Discussion on the Informatization Construction of Quality and Safety Supervision Management in Construction Projects

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Abstract: In construction engineering quality and safety supervision management practice, based on three core elements of responsibility implementation, physical inspection, accident handling at the same time combined, this paper puts forward informatization construction in improving regulatory efficiency plays an important role. The paper summarizes the overall logic and construction focus of informatization from the four main pathways include: build a unified regulatory data ecosystem, build intelligent monitoring platform for crucial links, promote regulators and enterprises, building block trading data interaction tools between credit information management module. Gradually, it introduces the use of information technology to realize digital and intelligent upgrading throughout the whole supervision process, so as to provide practical reference for solving problems like data fragmentation and lag in traditional supervision.

1. Introduction

As construction project scales and complexity expand, the traditional quality and safety supervision model characterized by manual inspections and paper records faces growing challenges including data fragmentation, imperfect risk prediction system, poor responsibility tracing ability. This issue involves the utilization of information technology to optimize re-organization and process control in the supervision chain, which is now essential for improving quality and safety in construction projects. This paper is aimed at the informatization construction of the core content of quality and safety supervision management in construction engineering, from a more detailed path to explore. The goal is to provide reference for establishing an effective, accurate and closed-loop modern supervision system and promoting the transformation of supervision mode from "after-the-fact treatment" to "prevention first and process control".

2. Content of Quality and Safety Supervision Management in Construction Engineering

2.1 Supervising the Implementation of Quality and Safety Responsibilities by All Project Parties

Need to delineate the responsibility scope of entities like Constructor, Surveyor, Designer, Contractor and Supervisor from the regulatory standpoint. Specifically, responsibility commitment letters are signed, and responsibility ledgers are established for the decomposition of quality and safety indicators to specific positions and personnel. The need for a supervision system to monitor real-time responsibility fulfillment Key points for dynamic checks include the accuracy of geological data provided by survey units, the integrity of structural safety calculations performed by design units, the conformity and acceptance process of contractors at construction sites, and whether monitoring units have implemented compliance supervision. For those who have failed in their responsibilities we must put in place interview systems, rectify orders within certain deadlines, deduct credit and so on, clarifying the duties of all parties to implement their basic roles for quality safety.

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2.2 Inspecting Physical Engineering Quality and Construction Safety Protection Conditions

In case of physical quality inspection, Concrete strength check can be done using rebound hammer method and Core drilling method. Do rebar scanning equipment check spacing of rebar and thickness of protective layer for concealed works? To avoid physical quality not meeting design specifications and acceptance standards, sampling tests for waterproof materials compatibility and the sealing condition of pipe connections should be carried out. The inspections of safety protection covers monitoring data for Deep foundation pit support structure deformation, upward spacing and ledger bar setting in high-formwork support, moment limiters and lifting machinery load limiter action effects details such as the edge protection railings height distance, scouring plank density covering. For the quality defects and safety hazards that have been identified, it is necessary to issue rectification notices, requiring the contractor to formulate targeted rectification plans and verify the results in order to eliminate potential risks of quality and safety.

2.3 Supervising the Investigation and Handling of Quality and Safety Accidents

In the event of an accident, the supervision department should take timely and decisive action, guiding the investigation team to proceed according to the "Four No's Principle" (no cause no inspection; no person responsible no handling; no rectification measures no closure; Education of relevant personnel could also not be avoided) [1]. This includes overseeing the investigation team in collecting primary documents, including but not limited to construction logs, monthly supervision reports and test reports. It shall be followed by site inspection, technical appraisal and personnel inquiries to determine the direct cause and indirect cause of the accident, clarify responsibility units and persons. Project technical requirements to ensure that the accident rectification plan is, through repeated practices of project implementation. Supervision ensures the responsible unit's completion of technical rectification and management improvements. Organizing and releasing the results of accident investigation work, as well as handling opinions, is conducive to warning and education.

