits of transportation, and they are crucial to economic growth. It is necessary to strengthen transportation economic management and provide resource guarantee for transportation. Therefore, it is necessary to establish comprehensive means of transportation, whose management system plays a crucial role in urban development planning, saving resources, protecting the ecological environment, and improving the level of urban transportation.

4. Development strategies for urban transportation planning in China under the "new normal"

4.1. Taking urban environmental carrying capacity as the basic premise in urban transportation planning

Environmental carrying capacity refers to the maximum development of society without affecting the

ecological environment. The urban development process will inevitably affect the environment, especially urban traffic, to a certain extent. Car exhaust emissions including carbon monoxide and hydrocarbons adversely affect urban air quality and endanger the physical and mental health of city residents. Under the "new normal," urban transportation planning must adhere to the coordination between automobile traffic and environment as well as limit the further development of automobile traffic within the maximum allowable transportation capacity [9]. In addition, in order to avoid serious environmental pollution caused by vehicles, transportation planning must be coordinated in the process of urban low-speed mode, so as to prevent excessive traffic congestion in the region and a downgrade in the quality of urban life. Urban environmental carrying capacity is the premise of urban transportation development and planning. The interaction between environment and transportation is an important factor that affects urban development and prosperity.

Traffic prediction and management planning should be taken as the basic means for the realization of urban transportation planning based on environmental carrying capacity. Transportation planning is mainly based on the basic standards of urban scale, environment, and fleet management, while the total number of vehicles in the city is controlled according to certain indicators, such as road capacity and social demand in the city. The latter serves as an indicator and guide in urban transportation development and planning. It effectively coordinates social demand with the urban transportation system and guides the city's future development. It is necessary for the overall flow to be fully controllable [10]. Other than that, it is also necessary to strengthen the management of urban transportation hubs and other core areas, guide and bypass highly congested roads through a variety of management methods, reduce regional air and noise pollution, as well as improve the overall living environment.

4.2. Urban transportation planning based on low pollution and low energy consumption

China's urban development mode of high energy consumption with high pollution has had a negative impact on the sustainable development of cities. At this stage, the Chinese government is gradually recognizing the importance of low energy consumption and low pollution. The low pollution urban construction mode also embodies the Korean urban development. Under the "new normal," urban transportation planning must adhere to the basic principles of low pollution and low energy consumption and integrate the low-carbon development model into future urban construction. First, it is crucial to strengthen the research and development of clean energy vehicles, increase the mileage, and meet the basic needs of the people for long-distance travel. The second is to build a comprehensive three-dimensional transportation system, encourage citizens to focus more on walking, cycling, and clean energy transportation, reduce vehicle exhaust emissions, and minimize energy consumption [11-14]. In order to promote the development of a comprehensive three-dimensional transportation system, it is necessary to realize the integration of the public transportation system and the slow traffic system in accordance with the primary goal of effective travel mode transformation. In particular, it can realize the effective connection between different systems according to specific traffic layout, movement route, and network environment, resulting in the formation of a relatively complete network transportation system. The development of urban infrastructure is inseparable from the transportation planning system. The improvement and optimization of the urban transportation network will lead to an increase in the number of vehicles. Therefore, in urban transportation planning, the design should be based on the basic principles of low energy consumption and environmental protection, so as to prevention urban congestion and the mismatch between supply and demand.

4.3. Focusing on public transport and central freight transport

With the continuous expansion of the city scale, the urban population and the number of traffic trips are

increasing, which will eventually lead to traffic congestion. Encouraging public transport is an important means to solve traffic congestion. Based on the experience of Japanese transportation planning, with the increase of urban population, urban transportation began to stagnate in the 1970s, but the Japanese government effectively solved this problem through a good public transportation system. Therefore, if convenient and high-quality public transportation services are provided to the citizens through urban transportation planning, the citizens will inevitably choose public transport as their primary mode of transportation [8]. The freight industry can also encourage container-based intensive freight transport. In order to achieve this goal, it is necessary to ensure the systematic planning of the urban railway system, the public transportation system, and the passenger logistics system. Since the construction of the rail transit system requires a large sum of investment and has high operating cost, if the city is not large enough, the construction has no intrinsic significance. Therefore, in China, it is stipulated that the one-way peak passenger flow must reach 30,000 people prior to the construction of urban railway. During the construction and planning of a rail transit system, it is necessary to make full use of the fundamental characteristics of the passenger flow distribution of the rail transit hub, in order to realize the comprehensive development of urban rail and road network. In addition, in the process of transportation planning, it is necessary to consider the position of logistics transportation in urban development and its significant impact on urban development, formulate corresponding logistics transportation policies, develop logistics transportation hubs, and reduce logistics transportation costs. The urban transportation development center should focus on public transport and large-scale freight transport. The main purpose is to meet the daily travel needs of the public and drive the development of urban economy, which is also the purpose of urban transportation development and planning.

4.4. Improving the construction and management of urban intelligent transportation network

Traffic congestion in big cities not only makes it difficult for residents to commute to work, but also affects their happiness and satisfaction in life. Furthermore, it hinders the development of cities. Numerous intelligent technologies are already being used in urban transportation, but there are still certain drawbacks. Therefore, it is necessary to further strengthen intelligent management, develop and make full use of existing technologies, as well as technicalize and intelligently manage urban transportation.

(1) Improve vehicle positioning accuracy
Road conditions should be updated in real time through satellite cloud images. The intelligent guidance system assists drivers and pedestrians identify the best travel routes almost immediately, so as to prevent more congestion on roads and the inconvenience caused by travelling under bad weather, such as rain and snow.

(2) Improve the quality standard and coverage of electronic eye monitoring equipment
Through intelligent monitoring equipment, barbaric traffic behaviors such as traffic violations and signal violations can be prevented, and the cooperation with manual law enforcement agencies can be achieved, thus bringing about a virtuous cycle of urban traffic.

(3) Improve the traffic accident handling capacity
Intelligent equipment and management means can be used to warn and prevent accidents, so that the transportation department may be able to handle and prevent minor accidents via remote command over on-site accidents. Traffic congestion and major accidents can be dealt with; in addition, casualties and economic losses can be reduced.

Urban traffic management is also an important component of urban transportation development and planning. Building an intelligent urban traffic management system is the main measure to drive urban economic development and improve traffic operation efficiency. With urban information sharing, traffic sharing, and public transportation development, a complete urban traffic information management system

is built. The urban intelligent transportation service management system is based on a top-level design, with the purpose of realizing information sharing, optimizing operation efficiency, stimulating urban economic domestic demand, and promoting urban-rural integrated development. The transportation information service management system has several characteristics, including integration and intelligence. It effectively improves the operation efficiency of urban transportation and further integrates urban development and urban transportation [10-16].

4.5. Promoting urban-rural cooperative development under the "new normal"

The harmonious development of urban and rural areas under the "new normal" is the essential requirement of future urban development, in which transportation planning should also be included, emphasizing the "people-oriented" concept of urban development. At present, the administrative division management brings about the artificial division of traffic and an obvious difference in the level of inter-regional traffic and infrastructure construction, especially the uneven distribution of urban and rural traffic resources. Urban and rural areas should be jointly developed, while breaking the urban-rural boundary, removing administrative restrictions, promoting rural transportation development, and providing convenient transportation services for local residents. The development of road transport network and public transport system should be taken as the premise, the driving role of towns should be clarified, and the construction of regional traffic infrastructure should be improved for the coordinated development of urban and rural areas in transportation planning. It is imperative to strengthen the optimal allocation of resources, narrow the gap between urban and rural areas, as well as arrange the layout of urban and rural road network in a comprehensive manner. Based on the principle of adjusting measures to local conditions, the urban traffic integration should be coordinated. In a city, traffic is the lifeline of urban development, and there should be a complementary relationship between a city and its traffic. People should begin considering urban planning as a comprehensive concept of urban development from a long-term perspective, adjust measures to local conditions, and accurately grasp the concept of population mobility in accordance with the geographical environment of the city. Furthermore, it is necessary to identify the soil conditions, climate, and ecological chain, as well as formulate scientific and comprehensive planning for the urban transportation network hub, while reasonably planning and designing the road layout, completing the layout of urban functional areas, and facilitating transportation.

5. Conclusion

In conclusion, in the process of urban transportation development, urban transport has engendered better traffic conditions for urban development and driven the development of urban industries, urban transportation, and urban economy. In the "new normal," in order to better realize urban transportation design and planning, urban transportation planning should assume the urban environmental carrying capacity as the basic premise, low pollution and low energy consumption as the basis, and public transport and central freight transport as the focus. The construction and management of intelligent transportation networks will be improved, urban-rural cooperation will be promoted, and the integrated development of urban transportation and urban planning will be achieved.

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A Comprehensive Evaluation of User Satisfaction with Industrial Heritage Reuse and the Optimization Strategies: Taking Zhonglian U Valley 2.5 Creative Industrial Park as an Example

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Abstract: The industrial heritage creative industrial park in Qingdao, which has been renovated and put to use, was selected as the research subject. Based on the data collected via the questionnaire survey and fuzzy comprehensive evaluation, the hierarchical analysis method was used to calculate the weights of indicators at each level and construct a comprehensive satisfaction evaluation model, aiming to ensure a comprehensive satisfaction evaluation and analysis of the use effect of industrial heritage following renovation and utilization. Based on the evaluation results, the existing problems in the renovation and reuse of industrial heritage in Qingdao were analyzed, and subsequently corresponding optimization strategies were proposed.

