

Block Chain based Remicon Quality Management

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Abstract –

Remicon, an important material constituting the structure of a building, needs an efficient quality management system throughout the entire process from production to delivery, including production management, shipment-transport management, and delivery management, to ensure the required performance by the contractor. Nowadays Remicon factories becoming smart factories and automated form for systematic and accurate management throughout the entire process from production to delivery, including product management, manufacturing facility management, transportation management and quality management based on advanced IT technology and computerization. However, data generated from sensor technology, big data processing technology, and SCM system, which are currently applied to the Remicon factory, are managed through single server management system. A single server has a high possibility of forgery and loss of data, which makes it less reliable for quality management of Remicon.

In this study, we propose a Remicon quality management system based on the hyper-ledger fabric, a private block chain. This is a system that can digitally generate information that needs to be verified by the quality manager to secure the quality of Remicon at each stage of 'mixing-transport-delivery' and share it to all nodes participating in the block chain network to guarantee data reliability. In addition, the Dapp (distributed application) of each node has different ledger access rights. So Remicon manufacturers belonging to different channels do not share sensitive information, but contractors and government can view the status of all Remicon quality management at the construction site.

Keywords –

BlockChain; Remicon; Ready mixed concrete; Quality Management; Concrete

1 Introduction

Ready-mixed concrete (Remicon), which is composed of raw materials, is manufactured by mixing materials according to the pre-designed mixing ratio at the factory. Unconsolidated, flexible concrete, which is Remicon, transported to the construction site within a regulated time and then subjected to a quality evaluation for constructability and durability through quality tests. Remicon, an important material constituting the structure of a building, needs an efficient quality management system in all processes from production to delivery, including production management, shipment-transport management, and delivery management, to ensure the required quality. The general Remicon quality management system manages mixing ratio reports, shipment-entry times, and field test reports based on paper documents. Most of the time, documents are accumulated for a period of time and then batched together and sent to the top, which takes considerable time and energy to organize and computerize the information [1]. This conventional quality management of Remicon can cause various problems. For instance, it is very difficult to informatize the data of the Remicon because when production period, mixing ratio management is completely dependent on the factory. Therefore, the contractor cannot accurately evaluate the Remicon quality [2]. In addition, Remicon has the characteristics of 'Just in Time', so the value as a product is lost after more than 90 minutes, so the supplier must send it to the site according to the date and time requested by the orderer [3]. However, there is no way to determine whether the specified time has been observed [4]. On the other hand, the quality test information is not shared in real time due to insufficient computerization of the quality test of the Remicon. Therefore, even if the one Remicon truck is judged carrying defective product, the defective Remicon continues to produce, and the defective Remicon continuously deliver in the field [2]. Also, it is difficult to check if the quality test inspection report issued by the quality management inspection agency is forged at the construction site, and even if the test report is kept, there is no basis to judge whether the test and inspection

were done if there is no raw data. [5].

Recently, research has been conducted on how to simplify the work by automatically computerizing the quality management data produced by the Remicon to increase the efficiency of the Remicon quality management and share data in real time [1][5][6][7]. For example, a Remicon production system using an internet network, real-time Remicon delivery-transport management through a location tracking device, and a quality test management system through a mobile device. However, existing information systems are managed through a central server and use a method of storing data in a central database. Centralized servers can operate as a single point of failure (SPoF) vulnerable to security, accessibility and availability [8]. These shortcomings, like Remicon's paper invoice documents, have the potential for concealment and manipulation. In addition, when a concrete defect problem occurs, there is a risk that it is difficult to determine the responsibility of the Remicon factory and contractor [9] through artificial intervention. With this solution, a new way is needed for quality managers to figure out the quality of Remicon without skepticism about the authenticity of Remicon based on reliable quality management data.

