



Construction Engineering Quality Traceability Management Method Based on Block Chain Technology

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Abstract

In the construction industry, the construction engineering quality traceability management method is affected by the occupation area and other factors, its disclosure efficiency is low, design a construction engineering quality traceability management method. According to the organization theory of the current construction management personnel, optimize the quality management mechanism of the construction project, take the construction goal as the guidance, use the blockchain technology to build an accurate control model, through the visual function of the blockchain, set up traceability management mode. Test results: The average disclosure efficiency of the construction engineering quality traceability management method in this paper and the other two construction engineering quality traceability management methods are 54.493%, 46.036% and 48.983% respectively, indicating that the application effect of the construction engineering quality traceability management method designed after the combination of block chain technology is better.

Keywords: *blockchain technology; construction quality; cad; management method; building materials; quality information;*

1. Introduction

Under the national development policy of comprehensively improving the quality and efficiency of development, the problems of unbalanced development and low quality management ability and level of construction enterprises in the construction industry are highlighted. At present, the quality management mode in the field of Construction Engineering in China is still the traditional management mode. There are still many problems in the actual implementation process. For example, there is no quality inspection before the use of building materials, resulting in unqualified materials being used in construction and quality problems. The construction unit did not cooperate with the supervision work, the work between the two stopped on the surface, and some potential quality and safety hazards were not rectified in time during the construction process. If the project construction quality control is not carried out, it will enter a vicious cycle. Most project construction

enterprises in China will face elimination. Of course, such elimination has already begun and the fittest will survive. For the quality information recorded in the construction process of the project, the management is improper, the query is inconvenient, and it is easy to be lost and tampered with. If there is a quality problem afterwards, it is difficult to trace the problem and determine the responsibility, etc. Strengthening the quality management of construction engineering and innovating the quality management mode of construction engineering are the problems to be solved at present ^[1-2]. Mainly reflected in: the quality management in the construction stage is the most critical link affecting the quality of the whole project. The construction stage is the main period for the generation of industrial value. Different from real estate developers, construction enterprises need to make more efforts in progress and cost, and construction enterprises must first do a good job in quality management. The construction stage is the main stage of building material consumption. Whether we can do a good job in material quality

management is closely related to the material cost, which directly affects the project cost [3-4]. Blockchain is actually a decentralized data storage module, which gives the maintenance right of the database to each node. Each node can see the complete data record, and no one can tamper with the data without leaving a trace. Blockchain allows information exchange between two authorized nodes directly without relying on a third party, and the normal operation of blockchain will not be disturbed by any node, even if a node crashes. Only by mastering the advanced construction technology, the management mind of the manager advancing with The Times and the theoretical knowledge of the protection level of the construction environment, can the construction level be promoted. Blockchain technology has the advantages of openness, transparency, high efficiency, low maintenance cost and clear responsibility allocation. The introduction of blockchain technology into the construction industry, with the help of blockchain decentralized storage, data can not be tampered with, transparent and traceable information and other technical characteristics, to create a new, information-based quality management means, to solve the current construction project quality management problems.

2. Construction engineering quality traceability management method based on block chain technology

2.1. Optimizing the quality management mechanism of construction projects

The quality of construction projects mainly refers to the project to meet the needs and expectations of the owners on the basis of the industry to meet the relevant standards and specifications. It mainly studies the quality of the main body of the project, such as whether the design of water supply and drainage, lighting and so on is reasonable. Project quality of construction engineering is referred to as project quality, which refers to the comprehensive characteristics of the project that meets the needs of the owner and complies with national laws, regulations, technical specifications and standards, design documents and contract provisions [5-6]. Engineering project quality management is to command and control the coordinated activities of the organization in the quality aspect of engineering project. Among them, product quality, power distribution, building mechanical and electrical engineering, decoration and so on all belong to the category of engineering quality. Project quality control can be divided into several specific control contents according to the construction process, project composition, project function and use value. The purpose of construction engineering quality management is to provide quality engineering and service for project users (customers, project

stakeholders). Construction project quality management is divided into construction unit quality management, design unit quality management, supervision unit quality management, construction unit quality management and supplier unit quality management [7-9]. In the process of construction projects, quality is constantly completed with the progress of construction. Therefore, quality control should run through every stage and every small project to ensure that the overall quality of the whole construction product meets the standard requirements, as shown in Figure 1:

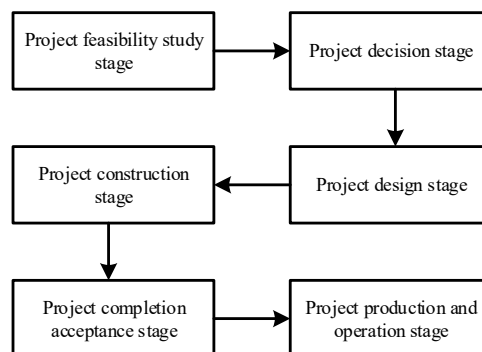


Fig. 1 Schematic diagram of quality management stage of engineering project

As can be seen from Figure 1, the quality management stages of engineering projects include: project feasibility study stage, project decision-making stage, project construction stage, project completion acceptance stage and project production and operation stage. The construction unit manages the other three major participants in the project - the design unit, the supervision unit and the construction unit. The 2D CAD drawings designed by the design unit are transferred to the construction unit and supervision unit, and the drawings are fed back to the construction unit. At this time, the 2D CAD drawings are the basis of construction, as well as the two-dimensional plane model of the project. The sub-items of each part together constitute the whole project, so the quality control of the project should be gradually carried out according to the construction process and construction stage to avoid omissions. Therefore, in engineering project quality control usually need to be subdivided into process quality and division, sub-item quality. The construction unit and the supervision unit will check the quality of the project based on the drawings, while the construction unit will carry out the construction based on the drawings. If the participants have any doubts about the details in the drawings, the design unit will be required to give a reasonable explanation, otherwise the drawings will need to be changed. According to the current organizational theory of construction management personnel, there are three organizational modes, namely functional, linear and matrix. In the process of engineering quality control, the quality of engineering project can also be reflected through its

function and value, and the rationality and economy of the project can be reflected through good construction process, reasonable control mode and good coordination. There are three basic principles of quality management: PDCA cycle principle, three-stage quality management principle and total quality management theory. The organization and rationale together determine the quality objectives and quality management plan. In the construction phase, the four parties need to check the quality regularly and propose solutions to quality problems. Finally, the construction and supervision unit can accept the project that passes the quality inspection. This requires the procurement of building materials on the control must be particularly strict. Based on the above description, complete the steps to optimize the construction quality management mechanism.

2.2. Blockchain technology builds precise control model

Blockchain has four core technologies: distributed storage, cryptographic function, consensus mechanism and smart contract, which respectively ensure the data storage, security, processing and application of blockchain [10]. The data layer encapsulates the underlying block structure and chain structure, including asymmetric encryption, digital signature, timestamp, Merkle Tree, hash function and other technologies. Generally speaking, data storage can be divided into centralized storage and distributed storage. Distributed storage means that data in the management method is stored jointly by all nodes in the management method, that is, each node is a database. Nodes do not need to access the third-party central server to obtain data, which ensures the credibility and accuracy of information acquisition. It is these technologies that form the foundation of blockchains that are tamper-proof and traceable. Combined with the principle of block chain technology, a few abstract factors are used to describe multiple influencing factors, that is, the influence factors with strong correlation are first classified into a class by mathematical model, and their commonality is found, which is used to describe this kind of influence factors. The expression formula is:

$$L = \begin{bmatrix} l_{11} & l_{12} & \cdots & l_{1p} \\ l_{21} & l_{22} & \cdots & l_{2p} \\ \cdot & \cdot & \cdot & \cdot \\ l_{q1} & l_{q2} & \cdots & l_{pq} \end{bmatrix} \quad (1)$$

In formula (1), p represents the common factor, q represents the special factor, and l represents the standardized variable with standard deviation of 1. The network layer of blockchain architecture includes P2P networking mechanism, data transmission and verification mechanism, etc. Consensus layer

encapsulates various consensus algorithms or consistency protocols among blockchain nodes. This layer is the key to ensure the correctness and consistency of data entering the chain, and is the core technology of blockchain. The next three layers are the necessary elements to build a blockchain, and the absence of any layer cannot be called a true blockchain. Construction quality information is multifarious. Food, medicine and other fields involve a lot of information from raw material procurement and wholesale, processing and production, distribution and transportation, warehouse storage to the final sale. For construction engineering, its quality management involves all the quality information of the life cycle. The product should reach the enterprise stipulated by the specific standards and requirements related to the quality, is the enterprise to the specific requirements of the quality control, to meet customer demand, is also an important index of evaluation of quality level. On this basis, the calculation method of equity function value is as follows:

$$F(\delta) = \sqrt[n]{|G - \delta| \sum_{j=1}^n \delta_j^2} \quad (2)$$

In formula (2), G represents the network data processing rate and δ represents the greed factor. When a block is successfully added to the blockchain, there needs to be a reward for the participant who contributed to the successful addition of the block. The calculation formula of reward distribution is:

$$P = \sum_{j=1}^n \frac{\varepsilon_{total}}{\varepsilon_{ij}} \quad (3)$$

In Formula (3), ε represents the reward period, and i, j represents the number of rewards in different periods. At the same time, the information amount involved in the participation of a large number of stakeholders is also very complicated. The distributed storage of block chain provides a new feasible scheme for the preservation of construction engineering quality information [11-12]. However, blockchain can realize that information can be transmitted between both parties without passing through a third party. In the construction engineering quality traceability management method based on blockchain technology, the tasks that constitute the process have a purpose. Therefore, in the stage of strategic decision-making, it is necessary to make clear the purpose of task implementation and lead the organization forward with the goal orientation, that is, to establish the target system. The decentralized network structure of blockchain is consistent with the construction engineering network structure. Construction engineering quality management takes teams of each type of work as units, sharing construction material information, logical relationship of

process cohesion, and service time of engineering equipment, forming a dynamic social network, while blockchain itself is a decentralized point-to-point network^[13-14]. Select a group of coprime integers in the control center at the bottom of the block chain to generate the shared sub-secret, which is expressed as follows:

$$D_m = \frac{(T_m + Q_m)^2}{2} \bmod \mu^2 \quad (4)$$

In formula (4), T represents the control center, Q represents the participant, and m represents the plaintext information of the master key. On the basis of Formula (4), the expression formula of user's public key and private key is obtained:

$$A = \frac{|g_k^2 - \mu^2| - 1}{\eta} \bmod \mu^2 \quad (5)$$

$$A' = \frac{\eta}{g_k^2} \bmod \eta^2 \quad (6)$$

In formulas (5) and (6), η represents the greatest common divisor, g represents the least common multiple, and k, μ represents the selection of two randomly independent large primes. Based on this, it is required that the establishment of strategic objectives of precise project quality control should be based on the needs of the owners and the characteristics of the implementation environment, actual demand and the ability of the implementation team, including the overall strategic objectives of project quality control and the phased objectives of project quality control. Construction engineering quality control is a dynamic process, and its control system construction and organizational optimization are no exception. Every process and every document in the system is also a process of gradual optimization. Their similar network structure makes it feasible to apply blockchain technology to the quality management of construction projects, thus establishing a network of trust between the various parties involved. Intelligent contract can achieve quality management automation, intelligent contracts have automatic payments, automated trading in other fields, and in the construction industry, has been the researchers study building codes and design code can be written into a computer language for automated inspection, so smart contracts can be well applied in the construction engineering quality management. Project communication management refers to the information exchange between each implementation subject of the project in the process of task execution according to their positions, responsibilities and task needs, which is conducive to the timely change and good execution of the task. The construction unit (owner) as the investor of

the construction project, the quality of the construction will directly affect the income of the owner, and the reputation of the owner will also have an impact. Therefore, the owner needs to manage all participants directly involved in the construction project, including ensuring the qualification of subcontractors and material suppliers, managing the authority of each unit and communicating with each unit in a timely manner. Therefore, communication is the basis of decision-making and execution in engineering quality control, and it is an effective means of series communication and transmission. Managers can accurately convey the enterprise's ideas, missions, expectations and performance information to employees, and guide and lead them to achieve the goals. Obtain real-time quality information of the whole construction project, and have a complete set of construction project quality information to ensure the security and stability of blockchain. Based on this, the steps of constructing precise control model are completed.

2.3. Setting the traceability management mode

With the increasing amount of data, the application development and modeling of block chain are studied, and the double chain design model of account block chain and transaction block chain is proposed. Considering that the owners themselves may not know much about blockchain technology and have no ability to design management methods that can be applied in practice, blockchain company nodes are introduced in the construction of management methods. In execution phase, first of all need to do is to let the participants clarification work plan of action, action plan, including quality plan, schedule and cost plan and construction of concrete plans, etc., the purpose of this work is to make the quality of administrators and the operators can clear goals and requirements of various participants plan, master the standard, to regulate their own behavior, Carry out construction or quality management work in strict accordance with the established plan to ensure the realization of the quality objectives identified in the planning stage. The owner chooses the blockchain company with corresponding qualifications, and delivers the technical maintenance and underlying design tasks of the blockchain to the blockchain company. The blockchain company designs the blockchain, visualizes and manipulates it, and delivers it to the owner, and provides consulting and maintenance services when using it. Combined with the characteristics of the building form, the construction unit, namely the owner, is taken as the holder of the whole blockchain to manage each participant, and the construction unit has the right to always access the management method^[15]. After the completion of the disclosure of the plan, the next step is the actual construction work, which must be carried out in strict accordance with the formulated plan. At the same time, all participants and members of the quality