Keywords: AHP; Industrial heritage; Reuse; Renovation; Satisfaction evaluation; Optimization strategy

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1. Research subject

Zhonglian U Valley 2.5 Industrial Park (thereafter referred to as "2.5 Industrial Park") in Qingdao City, Shandong Province, is located in Taiping Mountain Scenic Area, adjacent to Zelim Mountain Park, in the center of the city. It is divided into two areas, north and south, by the humpback road with a large drop. Formerly known as Qingdao Picture Tube Factory (built in 1960), it was renovated in 2008 and is now listed as an industrial heritage protection site in Qingdao. The entire park is characterized by cultural and creative industries, conforming to the 2.5 industry clustering.

2. Designing a comprehensive satisfaction evaluation system

2.1. Methodology

The questionnaire was designed, and the sample size was determined by reviewing literature, field research, and sample interviews. In order to ensure a scientific study, analytic hierarchy process (AHP) was used to establish a satisfaction evaluation model, and questionnaires were used to score and evaluate the two industrial parks. A combined method using questionnaire survey and free interview was used so as to prevent personal subjective factors from influencing the results and ensure that the questionnaire results are scientific. The interviewees included various users and investors of the industrial parks (park artists, staff, managers, and visitors), professionals from universities and design units, as well as residents in the vicinity

of the parks. The questionnaires were distributed in the two industrial parks from July 10, 2021, to July 20, 2021. The questionnaires were evaluated by means of structured questions, using a 5-point Likert scale. The semantic scale was used to classify five different levels: “Very satisfied,” “Satisfied,” “Generally satisfied,” “Dissatisfied,” and “Very dissatisfied.” The semantic values of 1–5 represent the evaluation scores from good to poor. A total of 100 questionnaires were distributed to the industrial parks, of which all 100 questionnaires were valid, thus matching the sample size [1-3].

2.2. Evaluation indexes

An industrial heritage creative industrial park satisfaction evaluation hierarchical structure model was constructed. Based on field research, questionnaire survey, and other methods, the suggestions of experts and scholars as well as previous research results were integrated; five major indicators, B1–B5, which are all closely related to the public and easily understood by the public, were carefully selected. Several influencing factors were considered, and multiple program layers were established under the five major indicators, with a total of 29 program layers: B1, C11–C15; B2, C21–C25; B3, C31–C35; B4, C41–C47; and B5, C51–C57.

2.3. Evaluation index weights

In determining the evaluation index weights, expert judgment, AHP, and fuzzy comprehensive evaluation were used. The judgment matrix of the five criterion layers (B1–B5) relative to the target layer A was constructed; the weight value K of each criterion layer relative to the target layer was calculated (**Figure 1**) and tested for consistency. In the same way, five judgment matrices of each scheme layer (C11–C57) relative to the criterion layer were constructed; the weight values of each scheme layer indicator relative to the criterion layer (K1–K5) were calculated, and their consistency tests were conducted separately. When the consistency ratio (CR) is less than 0.1, the judgment matrix holds. The CR value of each judgment matrix is less than 0.1 as shown in **Table 1**, indicating that the total ranking results of each layer have satisfactory consistency. The weights of indicators in each layer were combined to obtain the weights of indicators in each program layer relative to target layer A, as in **Table 2**.

A	B1	B2	B3	B4	B5	K
B1	1	1/5	5	1/7	1/3	0.0809
B2	5	1	7	1/3	3	0.2566
B3	1/5	1/7	1	1/9	1/5	0.0326
B4	7	3	9	1	5	0.4982
B5	3	1/3	5	1/5	1	0.1317

a.Weight determination of the 5 criterion layers relative to the target layer

B1	C11	C12	C13	C14	C15	K_1
C11	1	1	1/3	1/5	3	0.1053
C12	1	1	1/3	1/5	3	0.1053
C13	3	3	1	1/3	5	0.2454
C14	5	5	3	1	7	0.4971
C15	1/3	1/3	1/5	1/7	1	0.0469

b.Weight determination of B1 scheme layer relative to B1

B2	C21	C22	C23	C24	C25	K_2
C21	1	1/7	1/3	1	1/3	0.0589
C22	7	1	5	7	3	0.5014
C23	3	1/5	1	3	1/3	0.1278
C24	1	1/7	1/3	1	1/5	0.0544
C25	5	1/3	3	5	1	0.2575

c.Weight determination of B2 scheme layer relative to B2

B3	C31	C32	C33	C34	C35	K_3
C31	1	3	3	7	5	0.4641
C32	1/3	1	1	5	3	0.2017
C33	1/3	1	1	5	3	0.2017
C34	1/7	1/5	1/5	1	1/3	0.0436
C35	1/5	1/3	1/3	3	1	0.0889

d.Weight determination of B3 scheme layer relative to B3

B4	C41	C42	C43	C44	C45	C46	C47	K_4
C41	1	1/3	1	1/5	5	3	3	0.1126
C42	3	1	3	1/3	7	5	5	0.2155
C43	1	1/3	1	1/5	5	3	3	0.1126
C44	5	3	5	1	9	7	7	0.4181
C45	1/5	1/7	1/5	1/9	1	1/3	1/3	0.0276
C46	1/3	1/5	1/3	1/7	3	1	1	0.0568
C47	1/3	1/5	1/3	1/7	3	1	1	0.0568

e.Weight determination of B4 scheme layer relative to B4

B5	C51	C52	C53	C54	C55	C56	C57	K_5
C51	1	1/3	1/3	5	3	3	1	0.1317
C52	3	1	1	7	5	5	3	0.2959
C53	3	1	1	7	5	5	3	0.2959
C54	1/5	1/7	1/7	1	1/3	1/3	1/5	0.0288
C55	1/3	1/5	1/5	3	1	1	1/3	0.0580
C56	1/3	1/5	1/5	3	1	1	1/3	0.0580
C57	1	1/3	1/3	5	3	3	1	0.1317

f.Weight determination of B5 scheme layer relative to B5

Figure 1. Determination of the weight of each indicator

Table 1. CR for each judgment matrix

CR	CR_1	CR_2	CR_3	CR_4	CR_5
0.0852	0.0284	0.0581	0.0286	0.0387	0.0225

Table 2. Comprehensive evaluation index system and weights

Target layer	Guideline layer		Program layer	
	Name	Weights	Name	Weights
Comprehensive satisfaction evaluation model A of the renovated industrial heritage creative industrial park	B1 Road traffic	0.0809	C11 Traffic conditions around the park	0.0085
			C12 Convenience of access to the park by car	0.0085
			C13 Traffic condition inside the park	0.0199
			C14 Convenience of parking in the park	0.0402
			C15 Comfortable pavement in the park	0.0038
	B2 External spatial environment and perception	0.2566	C21 Whether there are noise sources and pollution sources around the park	0.0150
			C22 Overall style and industrial atmosphere of the park	0.1289
			C23 Attractiveness of the park environment	0.0326
			C24 Completeness of the signage system in the park	0.0140
			C25 Adequacy of outdoor public activity space	0.0661
	B3 Green environment	0.0326	C31 Degree of preservation of the industrial landscape of the park's historical heritage	0.0151
			C32 Attractiveness of the park's landscape artifacts	0.0066
			C33 Richness of landscape artifacts in the park	0.0066
			C34 Degree of greening in the park	0.0014
			C35 Utilization of green technology	0.0029
	B4 Perception after building renovation	0.4982	C41 Whether the functional zoning and flow lines of the park are reasonable	0.0561
			C42 Degree of reuse of existing industrial buildings and materials	0.1142
			C43 Degree of coordination between the addition and renovation of buildings and the surrounding area	0.0561
			C44 Recognition of building renovation methods	0.2083
			C45 Satisfaction with building color	0.0069
			C46 Satisfaction with indoor lighting and ventilation	0.0283
			C47 Reasonable length to width to height ratio of interior room	0.0283
	B5 Supporting facilities	0.1317	C51 Number and comfort of public leisure facilities	0.0173
			C52 Number and convenience of public restrooms	0.0390
			C53 Reasonability of staircase or elevator settings	0.0390
			C54 Brightness and effect of night lighting	0.0038
			C55 Completeness of barrier-free facilities	0.0076
			C56 Whether the number and location of garbage cans are reasonable	0.0076
			C57 Sufficiency of stores and cultural and sports facilities	0.0173

3. Results and analysis

3.1. Evaluation results

In the satisfaction evaluation model, each single index can only reflect a single situation of the park construction; hence, a comprehensive evaluation is needed to reflect the overall situation of the park. Using fuzzy comprehensive evaluation, the function expression formula is as follows:

$$Q = \sum_{i=1}^{m} \sum_{j=1}^{n} q_{ij} K_{ij}$$

where Q is the total satisfaction evaluation score following industrial heritage renovation and utilization; q_{ij} is the index score of the program level; K_{ij} is the weight of the corresponding program level, and m and n represent the number of indicators of the criterion and program level, respectively [4-6]. According to the above formula and the scoring statistics obtained from the questionnaire survey, the comprehensive score of the two industrial parks was obtained. With a score of 5 out of 5, the overall score of the 2.5 industrial park was 3.72, with reference to the satisfaction evaluation criteria of industrial heritage following renovation and utilization (**Table 3**) [7]; the 2.5 Industrial Park was categorized as "Better" and "Satisfied." This indicates that the respondents were satisfied with the renovation of the 2.5 Industrial Park.

Table 3. Satisfaction rating criteria for industrial heritage reuse

Scoring range	**[< 1.5]**	**[1.6–2.5]**	**[2.6–3.5]**	**[3.6–4.5]**	**[> 4.5]**
Judgment result	Very Poor	Poor	General	Better	Good
Satisfactory rating	Very dissatisfied	Dissatisfied	Generally satisfied	Satisfied	Very satisfied

3.2. Satisfaction analysis

The score of each criterion layer of the industrial park is shown in **Figure 2**, and the specific performance of each criterion layer was analyzed.

