

Total quality management practice of urban water environment rehabilitation project

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Abstract. The urban water environment rehabilitation project is a comprehensive strategic social project with large investment, wide scope and complicated construction conditions, which determines the uncertainty and particularity of the quality management of urban water environment rehabilitation projects. In order to improve the quality management level of urban water environment rehabilitation projects and promote urban water environment rehabilitation, this paper analyzes the characteristics of quality management of urban water environment rehabilitation projects from the viewpoint of the total quality management. Taking the Maozhou River urban water environment rehabilitation project in Shenzhen, Guangdong, China as an example, using the total quality management theory and causal analysis, the authors summed up the new quality management model, dual-collaborative quality management, for the water environment rehabilitation project, and some new technologies such as resident supervision system, closed circuit television inspection and data analysis technology were applied.

1. Introduction

The water environment refers to the water body that directly or indirectly affects the life and development of human beings around the human activity area. It also refers to the environment in which the water is produced, scattered and transformed in the natural world. Since the reform and opening up, the contradiction between economic development and environmental protection, humanities and ecology has become increasingly prominent. The pollution of the urban water environment is particularly serious. A large number of rivers are intercepted and landfilled, land plants are destroyed and hardened, and domestic sewage is directly discharged into rivers, causing a large number of urban groundwater sources to be polluted, the water environment is deteriorating, and water pollution is serious [1]. In response to these conditions, the Chinese government has implemented a series of policies such as "Water pollution Prevention action plan", "Guidelines for the Urban Black-smelly Water Remediation Work", "Opinions on Strengthening Ecological Environment Protection and Resolutely Fighting Pollution Prevention and Control" to comprehensively promote urban water environment rehabilitation.

The quality management is the core work and effect of the urban water environment rehabilitation project. According to the project process, the quality management work can be divided into four



stages: preparation stage, implementation stage, finishing stage and completion acceptance stage. Due to its wide range of projects, complex engineering types, long cycle, and difficult working environment and conditions, the urban water environment rehabilitation project makes the quality management more difficult, which shows the importance of the quality management of urban water environment rehabilitation project. Therefore, the quality management of urban water environment rehabilitation projects should be carried out according to the characteristics of the work at different stages and the characteristics of the project, key management should be carried out from the six elements of human, machinery, materials, method, environmental and measurement to improve the quality management level and achieve quality management objectives [2].

This paper analyzes the quality management characteristics of urban water environment rehabilitation project, taking the Maozhou River urban water environment rehabilitation project as an example, using the total quality management theory, summed up the new quality management model and new technology that can be adopted by the water environment rehabilitation project, which can provide reference significance for the future urban water environment rehabilitation project.

2. Characteristics of quality management

The particularity of the urban water environment rehabilitation project determines the importance of its quality management, and determines its quality is not only related to the use and investment effects of the project itself, but also has an important impact on the public interest and safety of the society. The quality management characteristics of urban water environment rehabilitation projects can be summarized as follows [3]:

- High impact of construction quality problems

The scale and scope of urban water environment rehabilitation project construction is much larger than other construction projects, some even across regions; the technology adopted is more complicated than other projects.

- More sub-items, changing conditions, and more implementation procedures

The urban water environment rehabilitation project involves a wide range of projects, many types of projects, many sub-projects, complex technology, long cycle, and difficult working conditions and conditions. These features increase the difficulty and risk of construction and increase the likelihood of quality problems during construction.

- High construction organization capacity

Urban water environment rehabilitation projects often have a large scope of projects, spanning the entire basin, involving many sub-projects such as sewage treatment, river improvement, and river landscape. The functions are numerous and the system is complex. It is required to complete in a limited time and space, but also to ensure quality and quantity, which is a great test for the contractor's construction organization ability.