2 Related Works

○ General Remicon quality management process

Currently, the Remicon industry is implementing quality management based on paper documents. In general, there are a large number of record registers for document management, which complicates the description and classification, and errors and loss of information occur during documentation. In addition, due to the excessive amount of documents, the documenting work through the manual of the quality

manager is burdensome, and the lack of quality management technique makes it difficult to establish history management and evidence data [6].

○ Digitalized Remicon quality management process

In order to solve these problems, large-sized Remicon companies such as Eugene, Sampyo, and Aju have recently built a service model to apply advanced technologies such as information and communication technology (ICT) and artificial intelligence (AI) to the Remicon industry.

Eugene Company has applied Air (Artificial Intelligence for the Remicon industry), a Remicon manufacturing/management system, to domestic plants. It aims to strengthen the competitiveness of autonomous production by improving production efficiency using sensor technology and optimizing logistics using AI.

Aju is building a service model applied with information and communication technologies such as machine learning, chatbots, and robot process automation. The quality manager can automatically check the aggregate usage and check the incoming and outgoing of the Remicon truck by mobile. In addition, it is possible to determine whether quantitative supply between aggregate suppliers is made by replacing paper invoices with electronic invoices.

Sampyo developed a chatbot to check the necessary information such as the Remicon shipment volume, delivery specifications, order quantity, and truck allocation interval in real time. In addition, by establishing an 'integrated operation system' that applies ICT technology, it is planning to integrate and manage individual shipments of 26 Remicon factories across the country into 5 regions.

Daewoo E&C introduced the concrete quality management mobile app 'Baroque' to all sites so that the site quality manager can digitize and track the concrete quality test work with the app. Concrete test log

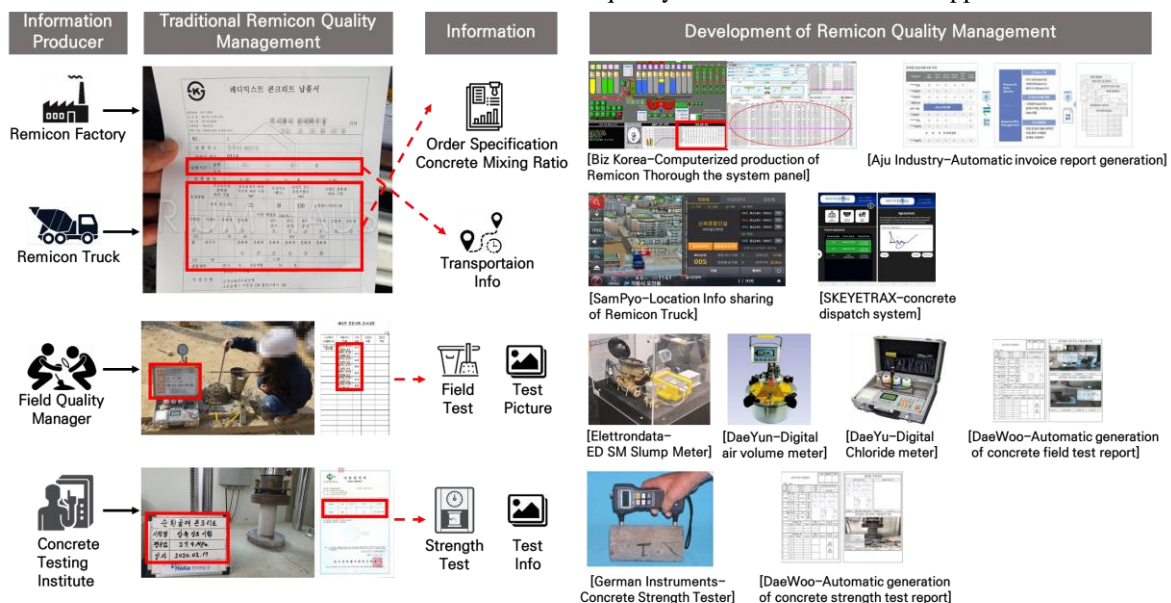


Figure 1. Remicon Quality Management Trend

includes construction site, concrete specification, concrete supplier, slump, air volume, chloride content, compressive strength of 7 and 28 days and test photo.