management Department of the Blockchain Technology Center should do a good job in collecting quality information for the convenience of quality management in the later stage. In the construction process, if an important construction link is encountered and multiple parties are involved, the scheme can only be implemented after blockchain simulation demonstration and consent of all parties. The owner has the following rights: add and delete users, set user rights, deploy and modify contracts, query quality information, and audit quality information. Based on the above, the basic framework of construction engineering quality traceability management mode is obtained, as shown in Figure 2:

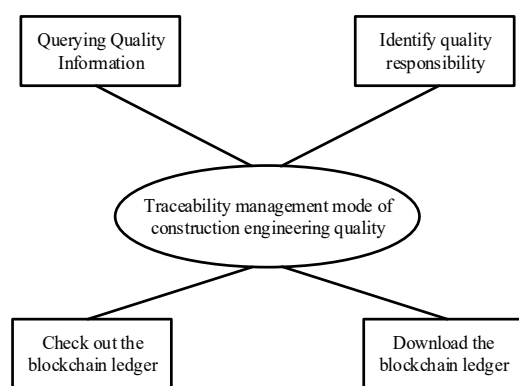


Fig. 2 Basic structure of construction engineering quality traceability management mode

As can be seen from Figure 2, the basic architecture of construction engineering quality traceability management mode includes: querying quality information, identifying quality responsibility, viewing blockchain ledger and downloading blockchain ledger. When the owner finds that the construction unit violates the production regulations, he can invoke the smart contract to execute punishment measures. In serious cases, he can kick the construction unit out of the block chain and terminate its access rights. Material suppliers are responsible for quality control of construction materials before site entry, and their operation rights include submitting relevant information of materials and certification documents such as product certificates to blockchain, and viewing and downloading material inspection results. Another major role of blockchain technology in this stage is to guide the construction. For key quality control points, operators can intuitively help them understand the design intention through blockchain's visual function when they cannot fully understand the design intention. In addition, the construction simulation, combined with blockchain technology, can clearly help the operator understand the construction steps, avoiding the operator's own experience in the construction, to ensure that the quality of work and product quality meet the plan. When all materials within the scope of its supply pass the on-site inspection, the material supplier will exit the block

chain after the supervision engineer signs and confirms. The general contractor shall be responsible for the supervision and management of the subcontractors and material suppliers, and shall be subject to the supervision of the owner and the supervisor. The main operation rights include: recording construction quality information, reviewing the quality information uploaded by subcontractors, viewing and downloading quality information, etc. Along with the advancement of engineering construction, the quality of the project will produce a lot of information, in order to later stage of quality management, all the participants at the completion of construction tasks at the same time, need quality information collection, information collection technology commonly used video imaging techniques, wi-fi technology and sensor technology, etc., when the quality information collected to a certain number, It should be submitted to the information management Department of blockchain Technology Center and uploaded to the blockchain building information model by the members of the information management Department, so as to realize the real-time update of the information model. Only owner authorized qualified subcontractors can enter block chain, owner different channels can be set according to the subcontractors, its only in this channel to contact the owner, the overall contractors and supervision, and can query and download its subcontractors contracts signed with the contractor unit within the scope of the project quality information, when after the termination of the contract, the owner can remove the block chain. By block chain building information model, construction management personnel can real-time view the overall situation of the project, such as through quantitative indicators and icon, can master the usage of material and money, etc, through 3 d roaming function, can master project details in all aspects, but also by click on the information construction in the model, understand the latest property data of building components. The supervision unit is responsible for supervising the work of the construction unit and reviewing the qualifications of subcontractors and material suppliers selected by the general contractor. Its operation rights mainly include uploading supervision records, retrieving intelligent contracts to check quality information, inquiring and downloading quality information, etc. The government units have the right to access and query the quality data of any time and project section. Based on the above description, complete the steps for setting the traceability management mode.