3. Pathways for Informatization Construction in Quality and Safety Supervision Management of Construction Engineering

3.1 Building a Unified Data Platform for Engineering Quality and Safety Supervision

During the top-level design stage, departments like Housing and Urban-Rural Development and Emergency Management must work together to set platform construction standards. Based on the released document, the Data Standard for Construction Engineering Quality and Safety Supervision Information, formulated by relevant departments in China, a data classification system that defines 8 major categories and 32 sub-items of important information is recommended to be prepared. This includes pre-construction preparation data such as basic project information, participating unit information, quality testing data, safety inspection records and accident handling information which will help ensure unified data caliber. The next step is to integrate, for existing databases, such as government service platform and engineering approval systems, which need to be comprehensively interfaced. Historical data migration should be done using ETL (Extract-Transform–Load) tools with 95%+ of basic project information being synced automatically. Verification of qualification information of participating units must be carried out in real time, and direct verification with the National Enterprise Credit Information Publicity System will ensure the authority and completeness of data sources [2]. The functional development focus should be on core regulatory needs, specializing in the development of core modules such as project filing management module, quality and safety inspection module (including hidden danger tracking and rectification), data statistical analysis module. The inspection module should support customizable inspection forms, on-site photo uploads and rectification deadline setting. The statistics module should be charged with multi-dimensional data visualization, report generation of regional quality and SAFE trend charts and participating unit credit rankings. The platform will be piloted for 3 months by over 10 municipal supervision department, and more than 50 construction enterprises. Collect minimum 200 scalable functional optimization recommendations. Fixing system vulnerabilities based on test feedback, ultimately reaching operational standards of processing no less than 100,000 data entries daily and response times of not more than 3 seconds after a launch [3]. After product launch, this should be followed by creating an operation and maintenance team for managing the release with quarterly data security audits and annual system upgrades to ensure the product runs as intended over time.

3.2 Developing Intelligent Monitoring Systems for Critical Engineering Links

Identify high-risk critical links in construction (e.g. deep foundation pit, high-formwork support, lifting machinery, steel structure installation stage), Requirements analysis and technological selection stage Monitoring indicators for each link: Deep foundation pit monitoring support structure displacement, groundwater level, and surrounding settlement; For high-formwork supports, we need to monitor the vertical axial force of columns, ledger deflection and frame tilt. It should be based on "IoT + Edge Computing + Cloud Computing" architecture for technology selection. Sensor items shall contain displacement sensors with accuracy 0.1mm and pressure sensor error less than 1%. The transmission latency of data needs to be controlled within 500ms [4], which requires edge computing gateways to have the ability to support 5G/4G dual-mode communication. A deployment density no less than 1 sensor per 500 ㎡ should be guaranteed in lines with the hardware requirement during system development and equipment stage. Each critical link should be monitored round-the-clock, in a dual-no blind way, with no less than 3 video surveillance devices. These modules consist of data acquisition, intelligent analysis and early warning handling which should be integrated into systems software through these final methods. The intelligent analysis module should integrate risk prediction models based on machine learning, trained with more than 5,000 historical risk data sets, with a recognition accuracy rate of at least 92% for risks such as excessive displacement in deep foundation pits or the instability of uprights in high-formwork. 25. Pilot Application: During the system debugging and functional verification process, 20 different types of ongoing projects should be selected for pilot application. It is important to verify data acquisition accuracy of the sensors and responsiveness times for issuing warnings. The time from warning generation to push to the supervisor's mobile terminal is less than 1 min. It is also necessary to test the data interface capability between the system and the regulatory data platform, ensuring monitoring data can be automatically synchronized to the latter-side platform every hour, forming a complete closed loop of "device monitoring -> data analysis -> warning pushing> handling feedback" [5]. Model algorithms should be optimized based on the effects of application after the pilot, expand the scope of system application, and eventually achieve wide intelligent monitoring coverage for all critical links of a hazardous sub-project whose risk exceeds a certain scale.