Biz Korea built their own Remicon quality management system to check material consumption in conjunction with panel and shipment management. In addition, it is possible to check whether the Remicon products are matched by automatically producing the shipping invoice. then, check the weighing error of the panel to manage whether it was produced according to the specifications.

○ limits of Improved Remicon quality management system

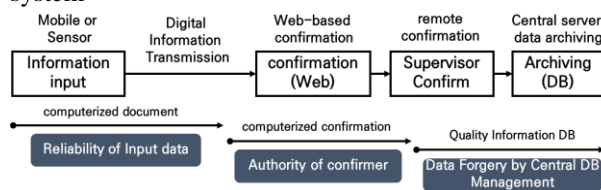


Figure 2. Limits of Improved Remicon Quality Management

Currently, Remicon's quality management is being researched by applying various technologies. It mainly deals with mixing ratio management, delivery management, and on-site quality testing to improve the efficiency of quality management that can occur during the mixing-transport-delivery process. However, the part regarding securing reliability of quality management data generated during the supply chain process of Remicon was found to be insufficient.

The management supervisory authority was keen on whether or not the quality management of Remicon has been carried out, and in April 2018, the Ministry of Trade, Industry and Energy conducted a "Survey on Eradication of Poor Remicon" to investigate whether the cement content was insufficient or the mixing ratio was manipulated. In addition, in August 2018, the Ministry of Land, Infrastructure and Transport inspected the status of quality management in 779 Remicon factory nationwide to intensively check whether the mixing ratio of Remicon materials was false, and also confirmed whether a quality test was conducted. As such, the emphasis is placed on the reliability of the quality management of Remicon.

○ Research for securing supply chain reliability

Wang, et al studied the transparency and real-time information sharing of PC quality data for each procurement step by utilizing blockchain in the PC (Precast Concrete) Supply Chain section [9].

Abeyratne, S.A conducted a study on the Ready Manufacturing supply chain using blockchain technology to strengthen the reliability of each participants and also mentioned the need to combine

blockchain technology with IT technology [10].

A Lanko researched on the efficiency of quality management of procured construction materials by introducing blockchain technology to minimize human intrusion using RFID technology in the procurement process of construction materials and to strengthen the reliability of information [11].

The Mediledger Project was developed by LinkLab and Chronicled to help manage the supply chain of medicines, including transportation of medicines that must comply with trajectory and tracking regulations [12].

N. Nizamuddin applied a blockchain technology to document management to study a system in which various stakeholders can verify and approve documents through a decentralized environment [13].

○ Theoretical considerations

Blockchain-based SCM (Supply Chain Management) is already applied to various industrial groups [14] and researched and proved that it can be sufficiently used in Remicon quality management through use-case. It is not difficult to implement an SCM system for efficient management by connecting individual quality management system at specific stages of mixing, transportation and delivery of the above-mentioned Remicon in one process [15]. Securing the reliability of quality management data using blockchain can be sufficiently approached by collecting and managing computerized data produced by the individual systems mentioned above. This prevents forgery and integrative management of data at the mixing-transport-delivery stage by integrating blockchain data storage with an existing Remicon quality management system rather than creating a new system.

3 Research Scope and Method

Blockchain technology meets the goals of this study with the advantage of sharing data using distributed ledger technology and securing the reliability of stored data. Therefore, this study intends to present a Remicon quality management system using blockchain technology.

In order to ensure the quality of Remicon, the information required by the quality manager is digitally generated and stored in the blockchain distributed ledger. Through this, the framework of the Remicon quality management system that can guarantee the reliability of data will be described.

It analyzes important quality-related data in the remicon production system using the currently developed Internet network, real-time remicon transport time management through location tracking device, and quality test management system through mobile devices.

In addition, it analyzes the data flow that distributes and stores the necessary information through the chaincode running on the blockchain.