- Difficult to evaluate

The quality of urban water environment rehabilitation project involves safety, applicability and cost control; it is concealed and difficult to evaluate. After the project is completed, it cannot be inspected for its intrinsic quality by simple disassembly or destructive inspection like other industrial products. Therefore, its quality assessment and inspection must be carried out throughout the entire construction process, achieving quality management throughout the process.

3. Project overview

The Maozhou River, as the largest river in Shenzhen, originates from the north of the Yangtai Mountain in Shenzhen. The total length of the mainstream is 31.29 km, and the drainage area is 388.23 km². In the Bao'an District, it covers two administrative areas, Songgang and Shajing, with 19 river surges and a total length of 96.56km, as shown in figure 1.

Along with the progress of reform and opening up and industrialization, the Maozhou River is facing serious problems of water pollution and siltation. The water quality of the mainstream and 15 main tributaries are worse than Class V of National Surface Water Environmental Standard, and

ammonia nitrogen, total nitrogen and total phosphorus are seriously exceeded.

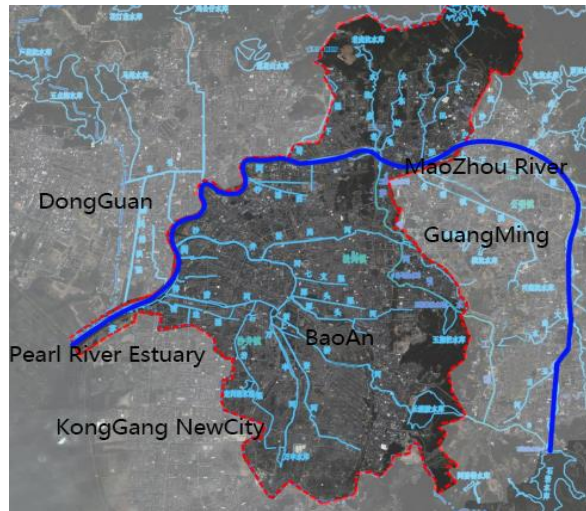


Figure 1. The Maozhou River.

In view of the serious environmental problems in the Maozhou River, the Shenzhen Government commissioned the Power China Water Environment Governance Co., Ltd to carry out the comprehensive water rehabilitation work of the Maozhou River Basin (Bao'an district) in 2016. The project is an integrated urban water environment rehabilitation project with a total area of 112.65 km² in the Maozhou River Basin (Bao'an district), including the drainage project, the pipeline project, the river comprehensive rehabilitation project, and dredging and sediment disposal project. It is related to the lives of millions of residents, therefore, more requirements need to be placed on safety management on the construction site of the urban water quality rehabilitation project [4].

4. New model and new methods of quality management

4.1. Application of causal analysis method

The causal analysis method is a method of making predictions based on the causal relationship between the development and change of things. By grasping the relationship between the main contradiction and the secondary contradiction, established a mathematical model to predict. The deliverable of the causal analysis method is the causal analysis diagram.

Because its shape is like the fish bone, the causal analysis diagram also called the Fishbone diagram. By analyzing essence through phenomena, looking for measures to promote the solution of the problem. It is a tool for analyzing characteristics (results) and factors (causes) that may influence characteristics [5]. In the quality management of water rehabilitation projects, a large number of project quality analysis and quality evaluation problems are often encountered. The causal analysis method can clearly express the relationship between the causes and the results, and turn the analyzed problems into structural graphics that is very intuitive and clear (figure 2). The causal analysis diagram for analyzing control of the six factors: man, machine, material, method, environment and measurement, to achieve the goal of qualified quality. Six factors are "causes", and quality is "result". Pre-control and active control can be achieved through this method.

From the above causal analysis diagram, we can clearly see six factors: man, machine, material, method, environment and measurement, which affect the quality of engineering. There are many reasons for each factor. Therefore, we can take the remedy to the case and take effective measures, eliminate or reduce quality problems and accidents to a minimum.

