Journal of World Architecture, 2026, Volume 10, Issue 4
http://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN 2208-3480

Application Research of Intelligent Technology in Bidding Management of Road, Bridge, and Tunnel Inspection Projects

Zonglin Zhou, Zhou Zhang*

China Merchants Chongqing Testing Center for Highway Engineering Co., Ltd., Chongqing 400067, China

Author to whom correspondence should be addressed.

Abstract: This study focuses on intelligent technology and investigates its application in the bidding management of road, bridge, and tunnel inspection projects. Based on the application demands and strategic framework for intelligent technology in such bidding management, the paper analyzes the key application points across four critical stages: tender preparation, bid preparation, bid opening and evaluation, and award decision and archiving. Practical implementation demonstrates that intelligent technology yields significant results in this context. With appropriate optimization, it can further enhance the level of bidding management and is expected to provide a reference for subsequent research and practice.

Keywords: Intelligent technology; Road, bridge, and tunnel inspection; Bidding; Intelligent evaluation; Intelligent decision-making

Online publication: August 31, 2026

1. Introduction

As a critical implementation guarantee for road, bridge, and tunnel inspection projects, the effectiveness of bidding management directly affects project quality and fund utilization efficiency. Under the traditional manual mode, bidding management for such projects suffers from numerous deficiencies, including inefficient bid document preparation, omissions in qualification review, difficulties in identifying bid rigging, subjective evaluation, and a lack of traceability throughout the entire process, as well as insufficient risk early-warning capabilities [1]. To address these drawbacks, this study introduces intelligent technology, systematically analyzes its application points, and verifies its effectiveness through practical implementation, aiming to provide a reference for future applications.

2. Application demands and strategic framework for intelligent technology in bidding management of road, bridge, and tunnel inspection projects

2.1. Application demands

Bidding for road, bridge, and tunnel inspection projects is characterized by strong professionalism, high qualification standards, and extremely demanding technical requirements, which distinctly differentiate it from general civil engineering tendering. Consequently, the demands for intelligent technology application are also rather specific. Under traditional manual management, oversights such as missing enterprise-specific inspection qualifications, staff certificates, and project performance records are common, making it difficult to prevent disqualification or performance fraud. The large volume of technical parameters renders the review of testing plans inefficient and prone to human error [2]. Moreover, practices such as bid rigging, collusion, and malicious low-price bidding are often covert, and the traditional post-hoc supervision model fails to detect and control them in a timely manner. To address these challenges, management must rely on intelligent technology to automatically perform compliance verification, streamline processes, enable dynamic monitoring, and support scientific evaluation and decision-making, thereby providing refined and standardized management support for the entire bidding process of road, bridge, and tunnel inspection projects.

2.2. Strategic framework

In the bidding management of road, bridge, and tunnel inspection projects, the application strategy of intelligent technology is to leverage supporting technologies such as big data, blockchain, and artificial intelligence to build an intelligent system for full-process control covering tendering, bidding, evaluation, and award decisions. During the tendering phase, intelligent document preparation and self-compliance checks are implemented; during the bidding phase, intelligent bid preparation and risk self-inspection are carried out; the evaluation phase employs AI-based intelligent identification of irregular behaviors; and the final award decision is made through an intelligent evaluation model [3]. This ensures the adaptability of the intelligent system to the entire bidding process, facilitating a scientific transformation from human-led operations to full-process digital and intelligent decision-making.

3. Basic application points of intelligent technology in bidding management of road, bridge, and tunnel inspection projects

3.1. Intelligent preparation and compliance risk control during the tender preparation phase

During the tender preparation phase, the core objective of intelligent technology is to improve the professionalism and efficiency of tender document preparation while effectively mitigating compliance risks. Therefore, management should rely on standardized databases and artificial intelligence technologies to enable standardized compilation and risk control. First, a dedicated template library for tender documents for road, bridge, and tunnel inspection projects should be established, integrating comprehensive data including regulatory provisions, industry standards, and model texts from previous similar projects. This library can then automatically match templates based on the specific project type, scale, and other actual conditions, intelligently filling in key content such as basic project overview, qualification requirements, and evaluation criteria, thereby reasonably shortening the document preparation cycle [4]. Second, an intelligent compliance

review system should be built, incorporating relevant laws, regulations, qualification standards, and risk control clauses to form a comprehensive database. On this basis, intelligent technology can be used to automatically identify various specialized items—such as evaluation indicators, inspection qualifications, and test precision calibration—automatically flag risks, and provide intelligent modification recommendations. Finally, the intelligent system classifies and archives the entire trace of the tender compilation and review process, automatically generates compliance review reports, and ensures full traceability, effectively eliminating professional loopholes and compliance risks at the source.