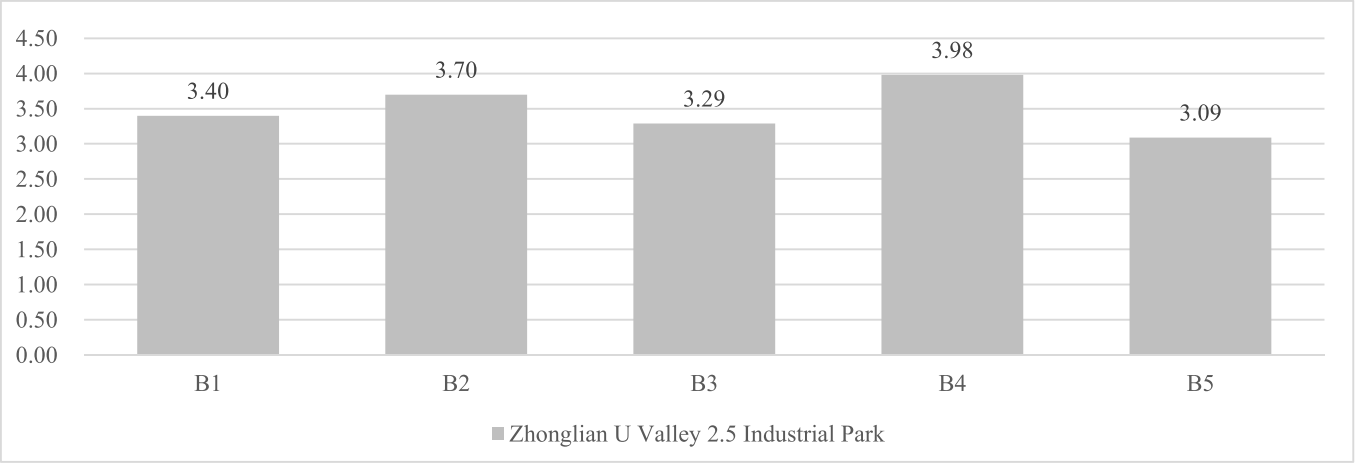

Figure 2. Score of each criterion layer of the two industrial parks

3.2.1. Road traffic guideline layer

In the road traffic guideline layer, the satisfaction rating of the 2.5 Industrial Park (3.40 points) was "Generally satisfied." The satisfaction rating of C14 (Convenience of parking in the park) (3.50 points) was "Generally satisfied," while the satisfaction rating of C15 (Comfortable pavement in the park) (2.45 points) fell under "Dissatisfied." The reason for this is that there are uneven stones over some of the ground

pavements, the gap between each stone is large, and they vary in size. Additionally, some of the ground surfaces are wasted, in which old stone slabs have been used to pave the ground. This enhances the industrial atmosphere of the park but reduces the comfort of the pavement. For children and women who wear high heels to work, it is also a safety hazard, thus causing dissatisfaction among some users.

3.2.2. External spatial environment and perception guideline layer

In the external spatial environment and perception criterion layer, the satisfaction rating of the 2.5 industrial park was "Satisfied" (3.70 points). The 2.5 industrial park's satisfaction ratings in the four scheme layers of C21 (4.60 points), C22 (3.72 points), C23 (3.61 points), and C24 (3.81 points) were all categorized under "Very satisfied." The satisfaction rating of C25 (3.46 points) was "Generally satisfied." This is similar to that in the field research. The 2.5 Industrial Park has a strong industrial atmosphere, with strong industrial facades, external staircases, and large smoke pipes that reflect a strong visual impact, a green environment, and more space for outdoor activities to meet the needs of users.

3.2.3. Green environment guideline layer

In the green environment guideline layer, the satisfaction rating of the 2.5 Industrial Park was "Generally satisfied" (3.29 points). The 2.5 Industrial Park had a satisfaction rating of "Generally satisfied" (3.29 points) in C31 (Degree of preservation of the industrial landscape of the park's historical heritage) (3.41 points), C32 (Attractiveness of the park's landscape artifacts) (3.50 points), C33 (Richness of landscape artifacts in the park) (2.90 points). In terms of C34 (Degree of greening in the park) (4.60 points) program layer performance, the satisfaction rating was "Very satisfied." Field research has confirmed that this is the case. The 2.5 Industrial Park has preserved large smoke pipes and some industrial process instruments in the renovation, set up characteristic landscape vignettes at different leisure sites, and made full use of the nooks and crannies of the park to build the "U Valley Garden," which provided users with a "back garden" for leisure walks. The "U Valley Garden" is popular among users. However, they are "Dissatisfied" with the 2.5 Industrial Park in relation to its use of green technology in C35. Although it is believed that the cost of eco-transformation is so high that it is not considered by the developers, the interview revealed that the respondents are not concerned about whether the park utilizes green technology in view of the little direct impact on users compared to other solution layers.

3.2.4. Perception after building renovation guideline layer

The 2.5 Industrial Park was categorized under "Satisfied" (3.98 points) in the post-renovation perception criteria layer. The 2.5 industrial park was categorized under "Very satisfied" in C41 (3.62 points), C42 (3.72 points), C44 (4.32 points), C45 (3.68 points), and C47 (3.76 points). The satisfaction rating of C41 (3.62 points), C42 (3.72 points), C44 (4.32 points), C45 (3.68 points), and C47 (3.76 points) was "Satisfied," whereas that of C46 (4.65 points) and C43 (3.45 points) was "Very satisfied" and "Generally satisfied," respectively. The 2.5 Industrial Park was formerly a picture tube factory, which had been transformed into an industrial park through addition, alteration, and demolition, preserving valuable factory buildings, large smoke pipes, some micro industrial elements of the original factory, and old trees around the factory area. The landscape steps at the terrace break the spatial fault brought by the height difference, and several terraces in the park are connected as a whole, thus weakening the sense of height difference and making users more comfortable and at ease; having a uniform architecture with lively red, white, and gray tones, the overall industrial atmosphere of the park is strong.

3.2.5. Supporting facilities guideline layer

C53 (Reasonability of staircase or elevator settings) (2.60 points), C54 (Brightness and effect of night

lighting) (3.50 points), C55 (Completeness of barrier-free facilities) (2.85 points), C57 (Sufficiency of stores and cultural and sports facilities) (3.45 points) were rated as "Generally satisfied." C51 (Number and comfort of public leisure facilities) (2.45 points) was categorized under "Dissatisfied." After field research, the outdoor leisure seats in the Industrial Park gradually weathered due to the lack of coating protection, and the wooden seats were covered with leaves and dust between the gaps of the wooden boards; thus, these seats were mostly non-functional; the landscape stairs were futile due to the large slope and uneven paving. Although the external steel stairs at the Industrial Park enliven the industrial atmosphere of the park, the steel stairs were not satisfactory as they emitted a "cold" feeling, thus reducing the usage rate. Upon interviewing foreigners, we learned that the number of public restrooms in the 2.5 Industrial Park are too few, and their locations are not strategic enough, making it difficult for people to locate them.

4. Suggestions for the transformation of the industrial heritage creative industrial park based on user evaluation

4.1. Improve the infrastructure of the park and enhance the core competitiveness of the park

The park should have good infrastructures in order to improve its core competitiveness. Developers and designers should focus on the indoor lighting, barrier-free facilities, greening, parking, and leisure facilities of the park to guarantee basic user experience.

4.2. Take the historical background of old factory buildings as the basis and bring into play the value of architectural transformation

Old factory buildings are rooted in the unique historical period and regional culture of urban development and people's needs. They have witnessed the growth of cities and carried the living memories and emotions of a generation of people. Renovating and reusing them have naturally become the focus of the government and citizens. Therefore, the inherent value of old factory buildings should be fully utilized in the renovation, so that the existing buildings and materials can be retained to the greatest extent, and the emotional attachment of the citizens can be safeguarded.

4.3. In-depth excavation of industrial park characteristics, precise functional positioning, and service objects

In view of the different characteristics of various industrial heritage creative industrial parks and their suitability to local conditions, the location of the industrial heritage, the scale of the factory, the level of protection, the characteristics of the building, and the degree of damage to the building all have a great influence on the renovated industrial park. For industrial heritage creative industrial parks with high heritage value and that are close to the city center, the industrial tourism development mode, which focuses on serving citizens and foreign visitors, may be considered. For instance, Textile Valley has become a travel base for many tourists following its designation as the second batch in the national industrial heritage list. For industrial heritage creative industrial parks with more recent buildings and that are far from the city center, a mixed mode of residence, office, exhibition, and leisure may be considered, or a city park open to the public can be established to serve the surrounding residents [8,9].

4.4. Improve public participation and create a vibrant open park

Compounded functions should be attached to create an open and vibrant park. Urban industrial heritage is a common and valuable treasure for people as it witnesses the development of the city and carries people's memories. It should not be confined to a specific object of use for a certain unit, a certain enterprise, or a certain group of people; instead, it should be a shared place for people to recall history and reminisce the past. Although the overall rating of cross-border e-commerce is high, research has revealed that cross-

border e-commerce is rarely open to the public, and it has become a workplace for enterprises stationed in the park. We strongly disagree with this practice. Industrial parks with industrial heritage value should be open to create compounded functions to attract different groups of people in the city, enhance the park's vitality, and showcase the city's industrial history.

4.5. Focus on ecological and cultural media to prevent excessive commercialization

According to the survey, the industrial park is slightly lacking in green ecology and cultural atmosphere, and its commercialization is so advance that it would also face the embarrassment of uniformity. In order to obtain more profit and maximize the investment scale of the park, some developers encroach on its green ecology and cultural space. This reflects the park's unreasonable pre-planning. In the future planning of industrial parks under the industrial heritage transformation category, emphasis should be on the ecology and cultural space, in which their commercial nature should be appropriately diluted to create an "ecology first" and cultural creative park [10].