4 BlockChain Overview

○ Blockchain

Blockchain is a distributed data storage technology. This structure ensures data integrity, reliability, and cannot be forged by disclosing and sharing transaction details to all nodes participating in the transaction in a P2P manner without keeping transaction records on a centralized server. There are two main types of blockchain. There is a type (permissionless blockchain) where anyone participates in and verifies transactions, while there is a distributed ledger system where only predetermined participants can access the network (permissioned blockchain)

	Public	Private
Access	Open read/write	Permissioned read and/or write
speed	Slower	Faster
Security	Proof-of-Work/ Proof-of-stake	Pre-approved participants
Identity	Anonymous/pseudonymous	Known identities
Asset	Native assets	Any asset

Figure 3. Difference between Public and Private Blockchain

The permissionless blockchain has the advantage that anyone can participate in transactions and verifications, but does not meet the purpose of this study in that all nodes participating in the network can view the information uploaded to the ledger. The purpose of this study is that the permissioned blockchain that allows only a predetermined participant to access the network (view data) is required in order to set the node authority so that only those concerned with Remicon quality management can access and input data [16].

○ Hyperledger Fabric

Hyperledger Fabric provides a permissioned network and security by keeping transactions confidential. In addition, it is possible to automate business processes using chaincode and verify the identity of network participants with the MSP function. Therefore, it is possible to clarify the responsibility and network configuration with reliable nodes. In addition, through the Channeling function, the ledger can be released only to authorized participants, thereby preventing indiscriminate data access.

5 BlockChain based Remicon Quality Management System

This chapter describes the development of a Remicon quality management system based on blockchain technology to increase the reliability of stored data. The developed system constructs a Permissioned-Private network using Hyperledger Fabric blockchain technology. Therefore, the important information produced at each stage of the quality management of the Remicon can be distributed and stored so that the quality manager can access the information.

○ system architecture

This system divides the chaincode function according to the type of information produced in each process of mixing-transportation-delivery and distributes the individual information on the quality management of Remicon.