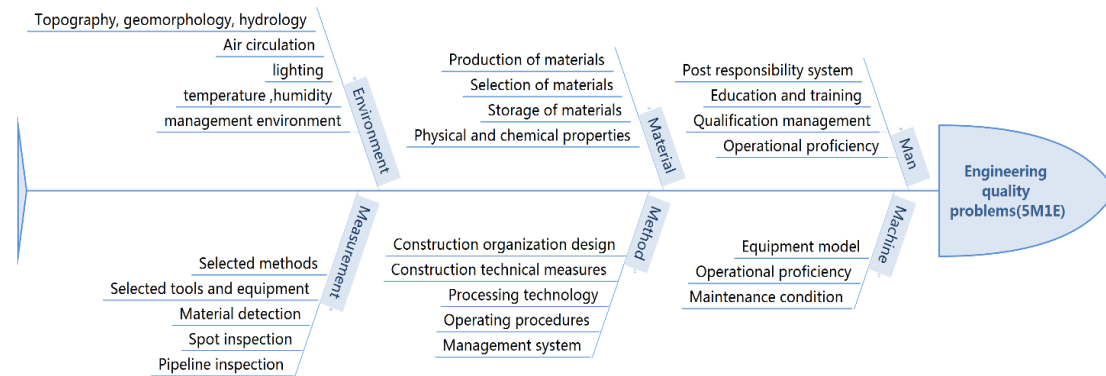


Figure 2. Factors affecting project quality.

4.2. Total quality management

Total quality management (TQM) refers to the quality management of all-round, whole process and full participation [6].

- All-round quality management, refers to the all-round management of behavioral quality and engineering quality. Behavioral quality directly affects the formation of engineering quality and is the guarantee of engineering quality. For the water environment rehabilitation project, the all-round quality management should also include the overall management of the behavioral quality and engineering quality of the participating entities such as design, owner, survey, supervision, construction subcontracting, construction general contract, and material equipment supplier. The quality negligence of one of the links or responsible parties will have a huge impact on the entire project.
- Quality management of the whole process, refers to the starting from the source, the whole process of supervision and control. From the identification of the project in the construction process to the acceptance and use, all the organic links and all the specific processes need to apply the “process method” for the whole process quality management.
- Quality management of the full participation, requires that quality control work be implemented to each employee so that each employee cares about the quality of construction. To achieve quality management for all employees, we must first achieve goal establishment and management. Because every role in the project, whether it is the operator or the manager, once the job responsibilities and quality objectives are determined, they should shoulder the corresponding quality functions, and devote themselves wholeheartedly to the activities of implementing the quality policy, and give play to the functional role that this post should have.

Through strict implementation of total quality management, and the three links of pre-control, in-process control and post-control, this study summarizes the new quality management mode, dual-collaborative quality management and some new technologies, including material bidding customization system, resident supervision system (pre-control); the first project and test section acceptance management methods, and the key process real-name system (in-process control); informatization quality management measures such as closed circuit television inspection (CCTV) of drainage pipe and data analysis technology (post control), engineering quality management level has been significantly improved.

4.2.1. Dual-collaborative quality management model. The water environment rehabilitation project has a wide range and difficult management. The project has created a dual-collaborative quality management (DCQM) model based on unified platform, including internal coordination management and external coordination management, which is conducive to the overall management and coordination of the entire project to improve the quality of the project.

Under the dual-collaborative quality management mode, the general contracting company is

regarded as the management platform. Internal collaborative management refers to the collaboration between the quality management department of the platform company and the project department of the bidding department. External collaborative management refers to the coordination of owners and supervisors, third-party monitoring and government quality inspection and safety supervision departments. There are unified quality objectives, management processes and standards, and technical acceptance specifications between the two layers of collaborative management. It is superior to traditional quality management methods which relies on the professional ethics of construction units, supervision units and third-party monitoring departments to ensure the quality of the project. However, it should be noted that in terms of external collaborative management, since the water environment rehabilitation project is a social project and there is no specific property owner, in this case, it is necessary to actively communicate with the government and residents, strengthen the publicity of enterprise engineering construction, and increase quality monitoring strength. While communicating with residents, we should appropriately strengthen the publicity of the quality and effectiveness of water environment rehabilitation to obtain residents' recognition and provide a more solid guarantee for the sustainable development of the project. At the level of internal collaborative management, the platform company and the project department also set up a work department and working mechanism for quality, safety and environmental co-management, clarified specific work objectives and main responsible persons, and established a traceability system for quality responsibility.

