Quality and safety issues and countermeasures of major water conservancy projects in Zhejiang Province

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Abstract. Water conservancy project is an important public infrastructure project related to the national economy and people's livelihood. The quality and safety issues of major water conservancy projects are the core work for the government to strengthen the management of water conservancy project construction. Based on the inspection and re-inspection work of major water conservancy projects in Zhejiang Province between 2015 and 2019, this paper analyzes the main problems existing in major water conservancy projects, points out the engineering quality and safety problems account for a large proportion, analyzes the changing trend of engineering quality and safety problems, points out the main causes of quality and safety problems as well as the causes of non-correction, and puts forward the corresponding solutions. On this basis, the main responsible parties and problems are analyzed, which provides reference and suggestions for the relevant participating units to strengthen the quality and safety management of major water conservancy projects in the future.

1. Introduction
Water conservancy project is a government public infrastructure project related to the national economy and people's livelihood. The concept of project safety has been deeply rooted in the heart of people, prompting more and more water conservancy engineering units to realize the importance of water conservancy project management[1]. Compared to other engineering projects, water conservancy projects have the characteristics of long construction period, many personnel involved, poor construction conditions and complex technology, which have become puzzles of water conservancy project management and evaluation[2]. In the process of water conservancy project construction, project quality and safety are affected by many factors, which is not only an economic and technical problem, but also a historical, social and political problem[3]. In accordance with the requirements of the general keynote of water conservancy reform and development of "Water conservancy projects make up for shortcomings, strong supervision of water conservancy industry", it is of great significance to strengthen water conservancy project construction management, deepen government supervision, strict market access, and comprehensively standardize water conservancy project market order[4].

The construction quality and safety supervision of water conservancy projects is an important means for the government to encourage all parties involved in the construction of water conservancy projects to ensure the quality of the project in accordance with laws and regulations. Strict and detailed
supervision in accordance with the law is the work requirement of water conservancy project construction quality and safety supervision in the new period[5]. Although the quality supervision of water conservancy projects has developed rapidly and achieved certain results, it also faces many difficulties and problems. Chen[6] and Wang[7] studied the difficulties and problems existed in quality supervision of water conservancy projects, and pointed out the main four aspects: the shortage of funds, backward methods, insufficient personnel strength and unreasonable supervision mechanism, and put forward the countermeasures at the same time. The construction quality and safety of water conservancy projects in the new era requires the implementation of comprehensive and scientific supervision work, which could promote the sustainable development of water conservancy industry. In recent years, the inspection activities of water conservancy construction projects as a kind of supervision and inspection behavior have received more and more attention and recognition from relevant leaders and experts in this field [8].

On the basis of collecting and sorting out the inspection and re-inspection data of major water conservancy projects in Zhejiang Province from 2015 to 2019, the main problems existing in the inspection and re-inspection of major water conservancy projects in Zhejiang Province will be analyzed. The recommendations and countermeasures for safety management are designed to provide reference for the inspection and re-inspection activities of water conservancy projects in other provinces in China.

2. Analysis of problems after the inspection of major water conservancy projects

2.1. Trend analysis of the number of inspection problems

Figure 1 shows the statistical results of major water conservancy projects reviewed by inspections from 2015 to 2018. Except for the number of problems in the first inspection project in 2015 (9.4 per project), the average number of problems in the projects inspected in the remaining years fluctuated around a relatively low level (2.4, 4.1 and 4.2 per year of 2016-2018 respectively), indicating that the inspection has strengthened the management awareness of water conservancy projects to a certain extent, and has played a certain role in promoting water conservancy project management. According to Figure 1, the number problems in 2015 was the largest, reaching 188, of which the number of project quality and safety problems was 55, accounting for 29.3%; in 2016, the number of problems reduced to 121, but the project quality and safety problem numbers were still 53, accounting for the largest proportion in recent years, reaching 43.8%; the number of issues in 2017 is basically the same as 2016, which was 135, and the number of quality and safety issues was 54, accounting for 40.0%; in 2018, there were only 22 inspection projects, and 92 problems were discovered, of which 37 were quality and safety problems, accounting for 40.2%. It can be seen from Figure 1 that although the number of problems found by the inspections after 2015 was relatively small, the proportion of quality and safety issues among the problems did not drop significantly. Instead, it rose to a peak of 43.8% during the inspections in 2016. It shows that the problem of project quality and safety is still serious and needs to be paid attention to. Follow-up analysis will be carried out specifically for this aspect.
Figure 1. Overview of inspection problems of major water conservancy projects in Zhejiang Province from 2015-2018