5. Conclusion and expectation

In the 2.5 Industrial Park survey, questionnaire survey and AHP were used for perceptual evaluation. From the perspective of users, both the advantages and disadvantages of industrial heritage renovation and reuse can be clearly identified. The purpose of optimizing the current situation of industrial heritage renovation and creative industrial parks is to ensure a reasonable reuse of industrial heritage, explore the needs of different users, innovate designs based on humanization, and actualize these sites as real gathering places for human flow rather than mere urban functional spaces.

Disclosure statement

The authors declare no conflict of interest.

Author contributions

G.Y. conceived the idea of the study, and W.R. performed the experiments, analyzed the data, and wrote the paper.

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Analysis and Research on the Thermal Environment of Subway Stations in Wuhan

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Abstract: With the rapid advancement of urban construction, urban subway construction in China has entered an advanced development stage and the thermal environment of subway stations has become a key factor affecting passengers' thermal comfort. To further understand the actual situation of the thermal environment of subway stations, field measurement and CFD simulation were carried out on a subway station hall in Wuhan from July to August 2021, and the thermal environment changes and influencing factors during subway operation were compared and analyzed. The present situation of the thermal environment in subway stations was analyzed, and some suggestions and measures for improving the thermal environment were put forward.

Keywords: Urban subway; Operating period; Thermal environment; Status analysis; Countermeasures and suggestions

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1. Introduction

Subway has become one of the main means of public transport. As of August 2015, 24 cities in China have opened subways, among which 14 lines have been opened in Shanghai Metro, with a mileage of 567 kilometers, followed by Beijing Metro with a mileage of 527 kilometers. It was forecasted that by 2020, 40 cities across the country will build subways, with a total planned mileage of 7,000 kilometers. According to the US Environmental Protection Agency (EPA) 1993–1994 tracking survey data of nearly 10,000 people, people spend an average of 7.2% of their time in the subway [1-3].

With the rapid development of urban construction, urban subway projects have entered a vigorous development stage [4]. While urban rail transit brings convenience, it also has a high consumption of electric energy. In our country, the energy consumption of the metro-environmental control system in southern cities accounts for about 1/2 of the total energy consumption, while the energy consumption of the metro-environmental control system in northern cities accounts for about 1/3 of the total energy consumption [5]. Subways (underground stations and sections) are wrapped in soil, and only the entrance and exit passages and piston air wells are connected with the above-ground atmosphere. The thermal environment and air quality of subway stations are common concerns and urgent problems to be addressed in subway construction and operation. Regarding thermal transport environment of subways, “Metro Design Code” GB 50157-2013 stipulates [6-9]: the temperature of station hall and platform public area should not be lower than 12 ℃ in winter, and the temperature of station hall and platform public area should not exceed 30 ℃ in summer, with relative humidity of 40%-70% and CO_2 concentration of less than 1500 ppm;

While much conveniences have been brought by subways, it also leads to higher requirements for comfort in subway environments [10-14]. At present, the research on subway environment by domestic and

foreign scholar mainly focuses on air quality. He Shengquan et al. studied the variation of $PM_{2.5}$ and PM_{10} concentrations in the air of platforms and carriages of Beijing Metro with time [15]. Scholars such as Aarnio, Cheng and Mugica monitored the concentration of respirable particulate matter in subway stations in Finland, Mexico and Taipei, China, respectively [16-18]. Some scholars have studied the thermal environment in subway stations or carriages. Wang Shugang et al. [10] have conducted long-term field tests on Shanghai and Beijing subways and conducted in-depth theoretical analysis, which has enabled domestic scholars to have a deeper theoretical and practical understanding of train heat dissipation, station temperature and flow field distribution. Wang Lihui et al. [19] tested and studied the piston wind in the tunnel and the temperature field and velocity field of the station hall platform of Shanghai Metro and recorded the change in platform temperature and station hall temperature. Ming-Tsun Ke et al. [20] studied and analyzed the thermal environment of Taipei, China subways under different working conditions by combining Subway Environmental Simulation Program (SES) and computational fluid dynamics (CFD), and found that the exhaust under the platform plate has great influence on the platform temperature field. Although many researches have been carried out on thermal environment, there is still a lack of in-depth analysis of various indicators of subway thermal environment and thermal environment in different regions.

In this study, a station hall of Wuhan Metro Line 2 was monitored and simulated on the spot, and the thermal environment status of the station hall was analyzed in depth during its operation period, and further suggestions and measures were put forward to improve the thermal environment of the subway, so as to meet the comfort needs of subway users and promote the healthy development of the urban subway environment.

2. Methods

2.1. Subway thermal environment monitoring

The subway station is located in a large station of Wuhan Metro Line 2 in Hubei Province. The station is divided into two underground floors: the first underground floor is the station hall floor, and the second underground floor is the platform floor. This study mainly monitored the data of station hall floor. Two monitoring points were set up on the station hall floor, respectively at both ends of the station hall. The distribution of instruments and equipment is shown in the **Figure 1**.

(a) (b)

Figure 1. The placement of instruments for measure the thermal environment of subway station

The monitoring instrument used in this study is shown in **Table 1**, which is composed of multiple sensors to measure air temperature, wind speed, noise, humidity and illumination. Temperature, humidity and illumination were recorded once every 10 minutes, while wind speed and noise were recorded once every minute. The collected information will be uploaded to the cloud platform and stored, which can be

viewed and downloaded at any time. The device was placed at a pedestrian height of 1.2 m, At the same time, the site was connected to an external 220V power supply. The measurement period is from July 15, 2021 to August 10, 2021.

Table 1 Monitoring instruments for metro thermal environment

Instrument	Measuring range	Measurement accuracy	Equipment size	Work environment	Picture
Noise detector (noise0501)	30db-120db	±0.5db	8*5*12cm	Air temperature: -40℃~+60℃ Relative humidity: 25%~90% Static pressure: 65kpa~106kpa	 
Wind speed detector(wind0501)	0.2m/s-10m/s	±0.02m/s	8*5*12cm	-10℃~+50℃	
Air temperature/ Humidity detector/ Illuminance detector	Air temperature: -10℃~+85℃ Humidity: -40℃~+125℃ Illumination: 0~65535lux	Humidity: ±0.3℃，±2% RH Black ball: ±0.5℃	12*8*6cm		 
Equipment integration			47*33*73cm		

2.2. Model establishment and boundary condition setting

The spatial three-dimensional model of subway station mainly uses the platform, station hall plan (as shown in **Figures 2** and **3**) and section to obtain specific information related to buildings. The simulated area of station hall floor was 143.7 m long, 19.4 m wide and 3.2 m high, while the simulated area of platform floor was 109.5 m long, 9.8 m wide and 3.2 m high. ICEM CFD 18.2 software was used to create the model, and the completed three-dimensional model is shown in **Figure 2**.

Because of the complex structure of the three-dimensional geometric model of subway station, the unstructured grid was adopted, and the unstructured grid has better adaptability to irregular areas. The grid is partially encrypted using the part functionality in ICEM, resulting in 6.78 million grids, as shown in **Figure 3**.

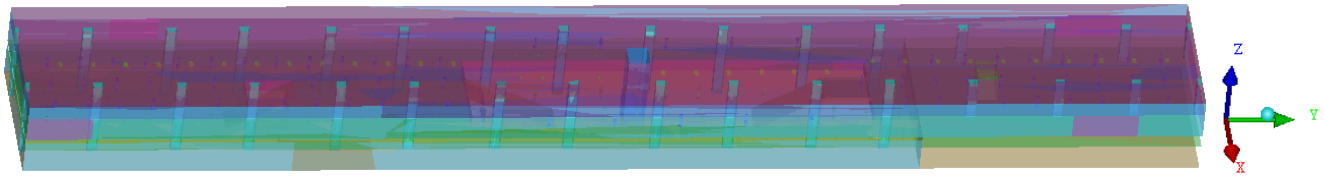


Figure 2. 3D model of subway station

Figure 3. 678w grid of subway station

3. Results

3.1. Trend analysis of temperature at each measuring point during operation period

The data was collected from 0:00 on July 28, 2021 to 23:50 on August 15, 2021, including the air temperature changes of two test points in the subway station during working, rest and outage respectively. During the investigation, a temperature acquisition sensor was used to continuously collect the air temperature data at two acquisition points, and the data acquisition interval was uploaded every 10 minutes, with a total of 5472 data collected (including 2736 data at each acquisition point).