3.2. Intelligent preparation and self-check during the bid preparation phase

In the bidding phase, the purpose of applying intelligent technology is to conduct efficient bid compilation and comprehensive self-inspection, taking into account the characteristics of bid documents—namely, data complexity, high error rates, significant non-compliance risks, and strong professionalism [5]. In practice, management should rely on AI models adapted to the road, bridge, and tunnel inspection field, interfacing with industry technical standard databases. According to the tender requirements, the system automatically reviews key technical components such as implementation plans, testing procedures, personnel arrangements, equipment configurations, and quality assurance systems, ensuring that the specialized technical parameters of road, bridge, and tunnel inspection align with acceptance standards, and preventing issues like homogenized solutions and insufficient professionalism. Simultaneously, the intelligent system's full-dimensional self-inspection function should be used to check each responding clause of the bidding documents, automatically verifying all key materials—including enterprise qualifications, project performance, personnel certificates, and quotation sheets—so that problems such as expired qualifications, missing quote items, and inconsistent personnel information are accurately identified, and an intelligent rectification list is generated. During this process, intelligent technology can also compare the similarity between the bidding text and existing project bid documents to self-check for duplication, and evaluate quotation reasonableness based on industry big data, thereby issuing timely warnings for abnormally high or maliciously low bids. In this way, various risks can be effectively avoided, the risk of bid rejection is significantly reduced, and the bid documents become more compliant, reasonably enhancing competitiveness.

3.3. Intelligent evaluation and precise assessment during the bid opening and evaluation phase

Bid evaluation is a core link in bidding management. Introducing intelligent technology into this phase can significantly improve work efficiency, reduce subjective bias, and prevent delayed identification of bid rigging, thereby establishing a standardized evaluation system that combines machine preliminary review with expert re-evaluation for road, bridge, and tunnel inspection projects. Using intelligent systems, various tender documents can be automatically parsed and processed, converting unstructured data—such as enterprise qualifications, inspection performance, bid prices, personnel and equipment, and technical parameters—into standardized ledgers, and replacing manual verification, thus greatly enhancing the efficiency of bid-opening data organization [6]. For key quantitative indicators such as qualification grade, performance scale, equipment configuration, and quotation reasonableness, the intelligent system can apply predefined review rules to automatically score and calculate, completing the evaluation in a fully unattended mode to avoid undesirable phenomena such as favoritism or subjective deviations. For nonquantitative content

like inspection techniques and quality control plans, AI technology can employ semantic interpretation and professional comparison methods to intelligently assess the scientific soundness and completeness of the solutions, marking existing issues and weaknesses to provide a reference for subsequent expert review. Additionally, the intelligent system can dynamically monitor risks throughout the bidding process based on multiple indicators—such as bid price differences, text similarity, and IP associations—thereby comprehensively enhancing the fairness and accuracy of this process.

3.4. Intelligent decisionmaking and closedloop supervision during the award decision and archiving phase

The award decision and archiving phase is the concluding yet crucial step in the bidding management of road, bridge, and tunnel inspection projects. In this phase, intelligent technology should focus on scientific decisionmaking, fullprocess traceability, and closedloop supervision, building a comprehensive management system for the entire bidding process. Specifically, management should integrate multidimensional data—including evaluation scores, enterprise credit, historical inspection quality assessments, and past performance records—into the intelligent system, and establish an intelligent decisionmaking model. This model can compare and analyze the comprehensive strength and performance risks of shortlisted candidates, automatically generate reference reports for award decisions, and provide intelligent technical support to effectively avoid lowprice awards that might compromise inspection quality, thereby ensuring the scientific and rational nature of the final decision [7]. Simultaneously, the intelligent system should record all information from the approval and discussion processes of the award decision, ensuring the verifiability and traceability of the decisionmaking process. In contract management, the system can intelligently extract core tender and bid clauses, automatically generate a standardized contract draft for the inspection project, and perform consistency checks between tender and bid terms, enabling timely identification and early warning of risks concerning construction period, pricing, quality, and liability for breach, thereby preventing issues such as yinyang contracts or conflicting clauses. For archiving and supervision, blockchain technology can be leveraged to encrypt and store all types of documents from the entire bidding process, ensuring data immutability and supporting fullprocess traceability, so that subsequent audit verifications and dispute resolutions have reliable evidence [8]. Finally, the project data accumulated by the intelligent system can be used to build a standardized bidding database for the road, bridge, and tunnel inspection industry, providing data support for intelligent bidding management of similar future projects, thereby forming a complete closed loop for the entire management process.