The chain code consists of an insert data function

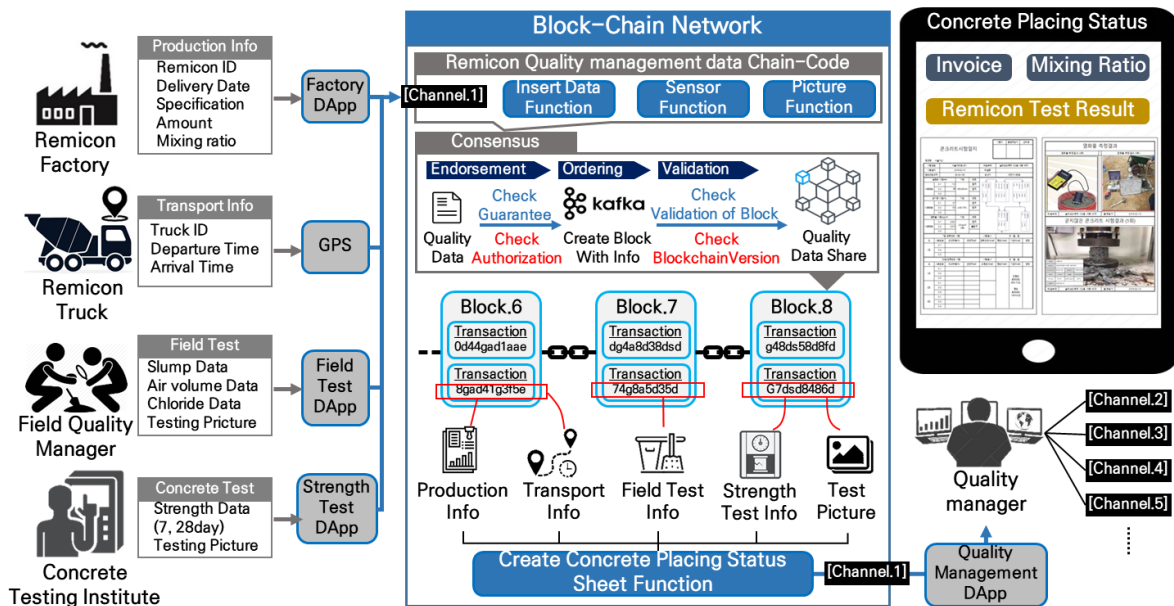


Figure 4. System Architecture

that stores the values input from the Remicon factory, a sensor function that stores GPS data of the Remicon truck and test data, and a picture function that stores pictures of the test process. It is composed of create concrete placing status sheet function for convenient reading by quality manager by reconfiguring mixing ratio information, transportation information, and test information.

Distributed client applications that operate on this blockchain-based Remicon quality management system are divided into Remicon factory, field quality managers, concrete testing institute, and quality manager according to the user's role. In order to use these applications separately for each user, Hyperledger's Membership Service Provide (MSP) function manages the necessary authority (account) to call each function of the chaincode for each user. The authorized user sends data through the application with the corresponding account. The transferred data is verified again through the process of identification and signature verification in the consensus process to verify the reliability of the data produced by the user (quality management data producer).

The Remicon quality management data of each step is called a create concrete placing status sheet function as an application for quality managers after a step of checking an account at the request of the quality manager. Therefore, the stored data is arranged in a certain form and the quality management of the Remicon is provided to the quality manager.

In addition, through the channel MSP, producers of Remicon quality management data can access the corresponding ledger, but not the data of other ledgers. For example, Remicon A factory can judge whether their Remicon has been properly delivered to the ordered site and tested, but cannot see the order history of Remicon B factory belonging to other ledgers. In this way, the quality manager can read the quality management contents of the Remicon in all ledgers, but it is designed not to share sensitive information among the Remicon factories.

○ Smart Contract architecture

The essence of the transaction is the invoking of a smart contract (chaincode), deployed into the blockchain network to enable interaction with the shared ledger.

Fig 5 illustrated the interaction flow with the chaincode. The client inputs the function name and arguments to initialize the truncation and peers access or modify the ledger via chaincode based on multiple application. Generally, two operations are involved in chaincode: the "init" and "invoke" functions. The "init" function is called when initializing or upgrading chaincode; "invoke" is used in response to transaction proposals to query or update the ledger. In this system, the "invoke" function is composed of eight specific functions: InsertDB, UpdateTransportationTime, UpdateSlump-Test, UpdateAirTest, UpdatePressureTest, Update-Picture and QueryDB.

