Blockchain-Based BIM Digital Project Management Mechanism Research

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ABSTRACT The construction industry lacks a comprehensive and overall scheme for the use and management of building information modeling (BIM) in the whole building life cycle, especially the use of BIM technology for asset management and facility management. However, there is little understanding and implementation of enterprise BIM. BIM influences and changes the new project management mode of the whole life cycle of construction projects from design to construction. The safety, audit, responsibility and value of BIM are the forward-looking problems in current BIM, but it is difficult to realize the whole process value management based on the contribution of all parties, it is not conducive to the popularization and application of BIM. From the perspective of new technology and the whole life cycle, this paper analyzes the development and promotion of Blockchain technology to construction projects, and puts forward the fusion point of BIM and Blockchain technology: multi-user, multi-stage, multi-target data fusion and traceability mechanism; It is a consensus process model of multi-party collaboration, interest balance, non-destructive transmission of building information, responsibility traceability and customer satisfaction. It realizes the supporting framework and implementation ideas of BIM and Blockchain technology in construction projects from the aspects of design technology, construction management, material scheduling and whole life cycle construction. This paper will provide some new ideas for the whole life cycle collaborative management of digital construction.

INDEX TERMS Building information model, complex architecture, digitization, digital construction, construction management.

I. INTRODUCTION

The construction industry lacks a comprehensive and holistic way of utilizing Building Information Modeling (BIM) throughout a building's life-cycle, where the transition to Asset Management (AM) and Facility Management (FM) is particularly lacking. Enterprise BIM is an emerging, unexplored, holistic organizational concept that is designed to support and optimize business management throughout the entire life-cycles of buildings and infrastructure. However, current understanding and implementation of Enterprise BIM is rare.

In the traditional construction project, the management process of planning, design, construction, operation and other stages are independent of each other, and the interests of

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the project participants are relatively independent. In the management process, the interest game is prominent, and the information is complex and difficult to be compatible, resulting in greater information loss and duplication of work, which makes the construction and operation management more difficult. Building Information Modeling (BIM) is a new tool in the fields of engineering, architecture, and civil engineering. It uses current digital technology, 3D/4D model technology, artificial intelligence (AI) and other new technologies as the basis, to realize the construction information digital modeling between the relevant parties in the construction project, civil engineering and other projects, and the construction process of each project. These are to strengthen the accuracy and efficiency of information transmission in the project process management and to motivate and measure the responsibilities, contributions, and values of all relevant parties in the whole process of the project [1]–[4].

BIM technology takes the design, cost, construction, and management of the construction project as the basis of the model; it standardizes the equipment products, building components, and skin systems required during the construction process, and then constructs the construction project digital model of construction; it realizes the real scene and process management digitization of construction engineering through BIM simulation, guide the production and on-site installation of construction products, and promote the process of digitalization, industrialization, and industrialization of the construction process.

Blockchain technology is a security, distributed ledger technology in information security technology, digital technology, Internet technology, data processing technology. It is characterized by security, traceability, decentralization, openness. In the blockchain, each node can participate in data processing, data recording, and provide a trust mechanism for trust between nodes, which helps to realize more open Internet application scenarios and provide effective support for the value transmission of Internet databases, data applications, etc. [2]. The construction project management model is gradually changing from the traditional hierarchical to the digital security of the Internet [3]. In the blockchain technology, each node in the chain needs to perform trust evaluation, and each operation of the node will result in a change in block information; within a period, the data processing information, transaction information, transaction information recorded in the block, and the status result will form a consensus; the blockchain is composed of a series of blocks according to the time record information, transaction information, and status results, forming a long record of the status change of the entire block.

With the development and promotion of the application of blockchain technology, many current research focuses on constructing the integration mechanism of blockchain and BIM Technology, and improving the digital application of BIM construction technology through this mechanism. Therefore, this paper proposes an innovative construction project management model that integrates BIM and blockchain technology. This model is in line with the current digital development trend of the construction industry and will enhance the digitalization, intelligence, and efficiency of construction projects. It will build a scientific and reasonable mutual trust, safe and efficient coordination mechanism between related parties, enhances cooperation between all parties, reduces resource waste, and promotes the efficient completion of construction projects.

The rest of the paper is organized as follows. Section II discusses the some related work. Section III describes supporting framework for integration of Blockchain and BIM. Section IV gives the processing mechanism of Blockchain and BIM. Some management mechanism of Blockchain and BIM are provided in section V. Finally, the paper concludes in section VI.

II. RELATED WORK

The existence of a management and supervision mechanism in the construction industry project chain has effectively maintained the market's ability to allocate resources to the survival of the fittest and promoted the steady and healthy development of construction projects. The construction project is a collection of multi-user, multi-stage, and multi-target data, which involves not only cost, schedule, quality, but also health, safety, environmental protection, etc., as well as owners, designers, engineers, construction parties, and suppliers. Different interest appeals such as the evaluation of business and third-party, resulting in different information flows. A construction project is a full life cycle process. From planning, evaluation to operation and termination, a large amount of data will be generated in each life stage. These data need to be traceable and accountable during the entire life cycle of the project.

