

Practice and Improvement of Quality Inspection System for Highway Engineering

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Abstract: Highway engineering construction involves numerous processes and has a long construction cycle, making it challenging to control the construction quality. The quality inspection system for highway engineering serves as an important basis for engineering quality inspection and safety management, providing clear standards and parameter ranges for engineering inspections. Therefore, the completeness of the inspection quality system directly impacts the effectiveness of engineering quality control. This paper mainly analyzes the composition of the quality inspection system for highway engineering, summarizes the current practice status of the system, and proposes optimization paths for its practical implementation, thereby providing references for the high-quality development of highway engineering.

Keywords: Quality inspection system for highway engineering; Inspection equipment; Inspection process; Practical assessment

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1. Introduction

Against the backdrop of the rapid development of China's transportation sector, the number and scale of highway engineering projects continue to expand. Meanwhile, driven by the dual forces of increasing car ownership and the vigorous development of the logistics industry, the quality standards for highway engineering have further risen. The quality inspection system for highway engineering serves as the standard basis for quality inspection, closely related to the overall quality of highway projects. However, there are still numerous shortcomings in the implementation of the quality inspection system in highway engineering construction, such as insufficient quality control awareness among construction personnel and non-standard equipment calibration, which are widespread issues. These problems subsequently reduce the regulatory and restrictive effectiveness of the quality inspection system for highway engineering ^[1]. Based on this, this article attempts to explore practical optimization paths for the quality inspection system for highway engineering by referencing the current implementation status of the system.

2. Composition of the quality inspection system for highway engineering

The quality inspection system for highway engineering is a quality specification and management system aimed at ensuring comprehensive, authentic, and reliable engineering inspections. According to the content of its specifications, it can be divided into different modules such as inspection personnel management, equipment management, process management, and supervision methods ^[2]. Firstly, inspection personnel management. Quality inspection personnel are the main entities responsible for implementing the quality inspection system and are tasked with advancing and controlling the inspection process. Therefore, the professional competence and experience of inspection personnel are closely related to the practical effectiveness of inspection work. As China's highway engineering projects gradually become more complex, encompassing not only road construction but also special engineering contents such as tunnels and bridges, quality inspection personnel need to comprehensively master professional knowledge and inspection skills related to highway construction techniques and quality standards to ensure the scientific nature of engineering quality inspections ^[3]. Secondly, inspection equipment management. In the quality inspection system for highway engineering, clear requirements are proposed for various inspection equipment, covering the entire process of inspection and management from equipment procurement to decommissioning. Thirdly, the inspection process for highway engineering is the implementation process of quality inspection. Based on specific practical processes, the quality inspection system divides it into five stages: inspection planning, sample collection, sample testing, data processing, and report generation, and sets corresponding standards for operations in each stage. Fourthly, supervision of highway engineering inspections is a fundamental guarantee for inspection quality. To ensure the objectivity and impartiality of supervision, both internal and external supervision mechanisms are stipulated. Internal supervision involves quality control of inspection work within the inspection unit, while external supervision involves supervision and inspection work conducted by superior management departments or third-party organizations. At the same time, clear punishment measures are proposed for engineering projects and responsible persons who fail supervision assessments ^[4].

3. Current implementation status of the quality inspection system for highway engineering

3.1. Mismatch between professional competence and practical operations of inspection personnel

The implementation of highway engineering inspection work relies on the operations of inspection personnel, highlighting their important role in the practical implementation of the quality inspection system. However, the current construction of the inspection personnel team for highway engineering in China is still imperfect, and the quality of the inspection personnel team needs improvement. On one hand, some experienced inspection personnel are accustomed to relying on experience to conduct inspection work and do not participate in training and learning in a timely manner, resulting in insufficient understanding of new construction techniques, materials, and inspection technologies, which seriously affects the quality of engineering inspections. On the other hand, some young inspection personnel have sufficient theoretical knowledge but limited practical experience, making it difficult for them to effectively combine theory with

practice in inspection work, thereby reducing inspection efficiency and potentially causing distortion of inspection results ^[5]. In addition, some inspection personnel have low professional ethics and do not realize the true significance of inspection work for engineering quality control, exhibiting laxity and perfunctory attitudes in their work, thereby challenging the authority of inspection work. The root cause of these problems is the mismatch between the professional competence of inspection personnel and their practical operations, which limits the implementation of the engineering quality inspection system.

