

# Internet of Things in the Quality Control of Cement Mixing Pile Construction

Yujuan Yao, Henan Technical College of Construction, China\*

## ABSTRACT

Cement mixing pile is frequently used in construction and has a great impact on the overall construction quality. This paper proposes the use of internet of things equipment in the process of cement mixing pile construction for automatic supervision, so as to achieve the purpose of overall construction quality control. This paper constructs IoT cement mixing pile construction quality control model iotcmp (internet of things cement mixing pile) based on BIM. The internet of things management and control model in this paper is implemented in the form of web. The research shows that the water-cement ratio of the cement mixing pile is 0.62 under the control of the internet of things when the cement dosage is set to fluctuate by 15%. The texture of the mixed cement product is clear, and the average compressive strength is 2.65mpa. In this case, the average number of standard penetration blows is 38. It can be seen that it is feasible to use the internet of things equipment to monitor the cement mixing pile in real time and evaluate the overall benefit.

## KEYWORDS

Cement Mixing Pile, Civil Construction, Construction Quality Control, Internet of Things Monitoring Equipment, Network Monitoring

## 1. INTRODUCTION

After decades of construction, China has basically formed a relatively perfect electromagnetic Internet of things cement mixing pile management and control system, including management system, laws and regulations system, frequency management equipment system, material rules system, etc., which has the following functions: Internet of things cement mixing pile resource planning, frequency allocation, Internet of things cement mixing pile environmental monitoring, Internet of things cement mixing pile management and control system Internet of things cement mixing pile interference analysis and coordination ability. In particular, there are many open theoretical and technical issues on the real-time and accurate reasoning of abnormal material use behavior and its intention, which are worthy of further exploration.

The existing research work mainly focuses on the time-frequency structure mining of cement mixing pile. Jiao Y proposed a time series segmentation algorithm based on sliding window approximate entropy, and then analyzed the parameters of the use mode of cement mixing pile corresponding to the time series of each segment. The algorithm can find the time when the use mode of cement mixing pile changes (Jiao, 2019). In terms of feature extraction, Yang J extracted multidimensional feature vectors from the time series of state evolution of cement mixed piles

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\*Corresponding Author

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according to the expertise of electromagnetic cement mixed piles from the characteristics of the time series itself and its physical meaning. Extensive clustering analysis of cement-mixed pile state evolution was performed based on cement-mixed pile state evolution and multidimensional feature vectors (Yang, 2020). Qiu J proposed that by analyzing the spatial-temporal characteristics, statistical characteristics, management and control department characteristics and network characteristics of cement mixing pile situation awareness data, we can obtain multidimensional structure information such as time-frequency structure, topology structure, protocol structure of cement mixing pile situation (Qiu, 2020). Bash Ba introduces the density based clustering algorithm into the extraction of spatiotemporal information by establishing the historical use model of cement mixing pile, and realizes spatiotemporal clustering analysis and spatiotemporal frequent pattern mining (Bash, 2020). Liu Z proposes a segmented modeling algorithm based on mahalanobis distance for fast detection of time-frequency structural anomalies and electromagnetic target anomalies according to the spatiotemporal periodicity of radio frequency usage (Liu, 2018). In recent years, the research of mining communication network topology from situation awareness data of cement mixing pile has also attracted scholars' attention.