A. BIM AND BLOCKCHAIN TECHNOLOGY

In recent years, the research and application of BIM technology has gradually migrated from the front end of the project to the back end. In the early development of BIM, it was mainly used in the planning and design stage, especially in collision detection, visualization and engineering calculation [4]. Then, in order to meet the development needs of green design, BIM derived functions such as energy efficiency analysis, structural analysis, progress tracking, etc. at the same time, maintenance, repair, demolition, scrap and other factors were also considered in the study. BIM technology has characteristics including information relevance, information consistency, information completeness, 3D/4D visualization, task coordination, process simulation, construction site optimization, and graphing. For example, in the visualization of 3D models, BIM technology can improve the rationality of the design plan; through the full simulation characteristics of the construction process, it can be simulated before construction, collision detection of project design and selection of construction plans, etc.; BIM technology is The relevant parties in the construction process provide an accurate and efficient construction schedule. The effective management, safety management and precise management of the whole digital process of construction projects require the efficient integration and effective support of BIM technology and blockchain technology [5].

Blockchain technology can also build a complete and coherent set of decentralized, tamper-proof, traceable and high-trust database technologies to ensure the security of data processing and data transmission. The transparency, fairness and traceability of blockchain technology are consistent with digital integrated management of construction projects. The blockchain is formed by linking a series of data blocks, and each block is composed of block header data and block body data. In the block header data, the block header information of the previous link and the evidence data of the integrity

of the blockchain database are included [6]. The block body data contains the transaction data and related processing data records that occurred during the verified block creation process.

Blockchain technology has attracted the attention of the construction industry due to its potential in information security, information consensus mechanism, information traceability, identity authentication, access control, BIM and supply chain process traceability management. Blockchain enables different partners to maintain a trusted and shared view of data. Blockchain is only attached to the BIM data structure. According to the design, it saves the complete history of changes and has considerable potential in the establishment of a more secure digital construction field [7], [8].

Dakhli *et al.* [7] proposed that blockchain can help save 8.3% of the total cost of residential construction. Li *et al.* [8] focused on the digital transformation of the construction industry and reviewed the current technology, environment, conceptual model, etc., and discussed the application and development trend of blockchain technology in digital construction. Zhou *et al.* [9] conducted research and analysis on the evolution of blockchain technology research and discussed the main research areas including basic technology architecture, privacy and security, digital construction, and smart scene applications, especially in edge computing and encryption mechanisms. Blockchain technology based on application requirements also has shown good advantages. Sheng *et al.* [10] researched the problem of the inability to ensure quality standards in the construction industry and proposed a blockchain-based framework to manage quality information, such as smart contracts, authorization sequences, and execution processes for processing quality information.

Xue and Lu [11] proposed a new Semantic Differential Transaction (SDT) method to minimize the redundancy of BIM and blockchain integration in response to the redundancy problem caused by the integration of BIM technology and blockchain technology. Perera *et al.* [12] studied the privacy and scalability of digital assets in the construction field and discussed that their privacy and scalability are 50% fragile and require blockchain technology to be improved. The industry research reports written by Penzes [13] pay more attention to the potential value-added applications of BIM and blockchain, as well as their integration in smart contracts and quality assurance. Relevant research shows that the integration of BIM technology and blockchain technology can promote the high efficiency, high quality, and high security of the construction industry. However, in the process of digital application, the information consensus mechanism, information traceability and the whole life cycle of digital construction still need to be further improved [14].

B. BIM AND SMART CONTRACT TECHNOLOGY

''Smart contract'' is a computer protocol used to verify, simplify and enforce the performance or negotiation of contracts, or eliminate unforeseen terms in contracts [15]. Smart contract includes several transactions between verified parties; they usually vary greatly in size and complexity and are executed by computer code. Because the contract terms are implemented based on a predetermined consensus mechanism, there is no need for a traditional trusted third party. Because the contract terms are implemented based on a predetermined consensus mechanism, there is no need for a traditional trusted third party. According to McNamara and Sepasgozar [15], the transformation from human language contract to technology-based system contract will cause new confusion. These problems arise from the following characteristics of smart contracts: (1) automation, which requires that all agreements be composed of fully defined terms; (2) decentralization requires a third party to verify work performance; (3) anonymity, which reduces the dependence of the contract on the business environment in which it is used. Blockchain has not been widely used in the whole construction industry. However, through the development of BIM business application mode, some attempts to integrate blockchain and BIM have been gradually realized [15]. For example, BIMchain integrates BIM into the blockchain in the form of BIM platform plug-ins [16]. Therefore, smart contract is of great value in the automation of construction process, which traditionally depends on the multiple interactions and contributions of project participants in the decision-making process.