2.2. Trend analysis of the rectification of inspection problems
After re-inspection, the overall rectification rate of the problems found by the inspection is shown in Figure 2. It can be seen from Figure 2 that the rectification rate of quality and safety issues is higher than the other issues, which to a certain extent shows that the participating units paid more attention to large proportion issues. In 2015, the overall rectification rate of the problems discovered by the inspection was the lowest, only 55.0%, and the corresponding quality and safety issues accounted for the lowest 29.3%; the overall rectification rate in the remaining years was above 85.0%, and the corresponding quality and safety issues accounted for the proportion are more than 40.0%. From 2015 to 2018, the overall rectification rate has shown an upward trend, and the rectification rate of quality and safety issues has been maintained at a high level, which is higher than the overall rectification rate; from 2016 to 2018, the rectification rate of construction management issues is the lowest of all issues, and lower than the overall rectification rate. This shows a certain extent that quality and safety issues are easier to rectify during inspections.

Figure 2. Rectification rate of major water conservancy projects
2.3. Analysis of the reasons why the project quality and safety issues were not rectified

The re-inspection work mainly checks the rectification of the problems found in the previous inspection. From the rectification situation, the management of the water conservancy project can be evaluated. This is also an effective supervision measure to strengthen the management of the water conservancy project. Therefore, the rectification rate is an important reference indicator for the effectiveness of water conservancy project inspection work. Table 1 lists the rectification of the project quality and safety issues found in the inspection projects from 2015 to 2018.

| Year | quality and safety issues rectified | partially rectified | unrectified | unqualified for rectification | rectification rate |
|------|------------------------------------|---------------------|-------------|-------------------------------|-------------------|
| 2015 | 55                                 | 42                  | 10          | 3                            | 76.0%             |
| 2016 | 53                                 | 46                  | 2           | 1                            | 95.8%             |
| 2017 | 54                                 | 52                  | 1           | 0                            | 96.3%             |
| 2018 | 37                                 | 35                  | 2           | 0                            | 94.6%             |

It can be seen from Table 1 that, in recent years, the rectification rate of inspected engineering quality and safety issues in major water conservancy projects has increased significantly. Some of the rectification problems in Table 1 are mainly reflected in three aspects: 1) project quality management system and behavior, 2) project quality assessment and project acceptance, and 3) project entity quality and safety. The rectification rate in 2015 was only 76.0%, which was the lowest ever. In 2016, the quality and safety issues of some rectified and unrectified projects were significantly reduced compared to 2015, but 5 issues that did not meet the conditions for rectification were added. The main reason is that, these re-inspection projects have been completed and cannot be rectified. In 2018, the completion rate of problem rectification was 94.6%, there were mainly 2 partial rectification problems, which were specifically manifested in the irregularities in quality inspection and construction inspection.

3. Project quality and safety issues newly found in the re-inspections

3.1. Analysis of new project quality and safety issues

To a certain extent, the newly added problems in the re-inspection can reflect the ability and importance of each participating unit to draw inferences about the problems found in the inspection. The re-inspection projects are divided into on-site re-inspection and data verification. The on-site re-inspection includes both a "looking back" of the previous year's inspection issues and the discovery of new issues. Usually, the projects with more serious issues found in the previous year are selected; the data verification only re-inspect the rectification materials of the previous year's inspection projects, and does not involve the discovery of new issues. Therefore, the newly added questions specifically refer to the on-site re-inspection projects. It can be seen from Figure 3 that in 2016, for the first time "looking back", there were many new problems, with an average of 5.8 per project. The number of new problems in the subsequent years remained at a low level, indicating that with the implementation of inspection and re-inspection, the construction management level of all participating units was steadily improving. The increase in 2019 compared with 2017 and 2018 was mainly due to new measures for the supervision and inspection of the construction quality and safety production of water conservancy projects released by the Ministry of Water Resources in 2019, which strengthened the intensity of reinpection of quality and safety issues, management of funds, and construction management.