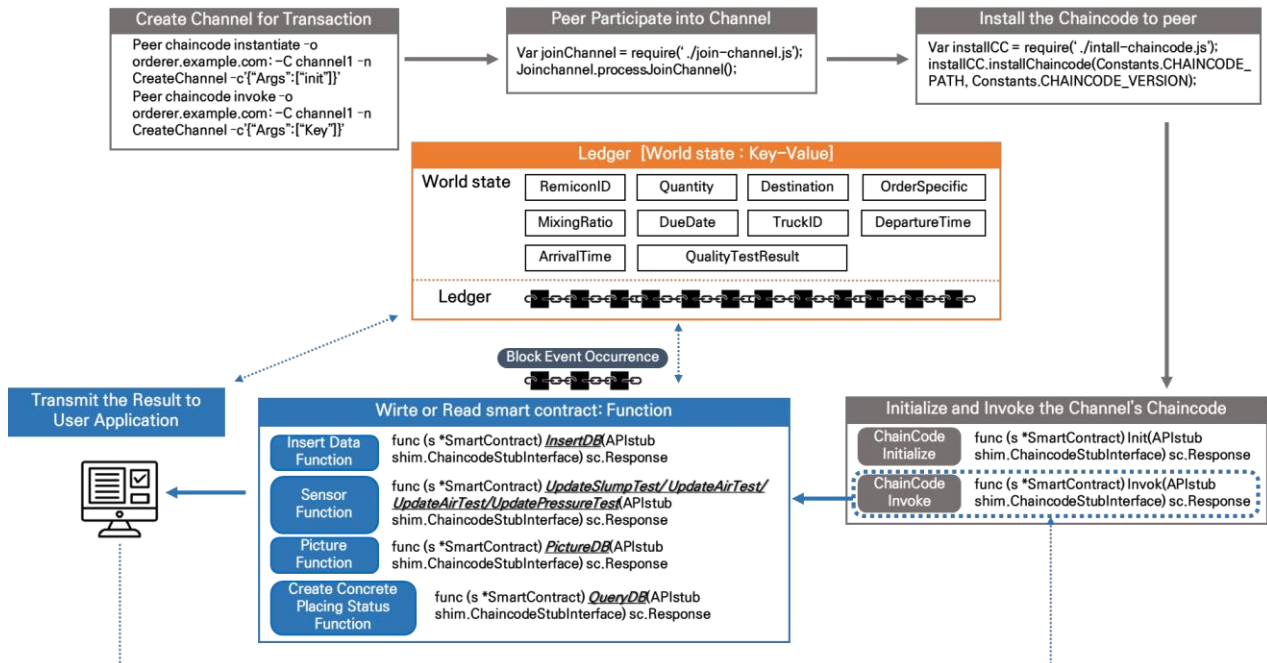


Figure 5. Architecture of Chaincode

Function Name	Invoke Authority	Explanation
InsertDB	Remicon Factory	Input the mixing ratio value into the Remicon mixing control panel
UpdateTransportationTime	Remicon Truck	Input departure and arrival times based on the GPS data of the Remicon Truck
UpdateSlumpTest	Field Quality Manager	Input sensor-based slump data
UpdateAirTest	Field Quality Manager	Input sensor-based Air Volume data
UpdateChlorideTest	Field Quality Manager	Input sensor-based Chloride data
UpdatePressureTest	Concrete Testing Institute	Input sensor-based Compressive Strength of Specimen data
UpdatePicture	Field Quality Manager/ Concrete Testing Institute	Upload the picture of while testing Remicon Quality
QueryDB	Quality Manager (Contractor/ Government/ Factory Quality Manager)	All Remicon quality data can be invoked and created in a certain form to be viewed as an application for quality manager.

Figure 6. Explanation of functions

○ Function

The functions and calling authority for storing or viewing Remicon quality management data through the client application are as follows Fig 6.

“QueryDB” function is used to obtain the Remicon quality management data and attributes value. The last seven functions are invoked when Remicon is produced, transported, and delivered, respectively.

6 Features of the Developed Remicon Quality Management System

In general, Remicon quality management checks whether the performance required by the contractor is secured on a document basis. It is difficult to judge the existence of improper quality management records that can be forged. In contrast, the developed blockchain-based Remicon quality management system used computerization and sensors as a way to minimize human intervention when storing mixing ratio reports produced at the mixing stage, compliance with time regulations during transportation, and test data after delivery. Therefore, it reduced human-error and allowed quality manager to view the reliable quality management data in real time.

○ Mixing process

Data for preparing shipping invoices are received from the Remicon panel, which is a system that automatically calculates the mix ratio of Remicon according to the order specifications of the construction company and automatically weighs raw materials. Input RemiconID, Quantity, Destination, Order-Specification, Mixing Ratio, Due date data into Remicon Invoice Info table in charge of Remicon production information in Production Process.

○ Transport process

Departure Time and Arrival Time are recorded in the Transportation Info table in charge of managing transport time information in the transport process by analyzing the GPS data attached to the Remicon.