BIM Technology represents the application of digital building model to improve the cooperation within the project scope. Ye and König [17] have studied the automatic billing in the construction project, and put forward a method to make the contract management and payment of construction project more simple, transparent and automatic. According to the elements of construction project, the quantity of work and the construction progress, the billing mode and flow chart for checking the contract are determined. If the contract project has been accepted, the payment procedure will start automatically. Hamledari and Fischer [18] discussed the concept basis of automatic payment system design, and studied the application of intelligent contract in realizing reliable payment and independent cash flow regulation of product flow state, aiming at the limitation problem that can be solved in digital building based on block chain and distributed smart contract.

Dounas *et al.* [19] studied the limitations of collaboration and trust in the framework of decentralized architectural design, and introduced blockchain infrastructure to create new operation and business models for architectural design through project governance, extending nominal collaboration to thousands of agents, and transferring trust to infrastructure rather than architecture design team. As a basic infrastructure, blockchain has the potential to solve some problems that hinder the design and construction industry from using BIM. It can improve the contract standard format and specification, and reduce the expensive and time-consuming management process in the project; The smart contract mechanism is established among different participants of BIM, and the

corresponding trust model is developed to enhance the trust relationship between different participants; In addition, it also includes: confidentiality, source tracking, approval, non repudiation, multi-party aggregation, traceable Inter Organizational record keeping, change tracking, data ownership, etc. Navari and Ravindr [20], Nawari and Ravindran [21] presents an evaluation survey of blockchain technology and its application in the construction environment, discussed the integration mechanism of blockchain technology with the BIM process, and discussed the integration methods of distributed ledger technology in BIM working environment by strengthening network security, providing more reliable data storage, authority management, ensuring change tracking and data ownership. Hasan and Salah [22] use the key functions of blockchain and Ethereum smart contract to provide immutable and tamper proof log, responsibility and traceability solutions for the application of digital asset delivery certificate, and use the smart contract to coordinate and manage customers Automatic payment of digital currency such as all interactions and transactions between digital content providers and file servers hosting digital content.

C. BLOCKCHAIN AND DIGITAL TWINS TECHNIQUE
The rapid development of cloud computing, blockchain, storage and Internet technology has led to the birth of digital twins (DTS). DT is a digital representation of real-world physical components, products, simulations, etc. The emergence of blockchain technology can improve the concept of DTS and the application of BIM by ensuring the transparency of digital construction industry, decentralized data storage, data invariance, audit fairness and point-to-point communication. DTS helps to visualize design in 3D/4D and virtually perform testing and simulation before creating any building components, so it plays a vital role in maintaining and maintaining BIM. DTS are expected to be popular in the foreseeable future because they can be used for configuration, monitoring, workload calculation, diagnosis and prediction [23].

Hasan *et al*. [24] proposes a DTS creation process based on blockchain to ensure the security, reliability, traceability, accessibility and non variability of transactions, records and data sources. At the same time, the author also proposes a method of using smart contract to manage and track transactions initiated by participants participating in DTS creation. Liu *et al*. [25] constructed an improved provably secure elliptic curve digital signature scheme to solve the problem that the weak randomness of elliptic curve digital signature algorithm (ECDSA) in blockchain technology will lead to the attack of forging random numbers. Firstly, two parameters are introduced into the scheme, which can effectively resist the weak randomness attack of Bitcoin ECDSA; Secondly, the scheme uses the Hamming weight of Hash function instead of Hash value to sign, which avoids the inverse operation in the signing and verification stage. Li *et al*. [26] proposed a new digital forensics (DF) investigation framework based on blockchain in the environment of Internet of things and

social systems, which can provide proof of existence and privacy protection for evidence item inspection. Based on the Internet of things forensics chain (IoTFC), the framework can provide good authenticity, invariance, traceability, flexibility and distributed trust forensics investigation between evidence obligees and reviewers. The details of evidence identification, preservation, analysis and display will be recorded in the blockchain.

Godager *et al*. [27] emphasized the relevance of all parties in the construction of enterprise BIM and the importance of standard work, studied the standards for the integration of BIM and the Internet of things to deal with structured and unstructured data, and further discussed the challenges and future research needs of enterprise BIM construction. Zhang *et al*. [28] studied the mapping relationship and development process between computer aided design (CAD) building information and BIM building information, as well as the advantages and disadvantages of different summers, and discussed the important impact of BIM Technology on building information. Feng *et al*. [29] studied and tested the independent indoor positioning framework based on BIM, and discussed the automatic extraction, transformation and visualization of BIM related data for the purpose of public safety; the mechanism of importing BIM files is proposed to reduce the shortcomings of BIM's independent indoor positioning framework. The rapid application and development of BIM technology in the construction industry has effectively improved the efficiency of the construction industry, reduced errors in the construction process and improved management efficiency. However, there are still many related problems to be solved in practical application, especially the integration with new technologies such as artificial intelligence, blockchain, cloud computing and big data, so as to further improve the data security Reliability and efficiency, etc. This related application mainly depends on the development from CAD to BIM and the corresponding hardware resources such as servers.

