Application of causal analysis to the safety management of urban water environment treatment project

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Abstract. There are a large number of hazard sources in the construction site, and each hazard source may cause a safety accident. Therefore, timely and accurate identification of hazard sources becomes a necessary for safety management at the construction site. Along with the characteristics of the construction site of the Maozhou River Rehabilitation Project, from the four aspects of management, people, environment and objects, the causal analysis method is used to analyze the hazard sources of safety accident at the construction site. According to the analyzed hazard sources, the total safety management of the project was realized through the PDCA cycle.

1. Introduction

With the rapid development of social economy and the intensification of human activities, China is facing a serious problem of water pollution. Deterioration of water environment has become a major constraint on the sustainable development of social economy. In response to these problems, China has formulated and implemented a series of policies, such as the Water Pollution Prevention Action Plan, Guidelines for the Urban Black-smelly Water Remediation Work and Opinions on the Full Implementation of the River Chief System [1]. In the water environment treatment project, the imperfect management mechanism, weak practical foundation and low participation of all members are the outstanding features of China's current safety management [2]. In recent years, the project safety has been highly valued by the government and society [3].

At present, China has the following problems in the safety management of water environment treatment projects: 1) The legal system is not yet fully mature, and there are no clear regulations on the management of small rivers and lakes; 2) The establishment of the organization is not systematic, mainly manifested in the unclear power of quality, safety supervision institutions and administrative departments, overlapping and separation of institutional settings, and the inability to integrate management and supervision organically, which lead to difficulties in supervision and other issues [4]; 3) The implementation of the system is not in place, the powers and responsibilities are not unified, and the professional safety management problem investigation mechanism is lacking [5]; 4) Many problems in safety management often encounter situations where material resources and financial resources are limited, which increases management difficulty [6]. Therefore, strengthening the safety management of river management projects is not only necessary, but also has great practical value.
The water environment rehabilitation projects are quite different from traditional building projects. They always involve in wide range and various types of projects, complicated technology, difficult operating conditions, and last for a long period, resulting in increase of the risk of construction and the possibility of accidents during construction, all of these emphasize the importance of safety. Therefore, we must actively control and strengthen safety management to reduce the occurrence of security accidents and achieve the purpose of effectively avoiding risks. The key to preventing accidents is to figure out the mechanism of accidents, identify the inevitable and accidental causes of accidents, then minimize the probability of accidents by eliminating inevitable causes and scientifically controlling accidental causes.

The PDCA (Plan-Do-Check-Action) cycle is a scientific procedure for the implementation of total safety management proposed by American scholar Deming. It is the basic theory in the safety management of engineering projects. The PDCA cycle mainly includes several stages of planning, implementation, inspection and disposal. Based on the plan, the safety is continuously improved through continuous implementation, inspection and disposal cycles. Among them, the PDCA small loop can be applied in any stage of the PDCA cycle.

With the increasing number of safety accidents in the process of water environment management, how to effectively solve the safety problem has become a topic of concern to the whole society. Combining the characteristics and implementation experience of the safety management of the Maozhou River Rehabilitation Project in Shenzhen, the authors applied the causal analysis method and PDCA cycle to the Maozhou River water environment treatment project and achieved good results.

2. The Maozhou River rehabilitation project
As the largest river in Shenzhen, the Maozhou River originates from the north of the Yangtai Mountain in Shenzhen, the total length of the main stream is 31.29 km, and the drainage area is 388.23 km². The Guangshen Highway to the Maozhou River estuary is the border river between Shenzhen and Dongguan. It flows from the southeast to the northwest of Shenzhen through Shiyan, Gongming, Guangming Farm, Songgang, Shajing, then it enters the Pearl River Estuary in the Shajing Democratic Village. In recent years, the pollution of the water bodies in the the Maozhou River Basin is very serious. The water quality of the tributaries is worse than Class V of National Surface Water Environmental Standard, and the water ecological environment needs to be improved urgently.

In view of the serious environmental problems in the Mazhou 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 water environment rehabilitation project with a total area of 112.65km² in the Maozhou River Basin (Bao'an district), including the drainage project, the pipe network project, the river comprehensive rehabilitation project, and dredging and sediment disposal project, total investment of the project is 15.2 billion yuan. The Maozhou River Rehabilitation Project involves in a wide range of projects, many types of projects, strong system, many sub-projects, many project participants, complex technology, long cycle, difficult working environment and high intensity. At the same time, this project has high social attention and influence. These features increase the difficulty of construction and increase the risk of construction. If the safety management work is not in place, it may cause an accident, causing casualties and property damage, which will have irreparable consequences for the enterprise and society. In view of this, the project management uses PDCA cycle and causal analysis to promote all-person, all-round, and whole-process safety management, thereby reducing the occurrence of safety accidents and achieving effective risk aversion.