3.3 Promoting Data Interchange Between Regulatory Systems and Enterprise Information Systems

Define data interchange standards and specifications. The “Interface Standard for Data Interchange between Construction Engineering Supervision and Enterprises” should be organized by regulatory authorities, explicit requirements such as data interaction format, protocol, frequency, etc. Daily construction enterprises should upload data (construction progress, quality acceptance records, etc.), supervision enterprise upload information (supervision log, standing record the next week, etc.). JSON format should be used uniformly for data, and HTTPS encryption transmission protocol should be used to standardize the process of transmitting data [6]. You should develop interface work. It is necessary to reserve a standardized data interface on the unified regulatory data platform corresponding to the three important scenarios of - data push interface, data pull interface and query interface by regulatory authorities. In addition, have the data push interface be able to support enterprises that are proactively uploading data at certain cadences. This would allow enterprise systems to provide regulatory authorities with a data pull interface through which they can pull and access the key data point after the receiving system has granted the necessary authorization for doing so. For enterprises, it is also necessary to change the system for managing projects and systems for quality and safety management by creating appropriate adaptation modules in accordance with interface standards. Large construction enterprises to complete the system amendment large, medium and small construction enterprises can hire third-party technical service agencies, complete the amendment completion rate of 100%. Should implement Data interface testing. Conduct group testing for data transmission: The integrity, accuracy, and timeliness of data transmission. Enterprises should have more than 98% consistency between uploaded data and data received by industry regulatory authorities, with a maximum data transmission delay of 30 minutes. A problem response mechanism should be established during the interface process to timely coordinate and resolve issues such as abnormal adaptation of interfaces, data format error types in a timely manner to form a " Data Interface Problem Handling Ledger" recording the type of problems, solutions and results [7]. Establishment of a data security guarantee system Some examples might be using data desensitization techniques to process sensitive enterprise information, for example, partially masking fields such as financial data and employee ID numbers. Implement security measures, such as firewalls and intrusion detection systems. Perform data security vulnerability scanning regularly and conduct a data security emergency drill on a quarterly basis to ensure protection in the process of data transmission, storage, and use to avoid dangers such as leakage and tamper. Finally, two-way data exchange is realized between the regulator system and enterprise information system, so as to promote regulatory efficiency and improve the level of enterprise management.

3.4 Establishing a Credit Information Management Module for Engineering Quality and Safety

In the process of setting credit indicators, it is necessary to establish a multi-dimensional credit evaluation indicator system based on the reality of quality and safety supervision. The indicators should include four first-level indicators—responsibility satisfaction, quality and safety inspection results, accident handling situation, and rectification implementation effectiveness—and 16 second-level indicators. Weight allocation as follow: Responsibility fulfillment (30%)+ Quality and safety inspection results (25%) + Reaction handling(25%) + Rectification effectiveness (20%) For each second-level indicator, specific scoring criteria will be established. For instance, if a construction enterprise does not conduct self-inspection as required, it deducts 3 points; if there is a general quality or safety accident, it deducts 15 points; if rectification is completed on time and the re-inspection passes successfully, it adds 2 points, ensuring that its evaluation indicators are quantifiable and operable [8]. In the phase of credit information collection, the methods of obtaining information include: automatically extracting information such as project filing, inspection records, and rectification status from the unified regulatory data platform (real-time collection), receiving industry associations, third-party testing agencies and other parties to report credit information (monthly summary), accepting public complaints and reports on credit information (verified by verification after entry into credit files), broadening channels for reliable sources of credit information. You must review the credit information collected, with a 100% pass rate required. Data not passing the review should be sent back for substantiation and enhancement. When implementing credit evaluation, the credit score of participating units shall be calculated by a weighted scoring method with full scores of 100. The credit level is divided into four grades by score: Excellent (90 points and above), Good (80-89 points), Qualified (60-79 points), and Unqualified (below 60 points) [9]. A real-time update mechanism should be established for credit information to be dynamically updated. Enterprise credit scores are dynamic and can change with every new piece of credit information. The credit tiers have to be re-assessed once every quarter. A credit repair mechanism must be instituted. Enterprises with poor credit may apply for credit repair according to law and within a limited period when they know that are no violations, thus passing through verification; after establishing their own systems of credit information management, enterprises can also make corresponding adjustments for the score obtained after repair. It maintains the dynamic and impartial of credit evaluation, guides participating units to take quality and safety management as the first consideration and promotes the overall credit level of industry.

4. Conclusion

The informatization construction of quality and safety supervision management of construction engineering is characterized by a close combination with the core regulatory needs, based on data integration, driven by intelligent technology, underpinned by data exchange keying and protected by credit management. Centralizing regulatory data management through a unified regulatory data platform The intelligent monitoring system for the critical links improves timeliness and accuracy of risk identification. Breaking information barriers are exchanging data between regulators and enterprises. The module of credit information management enhances the awareness of responsibility of participating entities.

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