In sum, BIM construction technology is developing continuously and blockchain has been widely used, but the problem of combining BIM construction technology with blockchain for construction design has not been well solved. First, many of the above studies have identified the importance of BIM technology in building digital information. Secondly, most of the previous work is centered on BIM or designed by relying on BIM through new plug-ins, which provides powerful functions for various construction processes and lacks the security, process tamper ability and traceability in the application process of BIM, so as to reflect the efficiency of BIM information.

In other words, for the current combined application of BIM and blockchain, in the process of BIM construction information processing, a lot of time needs to be reserved for the integration of blockchain technology, data structure and linked list structure. A new structural system needs to be specially designed and developed to better integrate BIM and blockchain, so as to

realize the better application and management of BIM technology.

III. SUPPORTING FRAMEWORK FOR INTEGRATION OF BLOCKCHAIN AND BIM

A. BUILD THE INTEGRATION MECHANISM OF BIM AND BLOCKCHAIN

The blockchain can be regarded as a blockchain list, and each block contains a set of transactions. Each block in the blockchain contains its own hash value and the hash value of the previous block (called the Parent Block). Therefore, each block is connected to its parent block, and the parent block creates a "chain" and returns to the first block. On the Internet of blockchain, due to the influence of the construction technology environment, BIM environment, and blockchain technology, it is necessary to share the information of every transaction of BIM. The integration of blockchain and BIM technology can better improve the security, integrity, and traceability of BIM. Adding a blockchain list to BIM technology helps to realize the processing and identification of BIM security, audit, supervision, etc. Figure 1 shows the structure of the integration of blockchain and BIM.
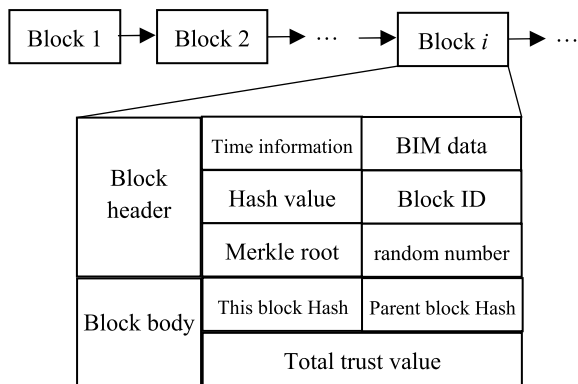

FIGURE 1. Blockchain and BIM integration structure.

In the mechanism of the integration of BIM and blockchain, the trust level can be established through decentralized autonomous organizations (DAO) and smart contracts. The trust level can be determined according to the mechanism of the integration of blockchain and BIM, which can be divided into: (1) A blockchain that runs completely in a BIM environment; (2) BIM and blockchain are integrated through a web connection; (3) BIM and blockchain are integrated through blockchain; (4) BIM runs its database completely As a decentralized blockchain.

B. SUPPORT FRAMEWORK

The supporting framework of construction project management process based on the integration of BIM technology and blockchain technology will take blockchain technology as the technical support and BIM model as the data information center of construction project. The technology supports the construction of BIM model security audit mechanism through blockchain technology, and defines the proof of work (POW) and security responsibility mechanism of construction project stakeholders. These build a safe, fair and credible workload computer system for construction projects, reduce the workload calculation, safety responsibility and many other disputes in the construction process of construction projects, enhance the multi-party collaborative trust in the process of construction projects, and effectively promote the in-depth thinking and management of construction project stakeholders from the perspective of the whole process of the project, multi-user and multi-objective.

Blockchain provides chain support for data longitudinal dimension traceability and security in digital building projects, while BIM model provides solutions for data vertical dimension information integration, digital modeling, workload proof and review in digital building projects. The supporting framework of BIM and blockchain integration provides a reference scheme for information "vertical and horizontal" management in the process of digital building projects. The establishment and implementation of the supporting framework requires the cooperation of project stakeholders, and it needs to be systematically constructed from the perspectives of blockchain technology, BIM model, management process, horizontal and vertical dimensions, from project planning to project termination, and the whole life cycle of construction projects, so as to make use of BIM technology and blockchain technology to meet the needs of all stakeholders in construction projects The whole life cycle provides accurate management. Figure 2 shows the whole process support framework of construction project based on the integration of blockchain technology and BIM.