4. Practical application of intelligent technology in bidding management of road, bridge, and tunnel inspection projects

4.1. Case introduction

To verify the effectiveness of the proposed application points of intelligent technology in bidding management for road, bridge, and tunnel inspection projects, this study conducted a practical application of the intelligent technology system based on the bidding process of a special inspection project for a transportation infrastructure facility. This project involved multiple provincial highways, bridges, and tunnels within the region, encompassing special disease inspections and annual routine inspections. The main inspection contents included road roughness, bridge structural bearing capacity, structural cracks, and tunnel

surrounding rock stability, among others. In practice, 42 bidding enterprises participating in this project were introduced, and evaluation indicators such as enterprise qualifications, technical solutions, performance capability, bid prices, and personnel and equipment were adopted. A localized intelligent management system was utilized to carry out intelligent management of tender compilation and review, bid selfinspection, bid evaluation assistance, early warning of bid rigging and collusion, and blockchainbased evidence storage. This approach replaced the traditional manual management model and achieved fullprocess digital and intelligent control in an unattended mode, thereby providing a practical implementation scenario for the application of intelligent technology in bidding management of road, bridge, and tunnel inspection projects.

4.2. Application effects

Under the project scenario of bidding management for road, bridge, and tunnel inspection, the practical application of the intelligent technology scheme yielded relatively significant results. Key indicators—including time spent on bid document preparation and review, accuracy of qualification and performance verification, identification rate of bid rigging/collusion and abnormal quotations, subjective deviation rate in bid evaluation, and incidence of process compliance issues—all showed marked improvement compared with the traditional manual management model. The comparison is presented in **Table 1**.

Table 1. Comparison of effects between intelligent technology and traditional manual management in the context of bidding management for road, bridge, and tunnel inspection projects

No.	Indicator	Intelligent technology	Traditional manual mode	Improvement
1	Bidding document preparation and review time (working days)	2-3	7-10	70.60%
2	Qualification and performance review accuracy (%)	99.6	82.3	21.02%
3	Identification rate of collusive bidding and abnormal quotations (%)	98.2	68.5	43.36%
4	Subjective deviation rate in bid evaluation (%)	1.5	11.2	86.61%
5	Incidence of process compliance issues (%)	1.1	9.7	88.67%

Based on the comparison of the practical application data above, it is evident that the rational application of intelligent technology has enabled reasonable optimization of bidding management for the case project of road, bridge, and tunnel inspection. It can effectively circumvent traditional issues under the manual review mode—such as oversight, subjective bias, and irregular transactions—achieving multidimensional control effects including cost reduction, efficiency enhancement, quality improvement, and safety assurance. Moreover, the entire bidding process under this model leaves traceable data footprints, which further enhances the transparency and credibility of bidding activities, creating favorable conditions for selecting the best bidder and ensuring the quality of engineering inspections.

4.3. Existing shortcomings

Despite the notable effectiveness demonstrated in the practical application of intelligent technology in this roadbridgetunnel inspection project case, certain shortcomings remain, leaving room for further improvement. First, the current intelligent technology system development is based solely on general bidding scenarios, inevitably lacking specificity in niche subdivisions such as specialpurpose testing and specialized inspections, and both the evaluation models and technical standards require further refinement [9]. Second, the intelligent bidding management system does not fully achieve data sharing with inspection qualification

databases, enterprise credit platforms, and transportation engineering inspection supervision platforms; updates to qualification, performance, and credit data cannot be synchronized in real time, which imposes certain limitations on intelligent evaluation and risk control within bidding management.

4.4. Optimization strategies

In light of the existing shortcomings in the application of intelligent technology to bidding management for road, bridge, and tunnel inspection projects, the following optimization measures can be adopted in subsequent practice. (1) Leverage the vast amount of historical project bidding data in the field of road, bridge, and tunnel inspection, classify detection scenarios into routine, emergency, and specialized types, and carry out targeted optimization of the AI evaluation models according to different scenario types, while reasonably incorporating specialized niche inspection indicators into the models, thereby comprehensively enhancing the professionalism and adaptability of the intelligent technology system [10]. (2) Build an integrated platform to enable data interoperability between the intelligent bidding management system and other relevant databases and platforms, thereby breaking down data silos among various platforms, allowing synchronized updates of enterprise qualifications, performance records, credit evaluations, and other data, and establishing a fulldimensional linkage control system for bidding risks.

5. Concluding remarks

This study focuses on the pain points in the current bidding management of road, bridge, and tunnel inspection projects and constructs a complete system for intelligent technology application throughout the entire process. The research and practical results demonstrate that, with the support of advanced intelligent technologies such as big data, blockchain, and artificial intelligence, the entire bidding process for such projects can be better managed, comprehensively addressing the shortcomings of traditional management models in terms of efficiency, quality, fairness, and supervision, and achieving efficient, standardized, and refined management for such project bidding. In future management, the intelligent evaluation models should be continuously optimized, data barriers among various platforms should be fully removed, and intelligent technology should be deeply integrated into bidding management, so as to provide intelligent technical support for both the bidding management and the overall quality improvement of road, bridge, and tunnel inspection projects.

Disclosure statement

The authors declare no conflict of interest.

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