4.2.2. Pre control. Pre control is mainly to control the quality of raw materials from the source. In addition to the conventional quality management improvement, the establishment of drawing review, construction team optimization, and presentation of drawings, the project mainly implemented pre-control measures including material bidding customization system and resident supervision system.

- **Material Bidding Customization System**

Qualified materials are the premise and basis for ensuring the quality of engineering construction. The materials here refer to the main materials used in construction projects such as pipes, steel, cement and various finished and semi-finished materials. In the tendering stage of raw materials, the Maozhou River project improved the quality requirements of materials, and proposed technical indicators of raw materials higher than the national standards, eliminating the errors caused by the instability of the production process and completely eliminating the unqualified raw materials. The quality of the pipe can reach 100% pass rate.

- **Resident Supervision System**

Resident supervision system, refers to the construction company that strictly controls the quality of purchased materials, dispatches management personnel to the main manufacturers of construction materials and components, and supervises the whole process of the quality of raw materials, production processes and production results. Through the resident supervision system, quality control can be carried out for each production process of the manufacturer to ensure the quality of the materials and the production schedule, and ensure that the materials and components delivered to the project site meet the design and specification requirements.

4.2.3. In-process control. In-process control, the purpose is to timely discover and deal with the quality problems that arise during the implementation process. Conventional measures include engineering meetings, engineering quality inspections, engineering quality acceptance, and engineering data compilation. Based on these routine matters of in-process control, the project also fully implements the key process real-name system to create standardization of quality behavior. Through the visual interpretation, such as the first project and test section acceptance management methods, to create entity quality control standardization.

- **The Key Process Real-Name System**

The key process real-name system is a system that clarifies the responsibility of each branch,

sub-project, key parts, and key links. Through the real-name system, strict quality control of the construction process, strengthen the management of construction records and acceptance data, establish a quality responsibility identification system for the construction process, fully implement the construction project quality responsibility commitment and the permanent signage system after completion to ensure the traceability of the project quality.

- The First Project and Test Section Acceptance Management Methods

The acceptance of the first piece of the project and the test section is an important part of determining the construction quality standard, process parameters, operation process and management requirements, and is an important basis for guiding the similar construction and quality acceptance in the later stage. The purpose is to use the first sample as the standard, and then to promote in the construction process of each inspection batch of the sub-project, strengthen the quality inspection procedures, standardize the quality awareness and quality behavior of the operators, and ensure the realization of the quality objectives from the construction source. Thereby driving the overall quality level of the project.

4.2.4. Post control. Post control refers to the method of implementing control in the next round of construction activities based on the analysis and comparison of the current construction results and the planned objectives, so that the quality management level is continuously improved. Routine measures include quality assessment and quality evaluation comparison system, quality problem reporting system, quality problems and quality accident handling. On this basis, the project emphasizes the application of technical means to improve the effectiveness of quality of post control. The engineering center laboratory and pipeline CCTV professional testing team were set up and included in the management of the company's quality management department. Sampling inspection of raw materials and physical quality, full-section endoscopic inspection and data analysis techniques for underground pipelines, ensuring 100% acceptance rate.