In this supporting framework, there are mainly: First, the technical dimension, which requires the support of hardware, software, Internet, cloud computing, and other infrastructure; the second is the policy dimension, which requires laws, policies, regulations, and development strategies policy support; the third is the process dimension, which requires strong support from relevant individuals, organizations to evaluate the various roles played in the whole process of the construction project and the impact on them; the fourth is the social dimension. The influence of environmental construction and social systems is reflected in the safety of data production, storage, and utilization, and whether its application will help the implementation of construction projects to be more environmentally friendly and green. In addition, it is necessary to monitor and evaluate the overall operation process of the supporting framework based on the concept of complete digitalization and life cycle of the construction project and provide accurate services for the relevant parties of the construction project with complete digitalization and life cycle.

C. CONSTRUCTION OF THE ENGINEERING MANAGEMENT MECHANISM OF BLOCKCHAIN AND BIM

The integration of BIM and blockchain realizes the precise control of the entire process and life cycle of construction
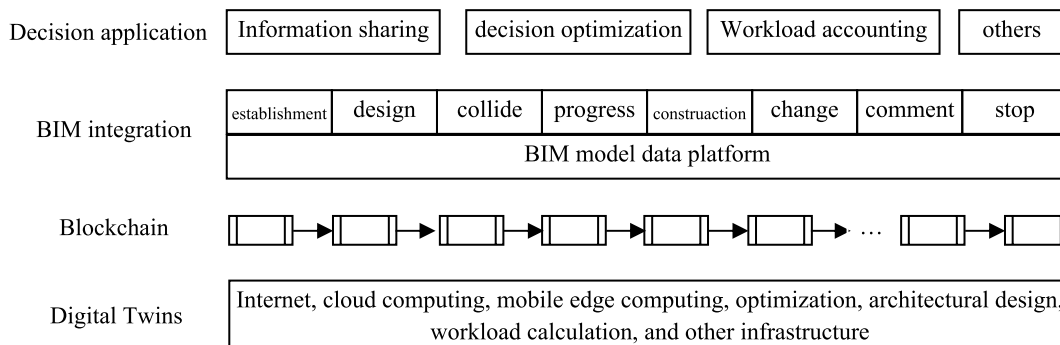
Decision application	Information sharing		decision optimization		Workload accounting		others

BIM integration	establishment	design	collide	progress	construaction	change	comment	stop
	BIM model data platform							

Blockchain	▢→▢▢→▢▢→▢▢→▢▢→▢▢→ … ▢▢→▢

Digital Twins	Internet, cloud computing, mobile edge computing, optimization, architectural design, workload calculation, and other infrastructure

FIGURE 2. Supporting framework for the whole process of digital construction projects based on the integration of blockchain technology and BIM.
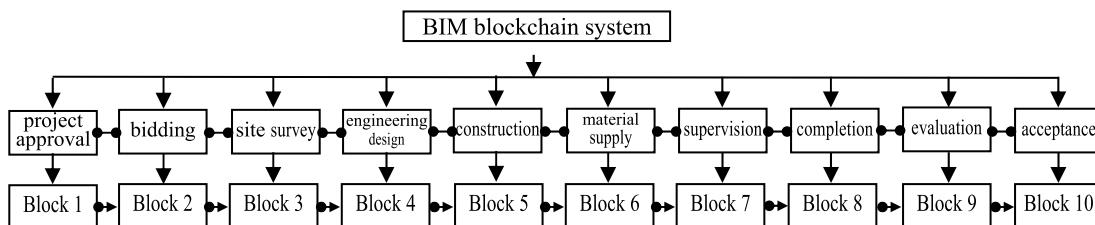

FIGURE 3. BIM blockchain project process.

projects, which reduces the design process and construction process changes, efficiency improvement, and waste reduction. Through the use of blockchain technology, the needs and responsibilities of related parties can be recorded in the BIM model, and the tracking and confirmation of related information such as the needs and responsibilities of the whole process of the project can be realized. Through the integration of blockchain and BIM, it is possible to realize the dynamic support of a series of project processes of the construction project, and to dynamically track and evaluate the achievement process and achievement degree of the project's multi-objectives. This helps to transform the traditional document-based linear stage model into a consensus framework for the whole process and life cycle of a construction project that combines multi-party BIM and blockchain.

The whole process of digital construction with the integration of BIM and blockchain can realize the management of refinement, accuracy, visualization, and plasticity. It can also fully mobilize the subjective initiative of all relevant parties, and the ability to quickly deal with and correct problems, thereby improving the overall construction project. effectiveness. If there is a problem at the construction site and the project design plan needs to be changed temporarily, the designer can promptly coordinate and communicate with the project that is not under construction through the BIM model to achieve timely resolution of the problem or related design changes. When there is a problem in the progress of the project because the blockchain is decentralized, the processing status of all relevant parties is equal, the relevant parties in the blockchain can spontaneously raise objections and discussions on the problem, and finally form a correction

plan after discussion and communication. Figure 3 shows the process of a BIM blockchain project.