Bash Ba further introduces the depth time-frequency residual network to effectively extract the characteristics of cement mixing piles in different time scales, which improves the performance of multi frequency joint prediction (Bash, 2019). Shahzad K proposed the prediction of cement mixing pile based on traditional deep learning, which not only brings considerable performance improvement but also is limited by a large number of available data and a large number of training time requirements (Shahzad, 2018). Zheng T proposed a cross band cement mixing pile prediction method based on deep transfer learning. The prediction model is trained by other frequency band cement mixing pile data with similar characteristics of cement mixing pile, which reduces the demand for training data and improves the timeliness of prediction (Zheng, 2019). Cotton SL proposed that the behavior intention of material use can be regarded as the external action performance and purpose abstracted from the data of cement mixing pile from the perspective of material use equipment, which is a deeper cognitive content compared with the situation of cement mixing pile (Cotton, 2020). Yan S pointed out that the existing research on behavior reasoning of cement mixing pile mainly focuses on reasoning and prediction of behavior evolution of cement mixing pile in time domain, frequency domain and spatial domain, but its research is limited to the state information level of cement mixing pile (Yan, 2019). However, the research results of feature extraction and knowledge discovery of cement mixing pile are independent and scattered, focusing on the discrete state perception of cement mixing pile, and the research on information acquisition of local or global situation of cement mixing pile is still relatively lacking.

This paper constructed the IOT cement mixed pile construction quality control model *iotcmp* (Internet of Things cement mixed pile) based on BIM. This model integrates IOT microdevices, connects equipment detection and detection modules based on the original cement mixed pile, connects to construction projects via 5G communication scheme, overall construction project management and control department. The Internet of Things management and control model in this white paper is implemented in the form of a web that uses a variety of data type interfaces, including Python and PHP scripts, and a functional business interface for system development.

## **2. CONTROL STRATEGY AND SIMULATION MODEL OF CEMENT MIXING PILE IN INTERNET OF THINGS**

### **2.1 Internet of Things Cement Mixing Pile Model**

The Internet of Things generally describes physical entities in a digital way, establishes holographic dynamic virtual models, and monitors, predicts, and controls the attributes, behaviors, rules and other elements of physical entities through virtual model simulation, simulation, and analysis of data

(YAO, 2020; Qi, 2021). In the early days, it was mainly used in the aerospace and military fields. In recent years, it has been applied in various stages of the life cycle of product design, manufacturing, service, operation and maintenance in many fields such as electric power, automobiles, precision instruments, and ships (Sheng, 20107). The Internet of Things technology has become a key technology to solve the interaction and integration between physical entities and data virtualization in intelligent manufacturing (Yin, 2020). The oil and gas field gradually introduces the Internet of Things technology, and through the integration of artificial intelligence, Internet of Things and other technologies, it is applied in equipment monitoring, cement mixing pile operation and maintenance, and dispatch operation (Tarver, 2019). Siemens' Smart Pumping software collects actual operating data from each pumping station, uses technologies such as the Internet of Things, artificial intelligence, and optimizes analysis in virtual equipment to achieve goals such as reducing energy consumption, reducing instantaneous pressure changes, and improving flow stability (Ding, 2018). The integration of new IT technologies such as big data meets the needs of intelligent manufacturing and cyber-physical systems (Ding, Wang, & Wu, 2020; Zhu, 2021). The Internet of Things cement mixed pile model is established based on the 5D model of the Internet of Things. As the theoretical basis for smart city construction, the components of the Internet of Things cement mixing pile model include physical cement mixing piles, Internet of things cement mixing piles, cement mixing pile service system and cement Twin data of mixing piles (Yucek, 2020). Through the real-time interaction of data and operations between the physical cement mixing pile and the Internet of Things cement mixing pile, the data integration and business integration in the whole life cycle of the cement mixing pile are improved, and the process of design, construction, operation and maintenance is realized in the physical cement mixing pile. The iterative operation of the Internet of Things cement mixing pile and cement mixing pile service system to achieve the integration of the two (Ding, 2017). The Internet of Things cement mixing pile system as a whole includes the cement mixing pile body, the cement mixing pile station, the storage and transportation medium and the surrounding environment (Sun, 2020). As the physical cement mixing pile in the cement mixing pile model of the Internet of Things, in addition to its basic oil and gas storage and transportation functions, it also needs to have the function of real-time perception, access and fusion of data. By installing various sensors, it can monitor the cement mixing pile and related equipment in real time. And the surrounding security, through the SCADA system and equipment electronic instruments to transmit voltage and other signals, while receiving the process analyzer, to achieve real-time monitoring of the construction status of cement mixing piles (Giannakis, 2018). On this basis, the real-time data of the physical cement mixing pile is uploaded to the Internet of Things cement mixing pile and cement mixing pile service system, and the data of the physical cement mixing pile is converted, cleaned and packaged, and the data of the cement mixing pile body is integrated (Laghate, 2018). In the whole life cycle of the solid cement mixing pile, the data generated at various stages are integrated, the real-time perception of the outside world is generated and an automatic response mechanism is generated, and the overall coordinated control and optimization of individual behaviors are used to achieve the goal of global optimization (Ding, Jiao, & Wu, 2018).