Table 2. A1, A2 point air temperature description

	A1 point air temperature (℃)	A2 point air temperature (℃)
Mean	27.09	27.92
Median	27.14	28.19
Max	32.47	32.11
Min	23.85	23.38

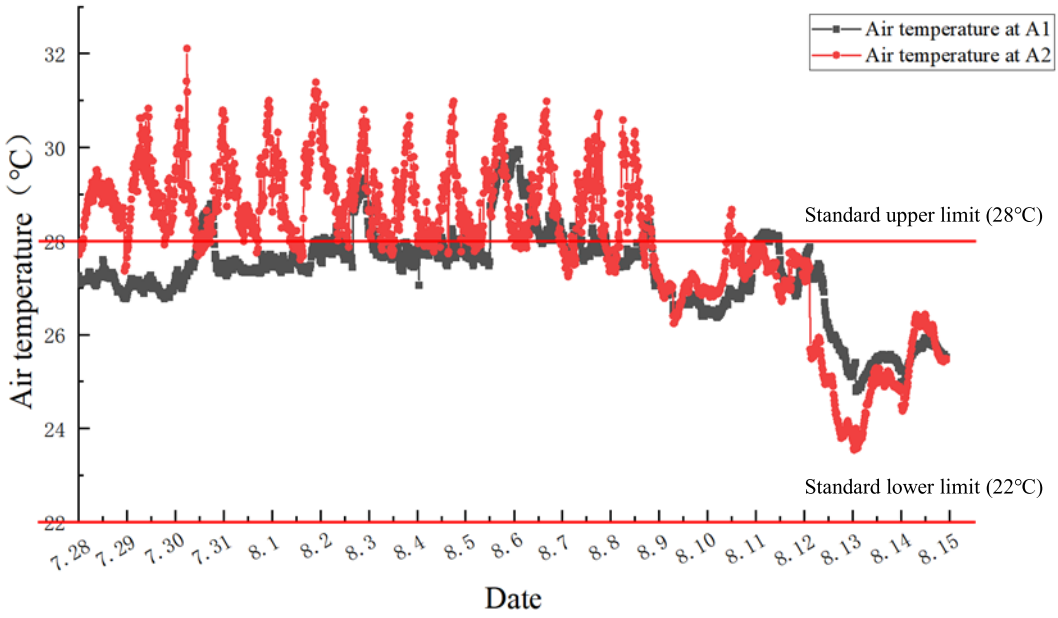
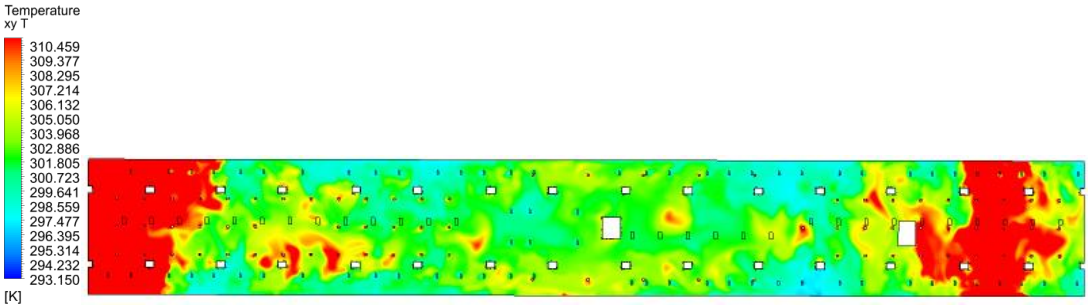


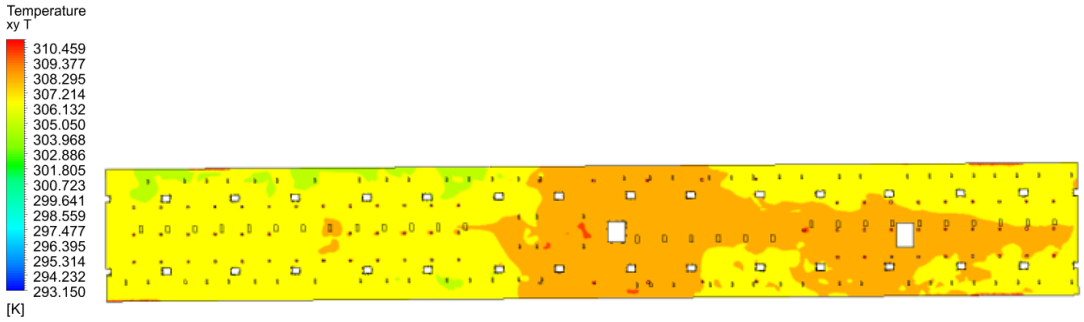
Figure 4. Scattered line chart of air temperature at each point in working days

Figure 4 shows the air temperature distribution at points A1 and A2 during the working day of the measurement stage. It can be seen that the overall distribution trend of the two curves is similar, and the data of both points fluctuate between 23–33 ℃. Before August 11th, the air temperature at A2 was higher than that at A1. The peak value of air temperature at point A1 is 29.95 ℃ (16:20 on August 5th), and the peak value of air temperature change at point A2 is 32.11 ℃ (12:10 on July 30th). The average air temperature at point A1 and A2 is 27.05 ℃ and 28.09 ℃, respectively. However, because the subway is located in an underground semi-open space, the air temperature fluctuates according to the change of weather (sunny days and rainy days). By consulting the local weather forecast, it was found that the outdoor weather on August 8–10, and August 12 and 13 was mostly cloudy or light rain, which leads to an obvious downward trend of air temperature distribution. The valley values of air temperature change at A1 and A2 points appeared at 21:00 (25.10 ℃) and 23:40 (23.53 ℃) on August 13th, respectively. The average variation ranges of A1 and A2 were 8.62 and 8.58 ℃, respectively. On July 28th to August 7th, the peaks and troughs of air temperature changed repeatedly throughout the day. From 6:00 to 19:00, the rail transit operation was relatively stable, and so the outside temperature tends to be stable.

3.2. Subway station environment simulation results



(a)



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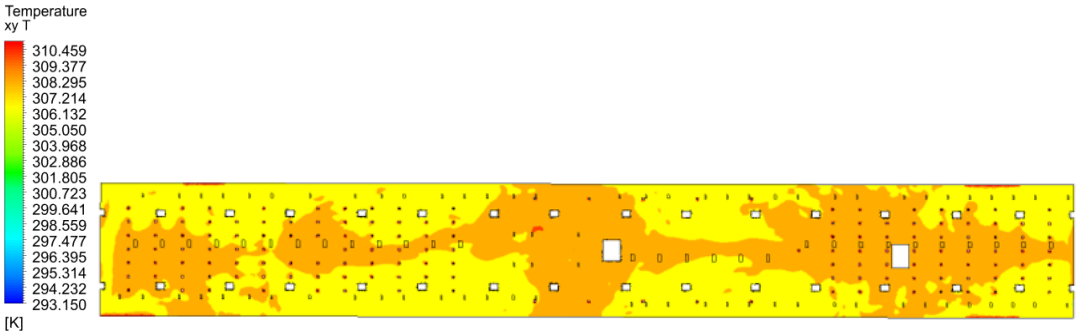

(c)

Figure 5. (a) Temperature field Z = 6 m for 75 unstabilized simple human bodies in each layer (b) Temperature field Z = 6 m for 75 stable simple human bodies in each layer (c) Temperature field Z = 6m for 150 stable simple human bodies in each layer

As shown in **Figure 5**, the temperature field of horizontal section with height Z = 6m is shown. The platform floor is 4.8 m high, so Z = 6 m is the position of 1.2 m high in the station hall floor. As can be seen from **Figure 5** (a): the temperature on the left and right sides of the region; is higher because there are four sections of entrance and exit passages, which are located at the four corners of the model, and the infiltrated air-cooling load brought by it causes such a temperature field. In **Figure 5** (b), the calorific value of the entrance and exit sections was evenly released into the air, increasing the overall temperature field level. The temperature of the atrium remains at a high level like (a), and the temperature of the right half of the atrium drops slightly due to the air supply temperature of the nozzle. In **Figure 5** (c), due to the increase of human body, compared to (b), there were some higher temperature areas on the left and right sides of the temperature field.

4. Conclusion

Urban subway construction is an important process of urban spatial evolution, which can guide urban space from independent space to multi-core network development, promote the integration of different types of urban space, and improve the spatial vitality of the old city. Urban transportation network with subway as the core is an important driving force for urban spatial evolution. Therefore, in the process of urban space development, a rational layout of urban subway will have a positive effect on urban space development. Therefore, a comprehensive monitoring system for the thermal environment of rail transit tunnels needs to be established as well as a corresponding database, and more data need to be collected, so as to provide sufficient data reserves for forming a complete theory of thermal environment change trend in rail transit tunnels.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Cultivation Path of Craftsman Spirit Among Construction Site Workers

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Abstract: : In order to improve the craftsman spirit of on-site construction personnel and accelerate the smooth transition of construction products from the development period to the mature period, a questionnaire survey method was used to investigate the characteristics of construction personnel of different levels and the problems existing in the cultivation of craftsman spirit. The results show that there was lack of awareness in understanding craftsman spirit among construction personnel, the consciousness of their own craftsman spirit cultivation was insufficient, and no effective measures have been taken to cultivate the craftsman spirit. Based on the research results, the ways to cultivate the craftsman spirit of on-site construction personnel are given.

Keywords: Construction personnel; Craftsman spirit; Cultivation path

Online publication: September 29, 2022

1. Introduction

The process of pursuing high quality and performance of construction products to energy saving, emission reduction, and recycling is of great significance to the cultivation of craftsman spirit of construction workers on site in line of the "double carbon" strategy.

Starting from the connotation of craftsman spirit, some scholars believe that "craftsman spirit" is a value upheld by employees, which belongs to the category of professionalism. It is the concept of paying attention to details, patience and concentration, and striving for perfection of products [1]. Other scholars have studied the correlation between craftsman spirit and product quality from the perspective of professionalism [2–4] and professional skills [5]. It was found that craftsman spirit had a significant effect on reducing the scrap rate of enterprise production and improving enterprise performance. Based on this, scholars have studied the path of craftsman spirit cultivation from different perspectives such as government, school, enterprise and market [6–8], but there are few studies on the of craftsman spirit cultivation construction personnel at construction sites. Thus, we proposed a research on the cultivation path based on actual situations.

2. Research methods and data sources

This study uses "Questionnaire Star" electronic questionnaire and random telephone interview to conduct online research, in consideration of factors such as gender, occupation, age, and so on. Investigation was

also carried out on the personnel of construction sites. A total of 252 questionnaires were distributed, recovered, and all questionnaires were valid and collected. The basic information of this survey sample is shown in **Table 1**. This basic information provides data support for the research on the cultivation path of craftsman spirit of construction site workers.