3.2. Non-standard implementation methods for equipment operation, maintenance, and calibration

Highway engineering inspections rely on the assistance of inspection equipment, so the condition and accuracy of inspection equipment are crucial for ensuring inspection quality. However, there are problems with non-standard equipment operation, maintenance, and calibration in the practical application of inspection equipment. Firstly, the quality control at the procurement source of inspection equipment for highway engineering is inadequate. Due to cost considerations, inspection agencies do not choose high-quality equipment during procurement, leading to significant errors in equipment application and making it difficult to detect quality issues ^[6]. Secondly, the work of equipment operation, maintenance, and calibration is inadequate. During the operation of inspection equipment, performance and accuracy may decrease due to equipment wear and tear, requiring regular maintenance and calibration by operators. However, operators do not effectively implement equipment maintenance systems, resulting in equipment not receiving timely maintenance and operating under high loads for extended periods, which can easily create hidden dangers in equipment application and subsequently affect equipment inspection results. In addition, failure to calibrate equipment in a timely manner or inaccurate calibration before application can lead to distortion of subsequent inspection results.

3.3. Poor connection and unreasonable control nodes in the inspection process

The construction of the quality inspection system for highway engineering should ensure the standardization of the inspection process. However, problems such as unreasonable node settings and poor connection in the inspection process are widespread in current inspection work. The problems with the inspection process can be summarized as follows: Firstly, no scientific inspection plan is formulated before the inspection work begins, resulting in inspection process settings that do not meet engineering inspection requirements and easily causing issues such as repeated inspections or missed inspections. Secondly, there is insufficient linkage between engineering inspection stages. Poor communication between stages in engineering inspections can easily lead to issues such as unreasonable timing for sample collection and improper management of sample transportation and storage, affecting the performance or information verification of samples and subsequently causing significant deviations in subsequent inspection results ^[7]. Thirdly, the setting of inspection points in the inspection process is unscientific. Control in some stages of inspection work is particularly important and directly related to subsequent inspection results, such as the sample collection stage. Sample collection needs to be typical to ensure that it can represent the overall construction quality of the project. However, some collectors do not evaluate collection points during sample collection but blindly collect samples, resulting in inspection results that are detached from reality and difficult to truly reflect engineering quality.

3.4. Inadequate supervision mechanisms and implementation assessments for system operation

The practical implementation of the quality inspection system for highway engineering requires supervision and assessment mechanisms as effective constraints and fundamental guarantees for inspection work. However, some inspection agencies have insufficient awareness of inspection work, leading to inadequate implementation of supervision and assessment mechanisms. Firstly, there are gaps in the supervision mechanisms of highway engineering inspection units, resulting in a lack of effective normative guidance for inspection personnel in their work and easily leading to non-compliant operations ^[8]. At the same time, the lack of effective supervision mechanisms can create a sense of luck among some inspection personnel, leading to perfunctory behaviors such as improper attitudes and inadequate execution in their work, thereby affecting the detection and correction of engineering quality issues. Secondly, the problem of external supervision deficiencies in highway engineering inspections is severe. Currently, highway engineering inspection supervision agencies lack proactive supervision awareness and have issues such as narrow supervision scope and low inspection frequency during the supervision process, resulting in limited effectiveness of external supervision. Inadequate external supervision work not only affects the detection of quality issues but also provides opportunities for data falsification within inspection departments, thereby preventing the effective detection and elimination of engineering quality issues and creating hidden dangers for highway engineering.

4. Practical optimization paths for the quality inspection system in highway engineering

4.1. Strengthening the construction of the inspection team

In the practical optimization of the quality inspection system for highway engineering, it is essential to build upon the optimization, adjustment, and restructuring of the inspection team to solidify their execution capabilities and enhance their professional competence. Firstly, it is crucial to strengthen the control over the source of the inspection team. During the recruitment process, comprehensive consideration should be given to candidates' professional theoretical knowledge, practical operational skills, inspection experience, and personal character. Meanwhile, to ensure that the recruited talent matches the needs of the inspection organization, reduce the acclimation period for talent in their roles, and lower training costs, enterprises can establish an order-based talent cultivation system with higher vocational colleges. The inspection organization provides talent cultivation requirements, while the colleges tailor the talent pool for the organization, thereby ensuring the quality of the talent in the highway inspection industry ^[9]. Secondly, effective on-the-job training for inspection personnel should be implemented. Regular training should be conducted for existing employees in inspection units, incorporating personalized training based on the characteristics of the inspectors to precisely match the training content with their growth needs. The training should cover the latest construction techniques, materials, inspection technologies, and equipment to ensure that inspectors' capabilities keep pace with the times. Thirdly, it is essential to enhance the professional ethics of inspection personnel. Currently, there is a tendency in talent cultivation within inspection organizations to prioritize skills over ethics, leading to violations such as abuse of power for personal gain among some inspectors. Therefore, in constructing the inspection team, it is also necessary to provide ideological guidance

to enhance their sense of professional responsibility, enabling them to consciously adhere to ethical standards and ensure the objectivity and impartiality of inspection work. Additionally, an incentive mechanism can be established to externally motivate inspectors to fulfill their duties diligently, thereby fostering a culture of integrity within the inspection organization.