The Internet of Things cement mixing pile is a digital model established for the cement mixing pile body, the cement mixing pile medium, the cement mixing pile facility, and the surrounding environment (Li, 2019). In terms of geometric shape, not only the three-dimensional simulation of the elements corresponding to the solid cement mixing pile, but also its physical characteristics are simulated. The model needs to be verified by finite element analysis, stress and strain testing, thermal analysis, aerodynamics, etc., to make it conform to the laws of physics (Willkomm, 2020). In addition, the Internet of Things cement mixing pile model also needs to establish behavior constraints, including equipment activation sequence, equipment linkage, operational safety compliance, threat behavior suppression and prompts and other constraints (Ding, 2020). Finally, during the operation of the cement mixing pile twin, the laws discovered through artificial intelligence, data mining and other technologies are gradually added to the Internet of Things cement mixing pile model. The Internet of

Things cement mixing pile is established synchronously with the physical cement mixing pile. In the design stage of the cement mixing pile, the model of the cement mixing pile body, related equipment and facilities, and the surrounding environment is established through the digital coordinated design of various disciplines to form the initial Internet of Things cement mixing pile; in the construction phase of cement mixing piles, according to the changes to the design phase, timely adjust the IoT cement mixing pile model, and establish corresponding virtual models for the compressors, valves, pump units and other equipment purchased during the construction process, and integrate them into the material networked cement mixing pile model.

## 2.2 Management and Control Decision of Cement Mixing Pile

Under the complex environment, the behavior of cement mixing pile materials presents the characteristics of evolution, multi-faceted and variability. Understanding the behavior of the material and understanding its intent is essential for the intelligent management and control of cement mixing piles. It can be used for single material recommendation to avoid strong interference, suspicious jump tracking of cement mixed piles, etc. Based on the historical data of cement mixing pile and the expert knowledge of electromagnetic cement mixing pile, from the perspective of behavior nature and task objectives, the behavior of material use can be divided into six typical types: frequency adjustment behavior, time selection behavior, power control behavior, interaction behavior of management and control department, beam direction control behavior and abnormal material use behavior. Reasoning for different material behaviors and their intentions will be a direction with rich research opportunities. Safety decision of cement mixing pile is the foothold of situation awareness and reasoning of cement mixing pile, and also the key to realize efficient and orderly utilization of electromagnetic cement mixing pile resources and intelligent safety control of electromagnetic cement mixing pile space. Build a cement mixed pile of Internet of Things architecture consisting of sensory layer, network layer, application layer, realize comprehensive intelligent perception, establish data center, integrate, store, analyze data, big data Enable intelligent applications through technology. In the construction and application of smart pipe networks, cement mixed pile based on Internet of Things and big data technology is the basis for ensuring the integration of virtual and real physical information of cement mixed pile, and smart city construction technology (Kanniga, 2020).