3. Application testing

3.1. Setting up the Test Environment

In the traceability management method of building engineering quality based on block chain technology, data is uploaded to the database for storage through

sensors and readers in the acquisition platform. The data information uploaded by the collection platform is collected from wireless sensors and electronic tags installed in transport vehicles, building materials warehouses and construction sites. The data information of building materials can be stored through the data upload interface of the storage platform. If you want to check the relevant quality information of the construction-based column after the completion of construction, or if the quality problems of the construction-based column need to be traced and determined, the construction unit, construction unit, supervision unit and government department can check the records through the quality tracing module. The traceability information of construction projects is stored in the blockchain-based database, and each participating node can make a corresponding query according to the traceability source code of construction projects through intelligent devices. Software tools: Autodesk Revit, Autodesk Navisworks, Magicad, Autodesk AutoCAD, Mount Olive, Autodesk 3D MAX, Lumion, Fuzor; Software platform: Glodon BIMSD, Glodon GCL; Hardware: tower workstation mobile workstation mobile terminal.

3.2. Test result

In order to test the practical application effect of the design and construction engineering quality traceability management method, the practical application test is carried out. The construction engineering quality traceability management method based on RFID technology and the construction engineering quality traceability management method based on process traction theory are selected to compare with the construction engineering quality traceability management method in this paper. Test the disclosure efficiency of the three methods under different floor areas. The test results are shown in Figure 3-4:

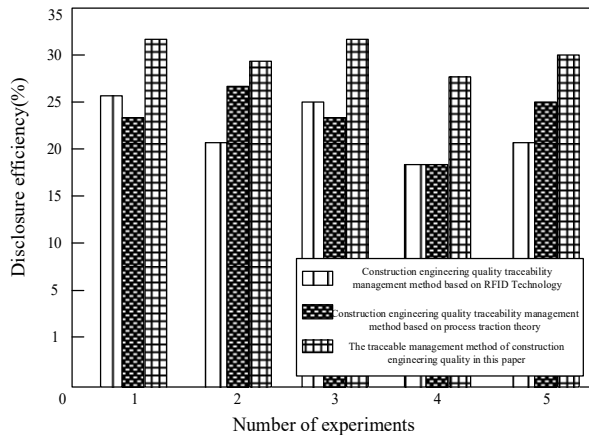


Fig. 3 Handover efficiency of an area of 20,000 m²(%)

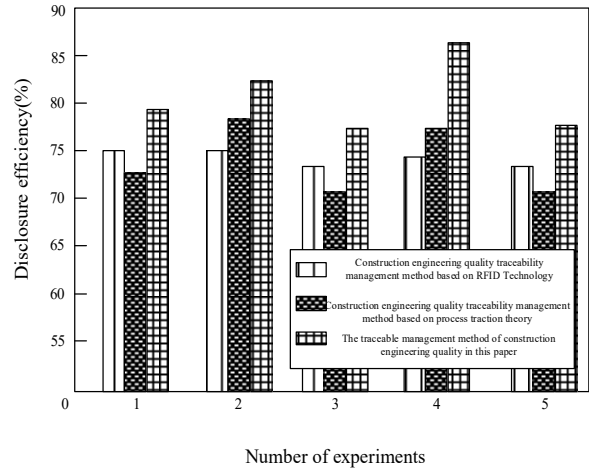


Fig. 4 Handover efficiency of an area of 80,000 m²(%)

As can be seen from Figure 3, the average disclosure efficiency of the construction engineering quality traceability management method in this paper and the other two construction engineering quality traceability management methods are 27.648%, 19.553% and 23.812% respectively. Figure 4 shows that the average disclosure efficiency of the construction engineering quality traceability management method in this paper and the other two construction engineering quality traceability management methods are 81.337%, 72.518% and 74.153% respectively.

4. Conclusion

Based on the analysis of the status quo of quality management of construction engineering, the block chain technology is innovatively introduced by referring to the cases of quality management of other industries using block chain. The requirements of quality management of construction projects are clearly put forward, and the close relationship between different stages and links of construction projects is analyzed. Through the analysis of the technical characteristics of block chain combined with the shortcomings of the current quality management work, the feasibility and advantages of the application of block chain in construction engineering quality management are clarified. Then research and analysis of the construction project quality management participants' responsibilities and work content, determine the strength of the construction project components. The future research direction needs to expand the research scope to the whole life cycle of construction engineering and put forward more perfect management methods on the basis of existing research.

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