- Circuit Television Inspection of Drainage Pipe

Circuit television inspection (CCTV) of drainage pipe is a detection method that uses modern and informational means to obtain engineering quality information in a non-destructive manner. The implementation steps of the technology are as follows: First, through the conventional measuring equipment, obtain the ground elevation of the pipeline system, check the well coordinates, pipeline depth, pipe diameter and other detailed data; Then, through the CCTV detection device, the pipeline is video-detected once from upstream to downstream, and the detection result is stored by two methods of video recording and picture capture; Finally, combined with pipeline geographic information data and CCTV test results, a comprehensive analysis of the pipeline situation is carried out, and a solution to the rectification plan is proposed for different situations. After the project is completed, CCTV was used to do 100% inspection of completed pipelines to ensure that all acceptances of the project are qualified.

- Data Analysis Techniques

In the process of engineering inspection, you can find some quality problems in the implementation of the project, as well as data on the quality completion of the project implementer. The project analyzes the data, rationally uses quality management analysis tools to solve quality problems, and improves quality management. For example, using Pareto charts, the quality problems and quality improvement projects that occur will be arranged in order of importance, and the main causes of defects will be discovered and identified in time; Use the quality control chart to determine the quality control objectives and the actual project quality operation, analyze the quality management unit quality management trends, and promptly propose quality warnings. Through the analysis results obtained by these quality analysis tools, the supervision and inspection work was carried out in a targeted manner, and good quality management effects were achieved.

5. Conclusions

This paper analyzes the characteristics of quality management of urban water environmental

rehabilitation projects, taking the Maozhou River urban water environment rehabilitation actual project as an example, using the total quality management theory, summed up some new quality management model and new technology: including material bidding customization system, resident supervision system (pre-control); the first project and test section acceptance management methods, and the key process real-name system (in- process control); informatization quality management measures such as closed circuit television inspection (CCTV) of drainage pipe and data analysis technology (post control), which have improved the quality management level of the Maozhou River rehabilitation project and has certain reference value for similar projects.

Summarizing its advanced quality management experience, this study also made suggestions on training methods, building information platforms and establishing information management control center.

- Improving training methods and strengthening quality culture construction

The urban water environment rehabilitation project involves many units and personnel. The quality management atmosphere of each bidding section is different, and the quality of the participating personnel is uneven. These reasons will make the management and coordination of the entire project difficult. In this case, in addition to the regular training work, the training method should be innovative. For example, while fixing the labor service team, it is also possible to integrate the handheld teaching and micro-curriculum mode, so that the veteran can lead the training with experience and enhance the quality consciousness without losing the fun.

- Building an information management platform

In order to improve the effectiveness of quality management, we should pay attention to the application of information technology and build a quality management platform. Through the network platform, the construction quality of the project site can get real-time guidance and control. It can realize the effective coordination of all parties, summarize the needs of all parties on the same information platform, and transmit and process information according to the needs of all parties. The quality control specifications and standards are integrated into a database, making structured information easy to call, better supporting decisions, and increasing the scientific and accurate quality control.

- Establishing an information management control center

New technologies such as video surveillance and Quick Response (QR) codes can be integrated into the BIM model. The command center can understand the construction of each segment in real time through models and monitoring. The project progress is docked with the model. According to the existing progress data and the planned target, and data quantification, the rationality of the human, materials, machines is grasped, the construction period is guaranteed, and the quality management level is improved.

6. Future Perspectives

This study summarizes the six factors affecting the quality management of water environmental rehabilitation projects through causal analysis, but lacks the analysis of the impact level of various factors on quality. Later research will add multi-criteria analysis methods to identify key factors that have a high degree of influence to focus on controlling and improve the quality management level of water environmental management projects. In addition, in view of the development of GIS technology in the field of water environment, a large number of basic data of watershed management have been accumulated, and later GIS technology will be applied to quality monitoring of water environment rehabilitation, and spatial analysis calculation and distribution display for diagnosis of main problems of water environment quality can be realized, to provide Informatization and visual management for water environment rehabilitation projects and improve rehabilitation level.

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