Before the construction of cement mixing pile, based on the prediction of future operation and the historical data of other cement mixing piles, the iterative simulation analysis of operation is carried out to simulate the whole process of cement mixing pile construction. In the specific operation process, simulation analysis can be carried out according to the oil and gas medium and transportation volume of each specific transportation, and the operation situation can be predicted and analyzed to ensure safety and efficiency. At the same time, the Internet of things cement mixing pile presents a realistic three-dimensional visualization effect, and the management and control departments (designers, construction personnel, operation personnel, maintenance personnel, etc.) have stronger interaction, so as to stimulate inspiration and improve efficiency.

Based on the enterprise information management system and industrial control system, cement mixing pile service system provides system support and services for intelligent management and control of cement mixing pile. For example, after receiving the task of natural gas transportation, through the analysis and mining of twin data of cement mixing pile, it makes resource allocation scheme and initial operation plan to meet business needs and constraints. Based on informatization and automation, the cement mixing pile service system realizes “digitalization of state information, optimization of dispatching operation, automation of operation control, and timely early warning and emergency response”, continuously strengthens the “prediction, prediction, and pre adjustment” ability of the control system, and helps to improve the work efficiency and control level of front-line dispatching, planning and dispatching management personnel, continuously revise and optimize the transportation plan to ensure the safe, environmental protection and economic operation of cement mixing pile. The Internet of things cement mixing pile effectively integrates the multi-level management function of

cement mixing pile service system, realizes the operation optimization configuration, energy efficient utilization, equipment maintenance optimization, and the safety improvement of cement mixing pile body, so as to ensure the safe, stable and efficient operation of cement mixing pile.

The twin data of cement mixing pile includes the design, construction, operation and enterprise management data of cement mixing pile. The management of domestic and foreign cement mixed pile data and surrounding environment data is relatively mature. Taking the apdm model as an example, based on the GIS spatial database, using the center line of the cement mixed pile as the core, the absolute mileage, the related data of the cement mixed pile body, the environmental data, and the equipment and equipment of the cement mixed pile are used. The most mature application in China is the integrity data model of cement mixing pile. Based on the apdm model, combined with the integrity work of cement mixing pile in China, the model adds relevant contents such as cement mixing pile encroachment, engineering drawing, risk source, hydraulic protection, etc. The existing data model provides the basis for the collection and management of twin data of cement mixing pile. The twin data of cement mixing pile is mainly composed of entity cement mixing pile, Internet of things cement mixing pile, cement mixing pile service system and related data generated by the interaction of the three. The Internet of things cement mixing pile is the virtual form of entity cement mixing pile. There is an intersection between the two data, we call it the cement mixing pile foundation data. The basic data of cement mixing pile mainly includes the centerline of cement mixing pile and infrastructure data (including pipe information, anticorrosive coating, elbow, cement mixing pile, crossing, station, equipment and other relevant information). In this process, the entity cement mixing pile and the Internet of things cement mixing pile are synchronous. The data related to solid cement mixing pile are mainly real-time data collected by sensors and industrial control system, including stress and strain of cement mixing pile, meteorological data, station equipment operation data and oil and gas transportation data. Due to the huge amount of data collected in real time, not all of them are synchronized to the data of cement mixing pile foundation. The relevant data of cement mixing pile in the Internet of things includes the metadata defining the model of cement mixing pile in the Internet of things, that is, the basic definition of its geometric model, physical model and behavior constraint. Based on this metadata, combined with the basic data of cement mixing pile, the database of cement mixing pile in the Internet of things is constructed. The data related to the cement mixing pile service system includes the data related to the operation of the enterprise besides the ontology data of the cement mixing pile, which is related to the enterprise management. This type of data is closely related to the construction data of cement mixed piles and is part of the big data of cement mixed piles. The knowledge formed by data mining and big data analysis is another part of cement twin data. Cement Mixing Pile Twin Data enables interactive manipulation between all parts of the Cement Mixing Pile on the Internet of Things, provides holographic data for the Cement Mixing Pile, eliminates information islands, and is constantly based on integration.