○ Site Test process

The sensor corresponding to the test info table in charge of the Remicon quality test data put into the delivery process by receiving the slump value, air volume, and chloride content of the Remicon through sensorization of the on-site test equipment. In addition, pictures for each test are transmitted.

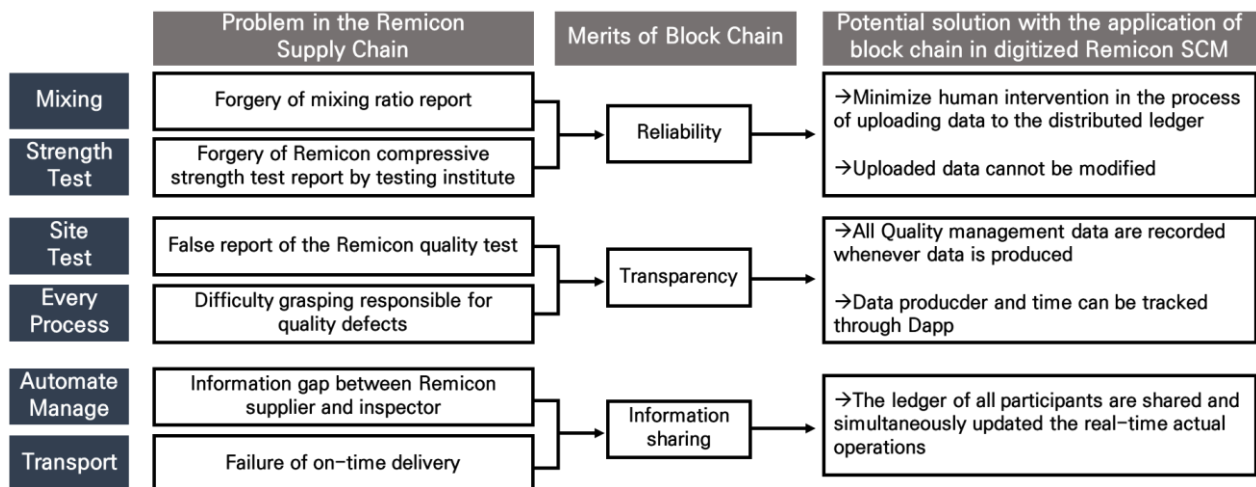


Figure 7. Advantages of System Utilizing Blockchain

○ quality test institution process

The strength of the specimen on the 7th and 28th is measured by the in-house quality testing laboratory or the external quality testing institution. After receiving the data through the strength measurement sensor, record the compressive strength of 7 and 28 days in the Test Info table in charge of the Remicon quality test data in the delivery process. Also, pictures for each test are transmitted.

○ Automation of Remicon quality management documents

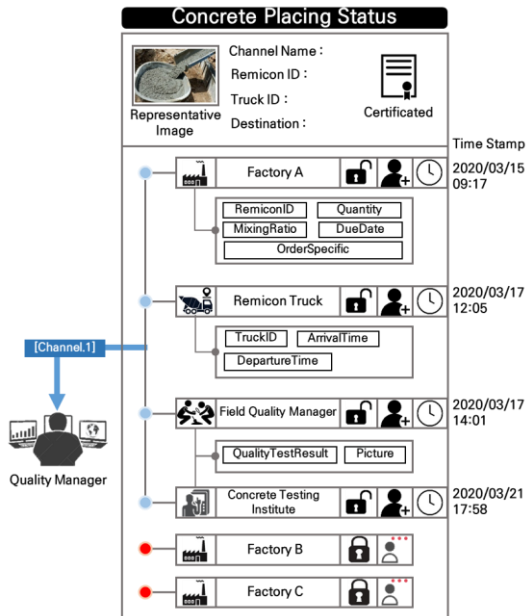


Figure 8. Data Produce Structure

The quality manager (Contractor, Government, Factory Quality Manager) can easily comprehend the status of the quality management of the Remicon by automatically filling in the digital document of the concrete placing status sheet in a certain form by calling all stored Remicon quality management data.