Digital construction is based on the application of blockchain technology, BIM technology, and other related new technologies. It is oriented to realize the digitization, visualization, integration, systemization, and reversibility of construction project information in the management stages of engineering design, engineering construction, and engineering acceptance. In order to meet the information management needs of various parties involved in cost management during the construction phase of the project. Figure 4 shows the project management structure of the integration of blockchain and BIM.

IV. PROCESSING MECHANISM OF BLOCKCHAIN AND BIM

A. IMPLEMENTATION PROCESS

The process of using blockchain technology: (1) data management; (2) authority to participate in the project; (3) consistency of the trust of related parties; (4) trust evaluation of third-party institutions; (5) project management control; (6) Project review; (7) Third-party organization review; (8) Consensus calculation of workload.

The process of using BIM technology: (1) The parties concerned agree to accept BIM management ideas and technology; (2) Is there a BIM budget for the construction project; (3) Is the construction project complicated? (4) Is the construction and operation and maintenance cycle of the construction project long-term? Through the BIM application of construction projects, the following goals can be achieved: three-dimensional understanding of construction
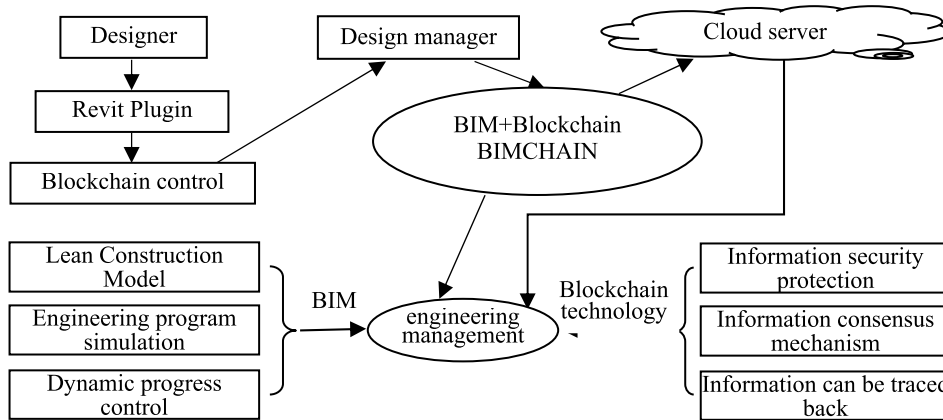
FIGURE 4. Engineering management structure of the integration of blockchain and BIM.
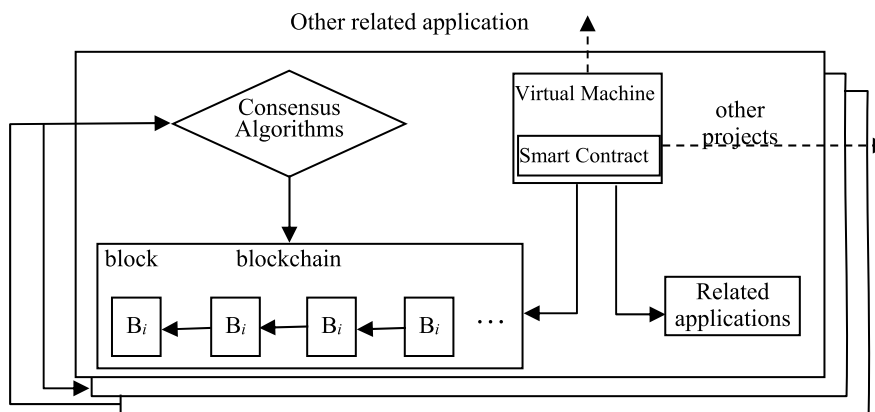

FIGURE 5. Smart contract operation mechanism.

projects, project duration control, project cost control, project quality and performance analysis, searchable task, accessible accurate design of task, construction electronic model, etc. Realizing the control of the complete BIM model can ultimately reduce the uncertainty and insecurity in the project process, improve management efficiency, and reduce waste.

When the construction project has decided to use the integration of BIM and blockchain, it is necessary to integrate BIM and blockchain into the fully digital and full-process life cycle of the construction project. (1) In terms of technology, it is transformed into cloud services, edge services, or local services according to the technical foundation and project requirements of the relevant parties. (2) In terms of policy, all parties involved in the project need to closely follow national laws, policies, regulations, and development strategies, and provide advice and suggestions for BIM and blockchain technology in standard-setting and governance plans in construction projects. (3) In the process, coordinate all relevant parties to reach a consensus, strengthen relevant personnel training, various planning and management work, and promote the in-depth integration and digitization of BIM and blockchain in construction projects through BIM and blockchain mechanisms. (4) In society, strengthen the

popularization of BIM and blockchain, and strengthen the training of related talents.