Table 1. Basic information questionnaire

Item	Option	Head / Proportion	Item	Option	Head / Proportion
Age	18-25	116/46.03%	Type of work	Manager	132/52.38%
	26-30	68/26.98%		Line technician	84/33.33%
	31-40	32/12.7%		Frontline operators	16/6.35%
	41-50	28/11.11%		Special operation personnel	20/7.94%
	51-60	8/3.18%	Record of formal schooling	Junior high school and below	24/9.52%
	60+	0/0%		Senior high	24/9.52%
Job level	0-3	96/38.1%		College for professional training	120/47.62%
	3-5	44/17.46%		Regular college course	64/25.4%
	5-10	64/25.4%		Master degree and above	20/7.94%
	10-20	16/6.35%	Gender	Male	176/69.84%
	20+	32/12.7%		Female	76/30.16%

3. Analysis of research results

3.1. Lack of awareness of independent understanding of craftsman spirit

Craftsman spirit is not only reflected in the level of professional skills, but also in the level of professionalism. Construction site construction personnel should take more initiative in understanding the connotation and concept of craftsman spirit, pay attention to the cultivation of their own craftsman spirit, improve their skill level while improving their ideological and political literacy, and strive to be a great craftsman for the country.

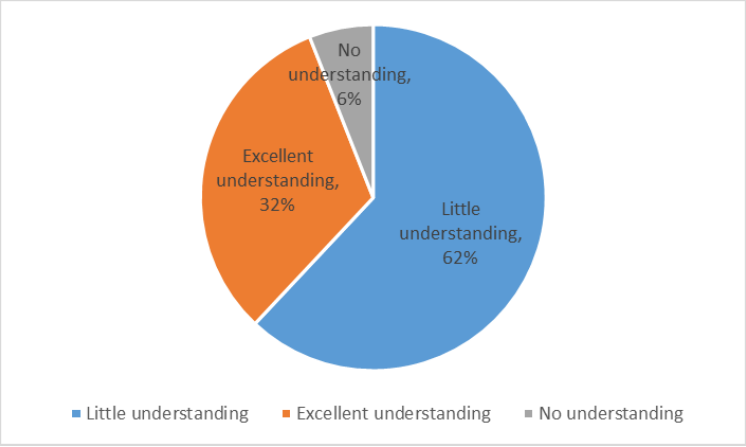

Figure 1. Understanding of craftsman spirit

Figure 1 shows that most of the construction personnel do not know much about craftsman spirit, with some completely oblivious to it. When the meaning of craftsman spirit is not understood fully, follow-up work is difficult to carry out.

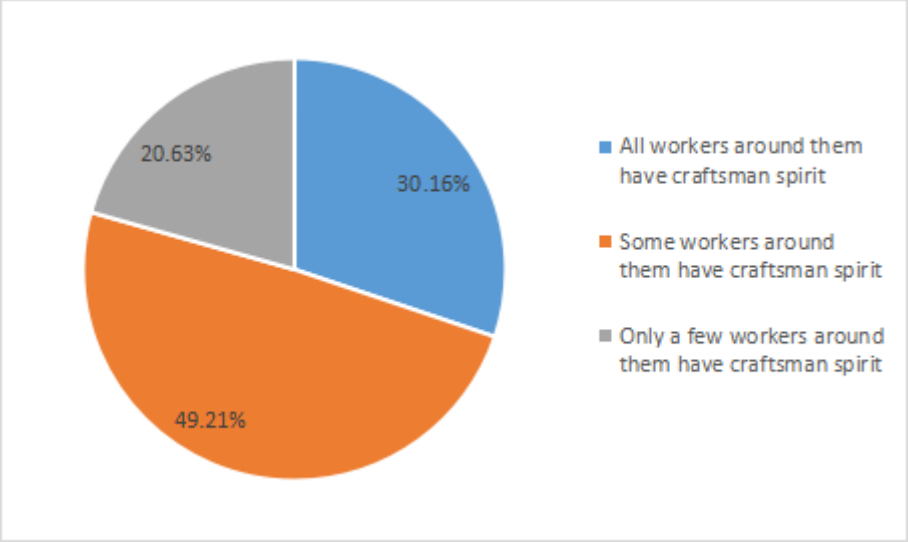

Figure 2. Investigation on the current situation of craftsman spirit in construction site

Figure 2 is results of a survey on construction workers who are very aware of craftsman spirit. It was found that about half of the respondents believe that only a small number of people on the construction site have craftsman spirit. The lack of understanding of the connotation of craftsman spirit, the biased understanding of craftsman spirit, and the lack of attention to craftsman spirit affect the cultivation of craftsman spirit. Therefore, it is crucial to cultivate the craftsman spirit of on-site construction personnel.

3.2. Lack of self-consciousness in the cultivation of craftsman spirit

When there is lack of awareness of cultivating craftsman spirit, the number of people who actually have craftsman spirit will not increase.

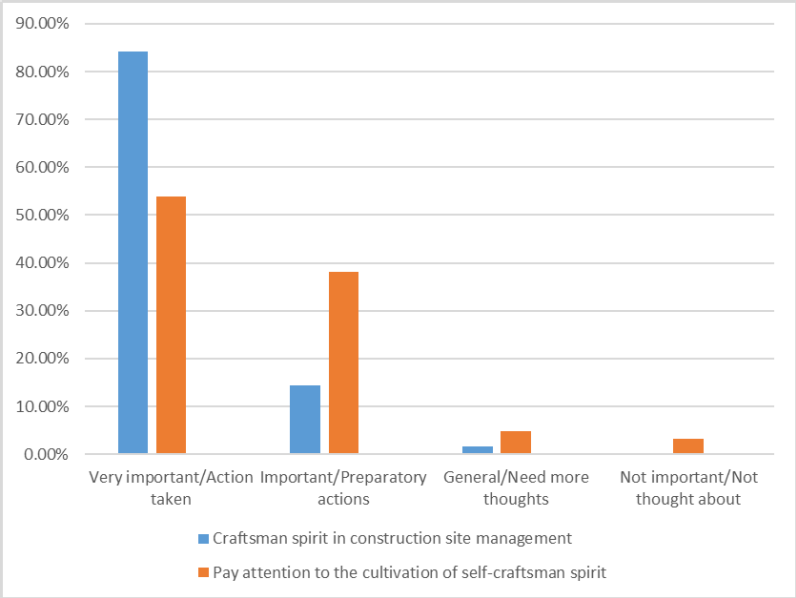

Figure 3. Investigation on the matching of craftsman spirit in construction site

It can be seen from **Figure 3** that the construction workers on the construction site are aware of the importance of craftsman spirit, but they do not pay enough attention to the cultivation of their own craftsman spirit. Both personal effort and a good objective environment for craftsman are needed in order to instil craftsman spirit among workers. An objective environment includes the current situation of the cultivation of craftsman spirit in the construction site, construction industry and society, the current publicity effect of craftsman spirit, and the guidance of craftsman spirit by enterprises and the state. Only when all the construction personnel begin to pay attention to the cultivation of their own craftsman spirit and take themselves as the centre of divergence can they promote the cultivation of craftsman spirit in the whole industry and even the whole society.

3.3. Different understandings of the connotation of craftsman spirit

China has a fine tradition of carrying forward the craftsman spirit since ancient times. With the change of the times, the connotation of the craftsman spirit has been advancing with the times.

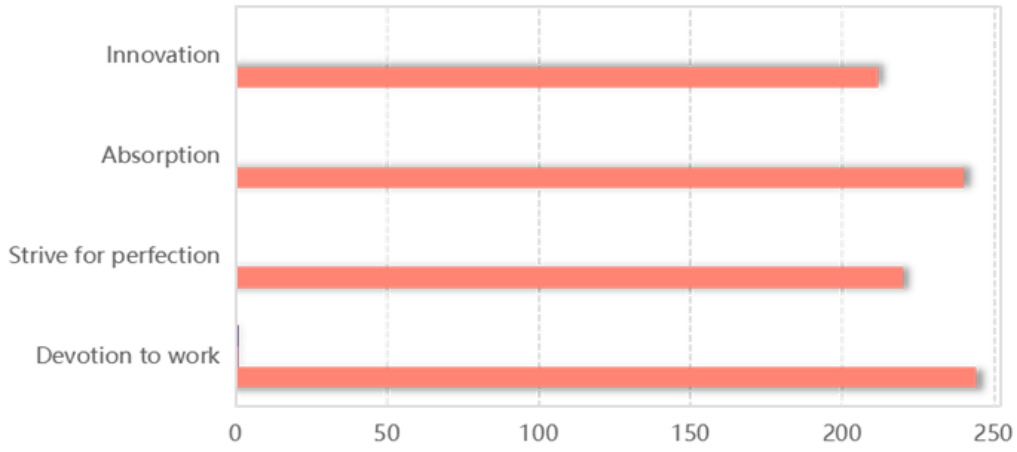

Figure 4. Understanding of craftsman spirit

It can be seen from **Figure 4** that the understanding of the connotation of the craftsman spirit by the construction personnel on the construction site is not uniform. The one-sidedness of cognition has made the cultivation of craftsman spirit difficult. Craftsman spirit can only be developed by understanding and internalizing the its connotation.

3.4. Propaganda effect is not ideal

There have always been problems in the construction industry, and the development of the craftsman spirit in the new era has provided new opportunities for the development of the construction industry. Therefore, it is particularly important to promote the cultivation of craftsman spirit in different ways so that construction workers can understand and embody craftsman spirit.