Among the 10 newly discovered problems in 2017, 6 were related to engineering quality and safety, accounting for 60.0%. It is manifested by the imperfect quality assurance system of the construction unit, the unstandardized organization and management of the project quality assessment work, the
insufficient number of construction self-inspections, or the incomplete inspection parameters. Among the 22 new issues added in 2019, only 3 were engineering quality and safety issues, accounting for 14.0%. At the time of the re-inspections, the proportion of engineering quality and safety issues was lower than that of the inspections, but reached a peak of 60.0% in 2017. Among the new issues, quality and safety still need to be given high priority.

Figure 3. Newly discovered problems and engineering quality and safety problems from 2016 to 2019

3.2. Analysis of subjects responsible for newly discovered issues

The main responsible entities for the new issues are divided into project legal persons, survey and design units, construction units, supervision units, and others (detection units, objective reasons, etc.). Figure 4 summarizes the situation of the responsible entities for newly discovered issues from 2017 to 2019. Among the 22 issues in 2019, the project legal person as the responsible entity accounted for 72.7%, which is mainly reflected in the uneven quality of project legal person management and management personnel. The project legal person did not pay enough attention to the inspection. On the whole, the main responsible entities for the new problems found in 2017 and 2018 are design and construction units. Significant changes occurred in 2019, the problems of the project legal person increased significantly, the design decreased significantly, and the construction still occupies a certain amount proportion. Therefore, it is necessary to strengthen the management of the project legal person and construction unit, so as to reduce the occurrence of new problems in water conservancy projects and fundamentally improve the quality and safety of water conservancy projects.

Figure 4. Number of responsibility entities of newly discovered problems from 2017 to 2019
4. Countermeasures

Based on the comparative analysis of the statistical results and problem attributes of water conservancy project inspection and re-inspections from 2015 to 2019, the following recommendations are put forward:

1. Continue to intensify the supervision of the rectification of the inspection project. Ensure that the problems discovered by the inspection will not recur, and improve the construction management level of the project legal person and the project supervision and management unit.

2. Continue to strengthen the implementation of re-inspection projects and increase investment. Establish and improve the accountability and assessment mechanism for unrectified problems in the inspection and re-inspection.

3. Further strengthen the application of inspection and re-inspection results. Strengthen the construction management training work, and improve the construction management level and sense of responsibility of the relevant practitioners such as engineering project legal persons, supervisory units.

4. Continuously improve the professional capabilities of inspection and re-inspection experts. Carry out continuing education activities in accordance with current policies, standards and new technologies in water conservancy, keep pace with the times, organize expert training, conduct seminars and exchanges for inspection experts, and improve business capabilities.

5. Strengthen construction management training. Strengthen the training of relevant practitioners such as engineering project legal persons, supervisory units. Through the holding of training courses and symposiums, to deepen the understanding of the issues that need to be addressed in engineering construction management, and to understand the most urgent issues that need to be resolved at the grassroots level.

5. Conclusions

Based on the inspection and re-inspection work of major water conservancy projects in Zhejiang Province in recent years, this paper focuses on the analysis of water conservancy project quality and safety issues, and studies the main manifestations of project quality and safety issues and the rectification situation. The main conclusions of this article are as follows:

1. Quality and safety issues account for a larger proportion than other issues, and it is necessary to focus on strengthening the management of project quality and safety.

2. The proportion of quality and safety issues in the inspection problems has been as high as 40.0% for three consecutive years since 2016, and the corresponding rectification rate has also been above 90.0%. To a certain extent, it shows that the quality and safety issues are easier to rectify in the inspection problems. Therefore, attention should be paid to controlling the number of engineering quality and safety issues from the source.

3. The number of new problems in recent years has decreased significantly compared with 2016, and has remained at a low level, indicating that with the development of inspection and re-inspection work, the construction management level of each participating units has improved compared with previous years.

4. Among the new issues, the responsibility of the project legal person and the construction unit accounted for a relatively large proportion. It is necessary to strengthen the management of the project legal person and the construction unit to reduce the occurrence of new problems in the water conservancy project.

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