B. THE IMPROVEMENT OF BLOCKCHAIN SMART CONTRACTS TO THE CONSTRUCTION INDUSTRY

A smart contract is automatic processing without human intervention based on a program prepared in advance according to a prescribed model. The main function of BIM manager smart contract is to connect the script in BIM construction with blockchain technology. The BIM manager can specify the number of design problems and solutions in the smart contract, and keep its identity register. It further maps and sets the number of decentralized autonomous organizations of problem owners, and checks and manages agent IDS registered as problem solvers or problem owners. Then, the contract deploys a new design problem instance, publicly solves it on the blockchain, and associates the ID with the ID of the decentralized autonomous organization problem Manager/owner.

In this paper, we propose a kind of intelligent contract processing method in digital building project, which can be used in any project contract, design process, collision detection, review, project schedule design and construction. In the

digital building project, each process of the project is in accordance with the pre-agreed rules and audit mechanism, and the smart contract processing can be realized after it is unanimously approved according to the mechanism of blockchain technology. Through smart contract technology, it can avoid Party A's default on payment, improve Party B's construction quality and work enthusiasm, and ensure the smooth completion of Party A's contract project. Figure 5 shows the smart contract mechanism in digital construction projects. The B_i in the figure represents the transactions included in each block. Figure 6 shows the smart contract process in a digital building project.
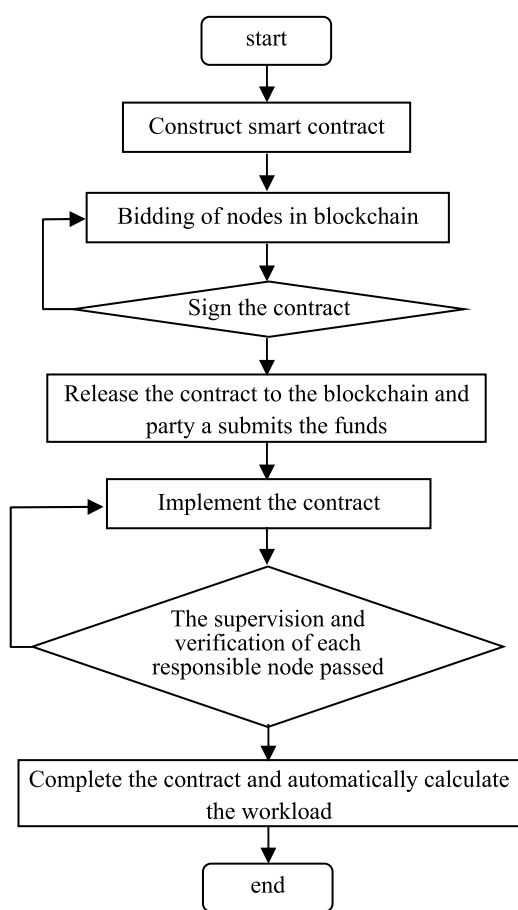

FIGURE 6. BIM blockchain smart contract process.

The advantages of the integration of BIM technology and Blockchain technology are more prominent in the design and construction stage. First of all, due to the equal status of each node in the BIM Blockchain system, when problems occur in the construction process of the project, each node can spontaneously raise objection and rectification opinions on relevant problems and responsibilities, and finally modify and improve the proposed scheme, which greatly improves the efficiency of the whole construction project; Secondly, each node in BIM Blockchain system participates in the common supervision of each construction project link, which has

the advantages of data sharing, openness and transparency, high degree of participation, convenient cooperation and exchange, and has a more positive impact on the smooth implementation of the whole project.

C. BIM's COLLISION CHECK AND REVIEW MECHANISM

The BIM information model has a better collision detection function. This function realizes the collision check and audit mechanism between BIM information models such as buildings and structures, structures and HVAC, mechanical and electrical equipment installation, and other equipment. This helps to discover various problems between the information models in advance, and timely feedback them to the design unit, construction departments, etc., and avoids the shutdown and rework problems caused by the information model problems in the later period and improves the efficiency of project design and project management. It has also laid a good foundation for on-site construction, general contracting management, and related parties.

BIM technology improves the retrieval and application of attribute information in the digital construction life cycle, and blockchain technology enhances the safety and reliability of digital construction projects. In real engineering projects, BIM information model review can expose and discover the problems in the BIM information model before the start of construction. Blockchain technology can be introduced into the BIM review mechanism to record application subjects at different stages changes in the attributes of the requirements and requirements, reduce the cost of changes and losses caused by errors, and improve the quality and efficiency of the BIM information model review work.

V. MANAGEMENT MECHANISM OF BLOCKCHAIN AND BIM

A. PROGRESS CONTROL AND DYNAMIC MANAGEMENT

BIM technology can realize 3D/4D visualization, process simulation, construction site optimization, etc. of construction engineering. It can adjust and arrange the construction site facilities, machinery, temporary buildings and personnel, optimize the site layout, and strengthen the coordination work such as construction progress control and process dynamic management of construction projects.