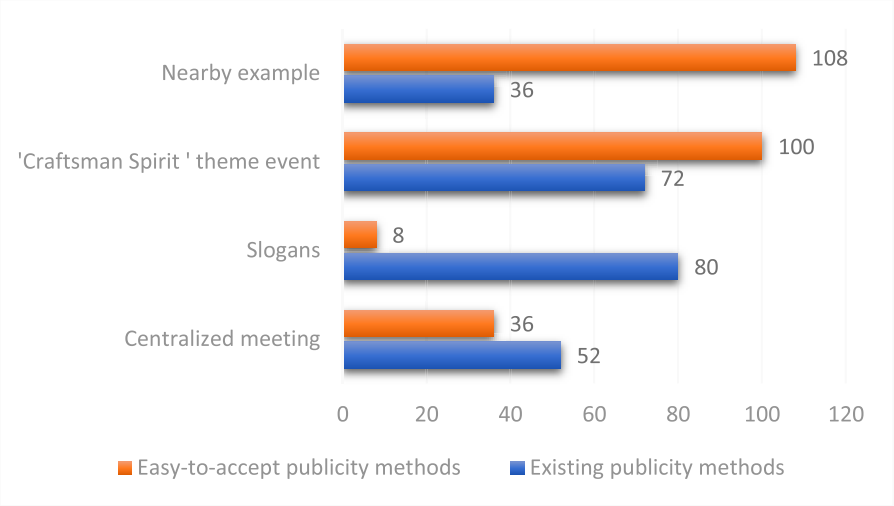

Figure 5. Craftsman spirit publicity research

It can be seen from **Figure 5** that the degree of investment in existing publicity methods is not proportional to their acceptance. The result of this phenomenon is due to the unsatisfactory publicity effect. Taking the most invested slogans and the most accepted role models as examples, it can be seen that most of the investigators understand craftsman spirit from the propaganda slogans, but in this way, the inheritance of the craftsman spirit is the least accepted; while only a small number of building site construction workers among the survey understand craftsman spirit from examples or role models around them, but the survey shows that it is the highest level of acceptance. The unequal publicity channels and information reception lead to unsatisfactory publicity effect of craftsman spirit and waste of publicity resources. Therefore, the preferences and acceptance of construction personnel on different publicity methods needs to be understood, followed by investment in corresponding resources, so as to balance the acceptance of construction personnel and the investment of publicity methods, and achieve reasonable publicity effect.

4. Conclusion and suggestions

4.1. Innovative talent training mode and promote craftsman spirit

4.1.1. Role of professional training in the cultivation of craftsman spirit

The construction site construction personnel requirements are increasing with time, more and more talents from colleges and universities are invested in teams of construction personnel at the construction sites. As one of the main training positions for construction personnel on the construction site, colleges and universities shoulder the important responsibility of cultivating people with morality. They should give full play to professional education, based on characteristics of architecture-related majors. In the process of education and teaching of architecture-related majors, cultural literacy and technical literacy are equally important in cultivating the craftsman spirit of college students and creating a professional construction of ideological and political elements with craftsman spirit.

4.1.2. Role of college and university curriculum in the cultivation of craftsman spirit

Professional courses have a strong supporting role in cultivating craftsman spirit. Colleges and universities should provide sufficient curriculum ideological and political education in the talent training program to realize reformation and strengthen the curriculum education orientation. Using the experiences of students

who became professionals, combined with the principles of curriculum design, as well as the exploration of effective teaching methods, the students will be more enthusiastic and the craftsman spirit can be cultivated.

4.1.3. Role of practical courses in learning craftsman spirit

Practical courses are a very important part as a training before students enter the working world. Colleges and universities can integrate the development strategy of science and technology culture at provincial and municipal levels, create an internship platform with various enterprises, initiate collaborations with enterprises, integrate the needs of society and enterprises into the practical courses, and guide students in choosing suitable internship positions according to the characteristics of each major, so as to realize a school-enterprise collaboration system. Grasping the construction of craftsman spirit plays an important role in the cultivation of talents in colleges and universities, providing more excellent basic conditions for students' inauguration and future development in their careers, and improving students' competitiveness after entering the society [9].

4.2. Enrich skill improvement platforms and practice craftsman spirit

4.2.1. Importance of role models in cultivation of craftsman spirit

The power of role models is of great significance to the cultivation of craftsman spirit. Pioneers may appear in all types of work on the construction site. Role models play a leading role in the construction site, driving the whole construction site to achieve the goal with high quality, thus promoting the cultivation of craftsmanship of all construction personnel. The construction personnel not only improve their own technological level in actual work, but also cultivate their own craftsmanship spirit through exposure. As the saying goes "take the example as a teacher", other construction personnel can learn from their firm ideals and beliefs, and actively practice the spirit of craftsmanship of a great country in the new era, and promote the spirit of craftsmanship in the whole enterprise, industry and society.

4.2.2. Master and apprentice culture inheritance craftsman spirit

Craftsman spirit is not formed instantaneously, but is passed down from generation to generation of Chinese people. Model workers, technical craftsmen and others can be invited to participate in the training and teaching of novice construction workers, so that the participants can be influenced by the craftsman spirit of the master. The work behavior, ability to solve problems, professionalism and so on of the experts, combined with the teaching of theoretical knowledge, can drastically improve the professional abilities of the novice construction workers. School-enterprise collaboration and work-study combination will be beneficial for students to adapt to the working environment and cope with a series of challenges encountered in the work process, and finally become a great country craftsman with craftsman spirit.

4.2.3. The socialist core values lead the craftsman spirit

The socialist core values include "patriotism, dedication, integrity, and friendliness" at an individual level, and the craftsman spirit, as a spirit of concentration and single-mindedness, is the enrichment and development of the core values of dedication. Therefore, the craftsman spirit should become the core value and principle that should be established in all industries [10]. As an important part of the construction industry, construction workers should understand and internalize the socialist core values and cultivate their own craftsman spirit based on the values.

4.3. Improve the quality of training methods, nurturing the spirit of artisans

4.3.1. Role of corporate culture in nurturing the craftsman spirit

Enterprises should first change their concepts, establish the belief of building a century-old store and national brand, regard craftsman spirit as life, and regard perfect quality as the added value of products [11]. An enterprise culture that values technology and values talents with the spirit of craftsmen as the core should be created. Besides, quality improvement and the establishment of a corporate brand should also be emphasized, so that the spirit of craftsmen can be inherited and continued. Influential corporate brand culture activities should be carried out, as well as craftsman-spirit themed activities, seminars and other activities. Experiences of craftsman can also be shared around, as well as passing down unique cultural characteristics, set up a model with craftmanship, play the role of model worker education, and truly cultivate high-quality enterprise talents with good will quality, professional ethics, responsibility and innovation.

4.3.2. Role of environmental culture in the cultivation of craftsman spirit

The function of environmental education should be highlighted, integrate the characteristics of construction site, integrate enterprise culture and professional culture into the construction site, and form an educational environment that highlights the spiritual connotation of craftsmen. A good environment has multiple positive effects. Construction personnel with the spirit of craftsman will always maintain their own progressive ideas and do their best to complete their work., This can make the construction site construction personnel who do not have the craftsman spirit begin to realize their own shortcomings, learn from the excellent construction personnel, and gradually be at par with or even surpass the excellent personnel ; In a long run, when all the construction personnel to achieve their own progress, a high-quality completion of the project can be achieved, leading to the improvement of the enterprise's image and helps in establishing a good corporate brand, and is therefore conducive to the sustained development of enterprises.

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Disclosure statement

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Cost Management Strategy of Highway Engineering Construction Stage Using the List Pricing Model

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Abstract: Highway engineering requires higher investment and requires a long time of management compared to other construction projects. There are many factors that affect the project cost during the engineering construction stage of a highway. The effective development of cost management in the construction phase of highway engineering under the list pricing model can avoid unnecessary waste and help control the cost of highway engineering. However, there are still some problems in the development of cost management in the construction phase of highway engineering, which will affect the role of the list-based pricing mode in cost management. This paper explores and analyzes the advantages of the list pricing model and the problems existing in the cost management of the highway engineering construction stage under the list pricing model, and proposes effective management strategies to improve cost management of the highway engineering construction stage.

Keywords: List pricing model; Highway engineering; Construction stage; Cost management

Online publication: September 30, 2022

1. Introduction

The list pricing model has many advantages over the quota pricing model. It can not only share risks, but also regulate the bidding behavior, and can also improve the transparency of bidding, which helps to enhance the competitiveness of enterprises. The value of the list pricing model needs to be fully maximized in the cost management of highway projects, and existing cost management problems need to be identified and analyzed, so as to further optimize and improve the cost management, and then effectively control the cost of highway engineering.

2. Advantages of the list pricing model

(1) It helps to share the risks

In the process of bidding for highway projects, the tenderee needs to accurately calculate the project volume according to the project volume and the calculation rules of the list pricing specification, and bear the corresponding risks. Bidders need to comprehensively analyze the cost, economic benefits and risks of the highway project. The next step is to carefully and reasonably formulate construction plan which includes determining the configuration of staff, construction materials and construction tools, further optimizing the construction plan, strictly controlling the cost of the construction site, and finally setting the bidding price of the highway project. At the same time, it is also necessary to bear the corresponding quotation risk, which is conducive to the reasonable sharing of risks.