3. Application of causal analysis
Causal analysis is a tool for analyzing safety characteristics (results) and factors (causes) that may affect safety characteristics. It helps to solve problems by grasping the status quo, analyzing the causes, and finding measures. There are a large number of hazard sources in the construction site, and each hazard source may cause a safety accident. Therefore, timely and accurate identification of
hazard sources becomes a necessary for safety management at the construction site. Combined with the characteristics of the construction site, the Maozhou River Rehabilitation Project uses the causal analysis method shown in figure 1 to analyze the incentives that may lead to safety accidents during the construction process. Through the fishbone diagram to analyze and control the construction safety, it is based on the management, people, environment and material as indicated in figure 1 to control the “cause” to achieve the “result” of engineering safety. That is, by controlling the “factors” to achieve qualified “results”, thereby achieving pre-control and active control.

3.1. Management
The safety management of the Maozhou River Rehabilitation Project has many contents and is difficult to manage; the security management level is large and the scope is large.

3.1.1. Safety management agencies. The project safety management organization consists of the project company, the bidding project manager department and the operation team, and establishes the project company safety production committee led by the project company and the special production team leading group of the safety management team. The organizational structure is shown in figure 2.

The project company safety production committee shall mainly perform the following duties:
- Implementing the national laws, regulations, rules, systems and standards related to safe production, and formulate project safety production;
Overall target and annual target, safety production target management plan;
Organizing and formulating a project safety production management system and implementing it;
Organizing the preparation of safety production measures and safety appraisal;
Coordinate and solve major problems in the safety production of the project.

The safety production leading group should hold at least one plenary meeting every quarter to analyze the safety production situation and study and solve major problems in safety production. The meeting shall form a summary, and the project legal person shall issue the participating units and supervise the implementation. The construction units of each tender section shall establish a safety production leading group and set up a safety production management organization.

3.1.2. Safety production management system. The safety production management system is a series of provisions designed to ensure safe production. It was established primarily to control risks and minimize hazards. In view of the hazard source and potential safety hazard of the water environment treatment project, the project develops a safety production management system from the following aspects:

- Consider which projects have risks and where they need to control risks;
- Consider the relationship between the various security management links, that is, the process;
- Consider the specific requirements for each link, that is, the application of the system;
- Considering the requirements of laws and regulations, converting the provisions of laws and regulations into the content of the system;
- Consider the contents of the system that need to be traced and set up records.

The safety production management system can transform the laws and regulations to ensure that the project company operates according to laws. The system can clarify the safety responsibilities, unify the safety work and production work from the organization and leadership, facilitate the division of labor and cooperation between the various levels of personnel, and do a good job in safety work, and it is also conducive to accident investigation, handling, and clear responsibility. Moreover, the system can standardize work processes and reduce the risks associated with construction process operations and equipment maintenance. The system may also stipulate the implementation procedures of safety-related work, such as hidden danger investigation, assessment rewards and punishments, accident handling, emergency procedures, etc., in order to eliminate, reduce, and resist various types of safety production risks.

In short, the implementation of safety management system is the primary task and guarantee work of safety production, and is an important condition for the development of project companies.

3.1.3. Safety production education and training system. Safety production education and training is an important safeguard for safe production. The purpose is to improve safety awareness, safety quality and safety skills to prevent or reduce the occurrence of safety accidents. The requirements for the development of the safety production training system are as follows:

- Establish a safety production education and training system, and clarify the requirements and contents, organization and management, inspection and assessment requirements of safety production education and training;
- Regularly conduct safety production education and training for employees to ensure that employees have the necessary safety production knowledge, familiar with safety production related laws, regulations, rules, systems and standards, and master the safe operation skills of this position;
- At least one safety production education training should be conducted for managers and operators every year, and the test should confirm that their ability meets the requirements of the post, and their education and training will be recorded in the personal work file. Persons who fail to pass the safety production education and training assessment shall not be employed;
• Regularly identify the needs of safety production education and training, formulate education and training plans, guarantee education and training costs, venues, teaching materials, teachers and other resources, conduct education and training as planned, establish educational training records, accounts and files, and educate and train the results. Conduct assessments and improvements;
• Timely statistics and summary of relevant records of employees' safety production education training and qualification certification, and regular review and inspection of employees' certificates.

After years of practice, the importance of safety production training has been confirmed. However, compared with foreign safety production training, China still has many weak links in safety production training. Therefore, it is necessary to strengthen safety production education and training, and play an important role in safety production training.

3.2. People
As an important factor affecting the safety management of engineering construction, it is essential to rationally and effectively manage the quality of personnel, the safety awareness of trainers, improve the technical level of workers, and standardize the construction operation procedures.

3.2.1. Personnel qualification management. All construction teams who undertake construction tasks in the project department must have valid qualification certificates and have complete admission procedures. Before entering the venue, staff qualification declaration forms and relevant supporting documents must be prepared, and all obligations stipulated in the contract must be strictly observed.

The entry personnel must remain relatively stable, and various types of work must be supported. According to the progress of the project, sufficient labors are ensured to meet the needs of production.