○ Data Base

Fig 9 show indicate what kind of data would be stored in blockchain. Remicon Invoice Info, Transportation Info, and Test Info data produced by each quality management data producer accessing the application with the corresponding account during the

Process	Remicon Invoice Info					Transportation Info			Test Info
	Remicon ID	Quantity	Destination	Order Specification	Mixing Ratio	Due Date	Truck ID	Departure Time	Quality Test Result
Production	Remicon.1	6m ³	A Jobsite	25-24-151	[W/C:34.29% , S/a:31.5% , W:6Kg , C:17.5kg , S:26.7kg , G:59.2kg , AE:175g]	2020-06-22			
Transportation	Remicon.1	6m ³	A Jobsite	25-24-152	[W/C:34.29% , S/a:31.5% , W:6Kg , C:17.5kg , S:26.7kg , G:59.2kg , AE:175g]	2020-06-22	Truck.1	2020-06-22 / 06:00	
Delivery	Remicon.1	6m ³	A Jobsite	25-24-153	[W/C:34.29% , S/a:31.5% , W:6Kg , C:17.5kg , S:26.7kg , G:59.2kg , AE:175g]	2020-06-22	Truck.1	2020-06-22 / 06:00	[Slump:25 , Air:4.7% , Chloride:0.3m ³ , Mpa(3):30 , Mpa(7):182 , Mpa(28):358MP] + Picture

Figure 9. DataBase Structure in Blockchain

quality management process are as follows. The data to be registered in the block chain is Remicon ID, quantity, Destination for Remicon, order specification from contractor, mixing ratio of Remicon, due date for delivery, Remicon truck ID, truck Departure-Arrival time, test result(slump, air, chloride, strength) and picture of test. This information is continuously recorded through a step-by-step process, and each data can know who and when stored the information and the account who generates the action. The action execution result is stored in the blockchain in the form of a transaction. By checking the transaction history, it is possible to grasp at what stage there is data forgery, and finally, to ensure the reliability of the Remicon quality management information producing. In addition, the quality manager can view reliable Remicon quality management data.

7 Conclusion

In this study, we proposed to form a trust protocol for quality management through transparent disclosure of quality management details among data producers by utilizing blockchain technology.

The proposed system can prevent the generation of false results by accessing the distributed application used by the producers of Remicon quality management data at each stage through the corresponding account. In addition, it is meaningful in that it is possible to perform the quality management of Remicon with integrity, confidentiality and reliability. This ensures transparency through the transaction history of which data is inputted and when data is stored according to the process, and makes it possible to clarify the responsibility even if a concrete defect occurs. since both the contractor and the Remicon factory can share the quality data, the factory can read the field test contents and have confidence in the quality of their product. In addition, the access rights of each blockchain network participant node's ledgers are different, so that remicon factory belonging to different channels do not share sensitive information like how much be ordered or paid, but contractors or national supervisory authorities, etc. can view the status of all remicon quality management at the construction site. it is expected that the national supervisory authority will be able to solve the problem of document forgery/falsification in the process of inspecting whether

the quality management of concrete at the site has been properly performed by reading the concrete placing status sheet of digital document based on trusted data.

In this study, in order to solve the Oracle problem (If information is posted on the blockchain, it is almost impossible to correct it, and forgery is impossible, so if incorrect information is uploaded from the beginning, the information cannot be trusted) when computerizing the Remicon quality management data produced at each stage, it was designed to minimize human intervention. This presupposes the direct transmission and reception of computerized quality management data generated from sensor technology, data processing technology, and SCM systems currently applied to the Remicon industry. In order to connect with the data transmission part of the computerized Remicon quality management system, it is necessary to open and interwork with the system API of the corresponding company, and optimization to meet compatibility is expected. In addition, due to the nature of the blockchain, all quality management data are disclosed, and sensitive concerns that each company's core technology is leaked out should be adjusted.

Acknowledgment

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