(2) It contributes to the norms of bidding behavior

With the list-based pricing model, the market and enterprises once again enjoy pricing power when carrying out bidding for highway projects, and the mandatory role of the quota is weakened, which greatly reduces the intervention of relevant government departments, and increases the “inquiry” when conducting bidding. In this way, errors, duplicates and missed quotations can be detected in a timely manner, which is more conducive to the regulation of market order, and change the old habit of only focusing on the total bid price and ignoring the actual price. In the process of bid evaluation, the bid price is measured through the formulation of basic standards, and the bill of quantities is added to the highway engineering bidding documents, which not only regulates the bidder's pricing behavior, but also avoids the occurrence of black box operations and fraudulent behaviors.

(3) It helps to improve the transparency of bidding

In the past, there were many drawbacks in the auctions of highway projects, and corruption occurred frequently. Although some auctions have set up registration, review, bid opening and bid evaluation, etc., it is still inevitable that there will be bad behaviors such as escorting bids, colluding bids and privately selling bottom bids. In order to win the bid, some bidders bribe the judges and owners, or create false bidding documents, certificates and materials.

The development of an auction using the list pricing model can prevent the occurrence of these behaviors and helps improve the transparency of bidding. Under the list valuation mode, the highway engineering quantity of the bidder is unified, which provides an important basis for the development of bid evaluation. Moreover, under the list pricing model, the market actually has the right to determine the price, and the role of the base number of a tender is weakened. In this way, the leaking of the base price of a tender can be prevented, which greatly improves the transparency of bidding.

3. Problems in cost management in construction stage of highway engineering under list pricing model

(1) Problems in the bill of quantities

The problems existing in the bill of quantities of highway works are reflected in the following: Firstly, the bidding unit adopts the engineering quantities of similar highway projects in order to save a certain amount of labor when compiling the bidding documents. Secondly, the bidding unit first calculates the rated engineering quantity, and then divides the engineering quantity with the help of calculation software, which is prone to the problem of lack of accuracy of the engineering quantity list [1]. Besides, the functionality of some bill of quantities compilers needs to be further improved because they are not able to compile bills of quantities with high complexity independently.

(2) Problems with corporate quotas

The list pricing model is designed to break the limitation of unified pricing by the relevant government departments in the past, so that the construction unit can give full play to its advantages in technology and price, thereby creating more benefits. However, some construction units have not established a relatively complete quota standard. The list pricing model can be formalized more easily.

(3) Problems in evaluating bids

The cost management work in the construction phase of highway engineering usually lacks a quotation clarification mechanism while using the list pricing model. This limits the full play of the role of pre-tender and affect the formation of the bid evaluation committee, causing the accuracy of the bid evaluation results to not be guaranteed.

(4) Problems in the contract

In order to resolve the problems in highway engineering cost and construction, necessary clarification and restriction needs to be made during the signing of corresponding contracts [2]. According to the requirements of relevant laws and regulations in China, highway engineering construction units need to track the list price prepared by the cost management department, and, supervise and manage the specific implementation of the contract. However, the audit of the actual implementation of contract regulations by various departments is not systematic, which leads to some problems in the process of contract implementation.

(5) Problems in construction

The development of cost management in the construction phase of highway engineering under the list pricing model is easily affected by human factors and external factors, which can easily lead to some property losses. Therefore, the contractor faces many risks, such as project management risk, quotation error risk, and so on [3].

4. Effective strategies for cost management in the construction stage of highway engineering under the mode of list pricing

(1) Engineering change management in the list pricing model

Engineering change refers to the change of some or all of the construction methods, technical indicators, engineering functions, construction materials, etc. according to the content of the contract during the construction of the project [4]. Engineering change management mainly involves two aspects, one is the engineering quantity, and the other is the comprehensive unit price. Among them, the management of the project quantity includes the determination of the project quantity and the on-site visa. The change of the project quantity is very important, so both the owner and the contractor attach great importance to the change of the project quantity, but it is often easy to ignore the comprehensive unit price change. Comprehensive unit price change will definitely have a greater impact on the cost of highway engineering [5] thus also deserves more attention. Based on the list pricing model, if there is a unit price that is more suitable for the change project in the bill of quantities, it needs to be executed according to the existing comprehensive unit price in the list. After conversion, the consolidated unit price after the change will be confirmed. If the applicable unit price for engineering change is not set in the bill of quantities, the contractor and the construction unit shall jointly negotiate on the comprehensive unit price for engineering change. In case of disagreement between the two parties, the final determination can be made according to the dispute provisions in the contract or by the project supervisor [6]. When implementing the unbalanced highway engineering quotation, the contractor often tries to benefit themselves, and the construction unit will try to reduce the adverse impact of the unbalanced cost. At this time, both the contractor and the construction unit will use the engineering change to explore opportunities that are beneficial to themselves. If the contractor applies the unbalanced quotation when bidding, and when the contract is signed, the unbalanced unit price is not adjusted, then it needs to be dealt with in accordance with the relevant regulations [7].

(2) Claims management of highway engineering based on the list pricing model

The execution highway engineering needs to be in accordance with the contract and relevant laws and regulations of the country. If one party faces losses because the other party fails to adhere to the contract, the losing party can request for a compensation [8]. At this stage, the construction claims in our country are usually made by the contractor. The procedure of claim is as follows: Firstly, if one party submits a notice of claim, the contractor needs to issue a notice of claim within the corresponding time in accordance with the contract [9]. Secondly, the relevant documents for the claim should be submitted. In the event of a project claim, the contractor needs to prepare relevant documents in a timely manner, and submit the documents to the engineer within 28 days after the notice of claim is issued, or within the

time period after negotiating and achieving an agreement with the with the engineer. The amount of the claim needs to be clearly stated in the information and the basis for filing the claim also needs to be provided. The third step of the process is processing the information of the claim. If the information submitted by the contractor is sufficient to prompt the engineer to determine the amount to be paid, then the engineer shall pay the certified claim amount in the month in which the claim information is received. If the contractor is not satisfied with the engineer's decision to deal with the claim, the following responses need to be made: The first step is sending the engineer a notice of intent to continue to reserve the right to claim [10]; secondly, after the completion of the handover of the engineering certificate, further claims can be made after the submission of the completion statement. The last step is to negotiate within the agreed time according to the contract, and if it still cannot be resolved, it can be submitted to arbitration.

(3) Improve the professional abilities and professional qualities of highway engineering supervisors

The professional abilities and professional qualities of the supervisors must meet the needs of their jobs. Only in this way can the construction progress smoothly, and the construction safety, various construction phases and construction quality be strictly controlled. At the same time, the supervisors also need to meticulously inspect the manpower, construction materials, and construction equipment invested by the contractor in the highway project, and make records at the same time [11]. The supervisors also need to review the relevant declaration materials submitted by the contractor for the progress payment of the highway project. It is also necessary to review the project change fee and the number of visas submitted by the road project contractor [12]. At the same time, it is also necessary to sort out the measurement data and payment data of highway engineering changes in accordance with the corresponding procedures. In addition, the supervisors also need to collect all the original materials generated during the construction phase of the highway project for subsequent use.

(4) Strengthen risk management

More financial, material and human resources are required to be invested in the construction of highway projects. If all parties involved in highway engineering construction do not pay enough attention to risk management, it will greatly increase the probability of risk occurrence, and may also cause greater losses [13]. At the least, it may lead to delays in the construction period of highway projects, resulting in the actual expenditure of all parties involved in the construction of highway projects exceeding the budget. And at the worst, it may be difficult to continue the construction of the entire highway project, resulting in irreparable investment. If all parties involved in project construction attach great importance to risk management, even when risks occur, there will be no mutual shirk, but an accurate response will be made in the first time, so as to reduce the losses caused by risks [14]. Based on the list pricing model, the owner is responsible for the risks caused by the project quantity in the bill of quantities, and the construction party is responsible for the risks caused by the unit price of the project in the bill of quantities. Risk management personnel of all parties involved in highway engineering need to conduct comprehensive collection, investigation and research on highway engineering data, and objectively judge the various risks hidden in highway engineering, establish risk identification awareness, and target them on this basis, so as to develop a detailed response plan in advance [15]. It should be noted that the identifiable factors that can cause risks need to be confirmed as soon as possible, and uncertain factors that will lead to risks cannot be blindly excluded, but decisions need to be made through careful research and analysis to avoid unnecessary impact on the cost management of highway projects.

5. Conclusion

in conclusion, highway engineering plays a very important role in China's economic development. In recent years, the volume of highway engineering has increased, and the control of highway engineering cost has

garnered more and more attention. In the process of highway engineering cost management under the list pricing model, it is necessary to strengthen the management of highway engineering changes, claims and risks. At the same time, it is necessary to focus on improving the professional abilities and professional qualities of highway engineering supervisors, so as to ensure the efficiency and the quality of highway engineering construction. Moreover, potential risks should be prevented, and the cost of highway engineering should be controlled, so as to realize the improvement of economic and social benefits of highway engineering, and improve the process of highway engineering construction.

Disclosure statement

The author declares no conflict of interest.

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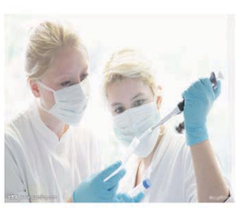

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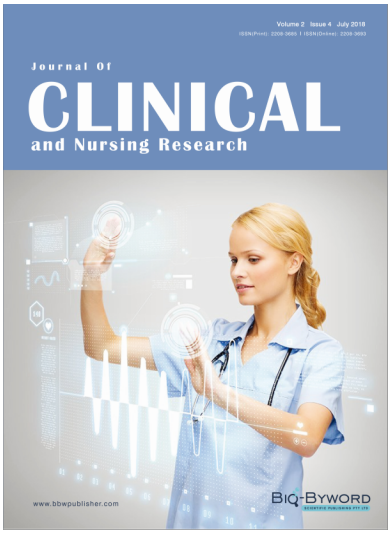

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