3.2.2. Staff education and training. The main responsible persons and safety production management personnel of each participating unit shall receive safety production education and training, and have the safety production knowledge and management ability corresponding to the production and operation activities they are engaged in. The main person in charge of the construction unit, the person in charge of the project, and the full-time safety production management personnel must obtain the safety production assessment certificate issued by the water administrative department at or above the provincial level before they can participate in the project bidding and engage in construction management.

3.3. Environment
In the construction of engineering projects, environmental factors are constantly changing, such as temperature, humidity, precipitation, and wind power during construction. The previous process provides a construction environment for the latter process, and the environment at the construction site is also changing. The ever-changing environment will have varying degrees of impact on the safety management of engineering projects.

3.3.1. Engineering natural environment. The environmental factors considered during the construction process mainly refer to the natural environment of the project. It mainly includes engineering geology, topography, hydrogeology, engineering hydrology, meteorology and other factors. These factors are complex and variable, and have a greater impact on the construction safety of the project. For example, in the eastern part of the summer, it is a typhoon-prone area. Pay attention to the drainage of the foundation pit and ditch, the protection of the slope, the waterproof treatment of materials and semi-finished products, and the emergency evacuation of personnel.

3.3.2. Engineering management environment. The project management environment mainly refers to the safety management system and labor environment used. One of the conditions for effective control
of safety management is the guarantee of the system. The basic work of safety management is the safety management system, including the establishment, improvement and implementation of the system. The project includes the main safety management system, safety accident management methods, safety production responsibility system, geological disaster prevention and control management methods, safety production training management methods, and safety production cost management methods. To improve the management environment, enterprises need to adjust the management department, clearly define the responsibilities and authorities of the relevant management departments, ensure that the functions of the enterprise management departments are fully set up, actively use advanced management methods, and formulate systematic management mechanisms to ensure that project management is also based on changes in construction conditions. Change, comprehensively implement the safety management system in a systematic manner, and continuously improve the management effect.

3.4. Object
In the process of construction, effective measures are taken to ensure the normal and safe use of machinery and equipment, and the prevention of construction equipment accidents is an important part of the project management of each construction unit. This ensures the safety of the construction personnel and ensures the smooth completion of the project. The realization of performance benefits is of great significance. Materials are the material basis of an engineering project and an integral part of an engineering project entity. Qualified materials are the premise and basis for ensuring the quality of engineering construction. To standardize the quality management of raw materials, the quality of the project should be controlled from the source to prevent the use of unqualified materials in the construction of the project. Qualified materials are also an important prerequisite for ensuring the safety of construction.

3.4.1. Material safety management. The necessary material identification plates shall be provided for the materials stored on site. The stacking of materials shall be smooth and solid. There shall be no water accumulation and sufficient carrying capacity. The stacking shall be stable and prevent rolling, sliding and collapse. During the storage, handling, hoisting and construction of materials, necessary protective measures must be taken, especially the protection of pipe joints, so as to avoid material damage, rust or deterioration. In the event of improper storage or material damage, rust or deterioration during construction and installation, the damaged, corroded or deteriorated materials shall be removed from the construction site in time to prevent the occurrence of safety hazards.

3.4.2. Mechanical equipment management. In fact, due to the performance and structure of the mechanical equipment itself, it has certain technical requirements for use. Therefore, in the course of use, it is necessary to use the machinery reasonably in accordance with the regulations, give full play to the use efficiency of the machine, reduce the occurrence of wear, reduce the use cost, and prolong its service life. For the maintenance and maintenance of mechanical equipment, the relevant mechanical equipment management department should grasp the progress of each construction project and the mechanical equipment information as early as possible, and reasonably arrange the secondary maintenance work during the use of mechanical equipment to solve the good use and maintain conflicts between the two. It is necessary to actively adopt advanced technology, use computers for auxiliary management, and send professional mechanics to the construction site to carry out standard maintenance according to the process flow. On-site mechanical operators should actively cooperate and supervise.

4. Conclusion
In such a long period of the Maozhou River, with many processes and complicated construction, PowerChina Water Environment Governance Co., Ltd. firmly adheres to the PDCA idea and realizes coordinated and unified comprehensive safety management from the two levels of platform company
and project department. During the construction process, the causal analysis method is used to analyze the four factors of management, people, environment and object. This method emphasizes the control of the source of danger, so that the traditional post-testing is the key to the prevention, continuous improvement, from the control results to the control factors. Sort out the various factors affecting security issues, sort them, and launch all the staff, all the doors, and participate in the whole process. According to the analysis results, the safety management work is decomposed and integrated, so that all the personnel involved in the project have defined their responsibilities and goals, and turned the passive safety management into a conscious and active self-management behaviour and comprehensive management of the management personnel. Improve the safety management level of participants and enterprises. As a typical case of water environment management, the safety management experience of this project can provide reference for similar projects.

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