On the basis of the design of the BIM comprehensive information model, a 3D/4D construction site simulation map is formed by combining the general layout plan of the project construction, the site layout plan, etc., and combined with the construction schedule plan, the 4D construction site simulation process can be realized. After the collision detection finds the problem, the general construction plan can be optimized, and the 3D/4D construction site simulation can be performed again until there are no obvious construction problems and safety hazards, etc., to better guide the subsequent construction. Figure 7 shows the construction of BIM-based construction site management simulation.
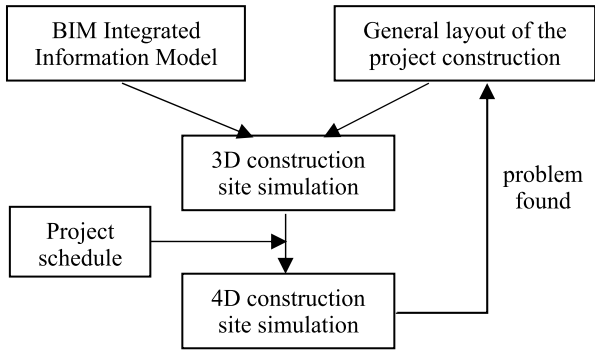
FIGURE 7. Construction site management simulation based on BIM.

B. CONSTRUCTION SUPERVISION MECHANISM

There are four key players in the digital management framework of BIM construction projects based on blockchain: owners, construction contractors, off-site factories, and logistics companies. The transmission and storage of their information are all through the blockchain, the Internet and the cloud platform, and so on. Figure 8 shows the construction process framework of the BIM construction project based on blockchain.
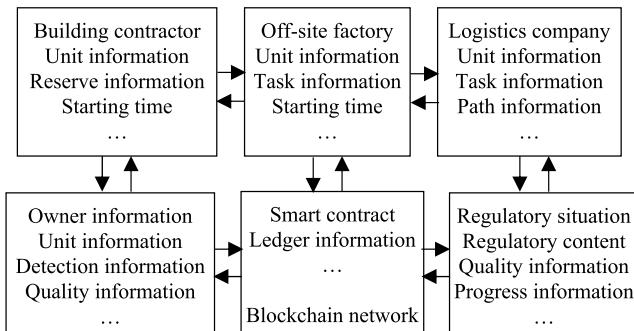

FIGURE 8. Blockchain-based digital management framework for BIM construction projects.
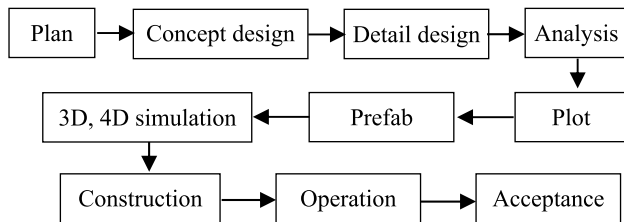

FIGURE 9. BIM construction project digital management flow chart.

C. INTEGRATED BIM MANAGEMENT MECHANISM

In a very complex project, the use of a blockchain-based digital management mechanism for BIM construction projects will make a large number of tedious calculations and construction tests in practice straightforward, and the security and review process of the BIM model will become faster.

This will save a lot of manpower and material resources in the actual environment, improve the construction schedule, and bring about a multiplier effect. Use BIM technology to display complex nodes, complex places, etc., and show the construction process in the form of animation for construction personnel to watch, which is clear, intuitive, and easier to understand. The digital management flow chart of its BIM construction project is shown in Figure 9.

VI. CONCLUSION AND DISCUSSION

In view of the current situation of difficult construction, serious waste and difficult cooperation mode in the construction industry, this paper studies the integration of building information model (BIM) and blockchain technology in construction projects, and constructs BIM digital project management and intelligent contract mechanism based on blockchain technology. BIM project integrated management platform based on blockchain has contract management, high trust, security BIM collision check, digital audit, engineering change, dynamic construction management, capital payment, workload accounting and other related task management and evaluation mechanism. On this platform, through the way of smart contract, confirm the payment path, clear the approval process, realize one click, penetrating payment, workload accounting, etc., which can play an important role in promoting data sharing, optimizing business process, reducing operating costs, improving collaborative efficiency, and building a trusted system in the process of building construction digitization, saving construction period, labor and cost. The cost of construction materials and other costs, for the construction of the whole industry chain digital produced some new thinking.

In order to build best BIM practices, interdisciplinary cooperation projects with participants in different roles need to be strengthened. Promote the application and development of BIM construction engineering through cooperative research and practice of the project and in combination with existing technologies and standards.

In addition, this study shows that the research and application of further development and use of BIM construction project digital management based on blockchain plays a key role in information security, efficiency and data sharing of BIM industry.

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