### 2.3 Simulation Mathematical Model of Internet of Things Management and Control of Cement Mixing Pile

Based on the analysis of the construction process and schedule simulation principle of cement mixing pile, the simulation mathematical model of cement mixing pile IOT management and control is established based on IOT data collection. The simulation model adopts the real-time construction time  $\tau$  And the real-time time time  $t$  is calculated by simulation. The objective function of intelligent simulation is expressed as follows:

$$C_R(\ddot{A}) = -\sum_{\forall Wb \in A} MS(Rb | t) \log 2(Pb | t) \quad (1)$$

$$SC(w1, w2) = \log 2 \frac{S(P1 \& P2)}{S(P1) * (P2)} \quad (2)$$

Among them, C is the comprehensive index that has a decisive influence on the construction progress of cement mixing pile, such as total construction period, appearance of key nodes, overall construction strength and balance, temperature stress state, equilibrium coefficient of bid section, etc. the comprehensive index can be dynamically adjusted according to the needs of site stage objectives and actual state; R is the site construction status, mainly including real-time construction progress, real-time mechanical matching relationship, historical weather statistics, real-time concrete temperature control status, etc; P is the simulation parameters, including real-time mechanical operation parameters, etc; S is the set of construction schemes based on the site construction status, including the pouring sequence, etc; MS is the resource allocation scheme, including personnel, equipment and other resource allocation; SC is the construction cost of cement mixing pile under the construction scheme. The process of automatic real-time updating of simulation boundary conditions is as follows

$$Hr(i)i = Gr(j)_i^1 + G_i^1, \quad i = 1, 2, \dots, n \quad (3)$$

$$G(H(i, 0), W) = Gr(j)_{w_i \in w} (Hr(i)(hhr(i), w_i)) \quad t=0 \quad (4)$$

G is the pouring elevation of the I dam section at the initial time of simulation calculation (t = 0), the layered scheme above the pouring elevation H (I, 0) and the joint grouting elevation of the j grouting joint; HR (I), HHR (I) and gr (J) are the real-time data of the I dam section respectively (τ = τ f) Pouring elevation, layered scheme above pouring elevation HR (I) and joint grouting elevation of J grouting joint, I is the total number of dam sections. The simulation parameters are automatically updated in real time

$$(\tau-1)(R(\tau)) = -\sum_{T0 \in X} P(\tau)(x) \log_2 P(Tt) \quad (5)$$

According to the parameter p (t = 0) at the initial time after the parameter historical big data analysis, the simulation parameter value process is obtained from the big data analysis from t0 to Tt; According to R(τ) by (τ- 1) to τ The relationship between real-time acquisition of construction parameters and time period big data can obtain the variation of construction parameters Δ P(τ) The process of development; According to the variation Δ P(τ) The process of real-time updating simulation parameters is determined. The construction state transfer equation is analyzed by simulation

$$P(\tau)(d_i, w_j) = P(\tau-1_i)P(w_j|d_i); P(w_j|d_i) = \sum_{k=1}^K P(w_j|z_k)P(P(t=0)_k|d_i) \quad (6)$$

$$P(t=0)(Ai, Aj) = \left[ \log\left(\frac{|x_{A_i} - a_{A_j}|}{P(\tau)_{A_j}}\right), \log\left(\frac{|y_{A_i} - y_{A_j}|}{R(\tau)_{A_j}}\right), \log\left(\frac{H(i, t)_{A_i}}{w_{A_j}}\right), \log\left(\frac{t-1_{A_i}}{h_{A_j}}\right) \right] \quad (7)$$