4.2. Standardizing the full-cycle management of inspection equipment

Inspection equipment primarily plays a supportive role in highway engineering inspections, enabling comprehensive, rapid, and precise detection of engineering quality through modern technological means, which is conducive to the timely identification of engineering hazards. However, if equipment performance deteriorates or is not calibrated in a timely manner, it can affect inspection results. Therefore, it is necessary to standardize the use and maintenance procedures for inspection equipment. Firstly, adopt a proactive approach to equipment quality control, starting with the procurement process. During equipment procurement, strictly adhere to the inspection requirements of engineering projects and screen equipment suppliers accordingly. The procurement department of the inspection unit can establish a supplier resource pool for comprehensive comparison of suppliers' credibility and qualifications and establish long-term cooperative relationships with high-quality suppliers to ensure the stability of equipment quality and cost. Secondly, inspect the specifications, range, and performance of the equipment to ensure it meets the inspection requirements of the engineering project, and conduct a re-inspection before the equipment enters the site to prevent substandard equipment from being used. Thirdly, establish a scientific equipment maintenance and calibration mechanism. Clearly define the maintenance and upkeep procedures and frequency for the equipment. Each piece of equipment should have an assigned responsible person who is in charge of daily maintenance, upkeep, and record-keeping to ensure full traceability of equipment maintenance and upkeep. Finally, for equipment calibration, establish a dedicated calibration process to provide reference for subsequent equipment users. Record the results after each calibration to assess equipment performance and condition. Additionally, equipment that cannot be calibrated should be promptly retired and replaced to avoid affecting inspection results.

4.3. Optimizing the inspection process for highway engineering

In the practical implementation of the quality inspection system for highway engineering, the control of the inspection process is particularly important. Firstly, before commencing inspection work, comprehensively review the engineering characteristics and key inspection points, and based on this, develop a comprehensive inspection plan. The inspection plan should cover inspection methods, sequence, frequency, and items to ensure that inspectors can efficiently carry out inspection work and avoid redundant or missed inspections^[10]. Simultaneously, the inspection plan should be dynamically adjustable to adapt to changes in the construction progress of the project and ensure synchronization between inspection work and the project. Secondly, ensure smooth links in the inspection process. Each stage of highway engineering inspection should have corresponding management procedures, and an effective links system should be established between stages. For example, sample collection should be precisely judged based on collection time, specifications, and area to ensure reasonable sample collection. Communication with transportation control personnel should occur before sample collection to ensure timely transportation after collection and avoid prolonged exposure affecting sample performance. Sample storage personnel should maintain contact with transportation

personnel to prepare for sample storage in advance and ensure compliance with storage environment and methods during storage.

4.4. Improving the system supervision and assessment mechanism

An effective supervision and assessment mechanism can provide a guarantee for the operation of the quality inspection system in highway engineering. Therefore, it is necessary to strengthen the improvement of the supervision and assessment mechanism. Firstly, establish a comprehensive internal supervision and assessment mechanism. The inspection organization should set up an independent supervision position directly under the highest management level of the organization to avoid supervision being influenced by other departments. A comprehensive internal supervision process should be developed to normalize internal supervision work. Any inspection issues discovered should be promptly reported, and corrective measures with deadlines should be taken to ensure that supervision effectively urges inspectors and enhances their self-management awareness. Secondly, strengthen external supervision and control. External supervision and assessment work should reasonably set supervision frequencies and adopt a combination of regular and irregular supervision methods to enhance the sense of responsibility among inspectors. Simultaneously, severe penalties should be imposed for behaviors such as tampering with inspection reports or fraud to enhance the binding force of supervision work and ensure the effectiveness of implementing the inspection system.

5. Conclusion

In summary, the original intention of constructing a quality inspection system for highway engineering is to provide a basis for engineering inspections, enabling orderly conduct of inspection work and ensuring the accuracy of inspection results. However, numerous issues persist in practical implementation, leading to inadequate inspection work, which can easily result in engineering quality defects and affect the safe operation and service life of highways. Therefore, it is necessary to further optimize the implementation paths of the engineering inspection quality system from aspects such as personnel team construction, equipment control, process optimization, and supervision and assessment to ensure the high-quality development of highway engineering construction.

Disclosure statement

The authors declare no conflict of interest.

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