Where:  $H(I, t)$  and  $G(J, t)$  are the concrete pouring elevation and joint grouting elevation of the  $I$  dam section and the  $j$  transverse joint at the time  $t$  of simulation calculation respectively,  $\Delta H(I, t)$  and  $\Delta G(J, t)$  is the pouring height and joint grouting height of  $I$  and  $j$  grouting joints from  $T-1$  to  $t$ . Automatic simulation calculation process:

$${}''H(i, t) = \frac{{}''P(\tau)^g \cap {}''P(\tau)^r}{{}''G(j, t)^g \cup {}''G(j, t)^r} \quad (8)$$

$${}''P(\tau) = (\Phi_a, \Phi_b) = \frac{\Phi_a^T \Phi_b}{\|\Phi_a\| \|\Phi_b\|} \quad (9)$$

$\Phi$  defines the pouring conversion process under the constraints of maximum dam height, construction machinery, construction process, temperature field, flood diversion, joint grouting and stratification. Real time automatic updating model of dam block sorting

$$L_r = \|D_I - D_O\|_2 \quad (10)$$

The model consists of two parts: a dam block sequencing model considering the factors of maximum height difference  $L$ , adjacent height difference  $D_i$ , cantilever height  $d_o$  and pouring interval, and a dam block sequencing adjustment model considering multi bid sections and their equilibrium. The matching model of warehouse surface and machinery is as follows

$$MC_R^{A_i} = M(t)_G^{A_i, A_j} \cdot C(x, y, z) \quad (11)$$

Where:  $MC$  is the matching relationship between the dam block sequence  $m(T)$  and the cable machine position  $C(x, y, z)$ . Constraints:

$$BB^*w_G^{C(x,y,z)} = \max \left\{ BWR, W_G \cdot \varepsilon(M(t)_G^{A_i}, M(t)_G^{A_j}) \right\} \quad (12)$$

Where:  $BB$  is constraint  $B$  including height difference limit  $\Delta H$ . Time constraint  $BT$ , mechanical working range constraint  $BWR$ , etc. According to the basic meaning of the IOT control simulation theory of cement mixing pile, the IOT control simulation formula of cement mixing pile is proposed as follows:

$${}''H(i, t)_{ik} = \sum_a^n M(t)_1 X_{ik} + \sum_b^n \tau_2 U({}''G(j, t)_{ik}) + BWR_{ik} \quad (13)$$

$$B\Delta H(y, y') = \frac{\sum_{i=1}^m (y_i - y'_i)}{m} \quad (14)$$

The simulation initial conditions include the real-time pouring appearance of dam block, the real-time appearance of joint grouting, the layered scheme of dam section, the grouting control parameters of joint grouting at different levels, the mechanical equipment resources, the maximum number of warehouses allowed to be poured at the same time, the overlapping proportion of warehouse surface, etc. Before the start of the first simulation, the data of grouting face is collected through the Internet of things, and the data-driven simulation parameters are automatically updated. The machinery group mainly includes concrete mixing plant, concrete transport vehicle, cable machine, warehouse surface leveling machine, warehouse surface vibrating machine and so on

$${}^{\prime\prime}D_L + {}^{\prime\prime}D_S + {}^{\prime\prime}D_R = {}^{\prime\prime}D \quad (15)$$

$$I = f(W^e D_1 + \delta^e) \quad (16)$$

The accumulated monitoring data is mined by using big data analysis formula, and the operation rules of construction machinery such as concrete mixing plant, concrete transport vehicle, cable crane, leveling machine and vibrating machine are analyzed in real time by means of parallel calculation, and all kinds of simulation data generated by simulation calculation based on the rules are added to the historical data pool to update the operation rules. A data center is shared for calling and updating simulation parameters during schedule simulation analysis. If each dam section of the dam is poured to the top and the joint grouting of each irrigation area is completed, it is judged that the dam pouring is completed, and then it is judged whether there are dam blocks meeting the pouring constraints in each dam section at the current time

$$B_a = g(W^d I + \delta^d) \quad (17)$$

$$j = \sum_{k=1}^k \sum_{i \in Ck} |x_i - u_k|^2 \quad (18)$$

After selecting m pouring dam blocks, the pouring sequence of these dam blocks is g (x)

$$G(x) = \sum_{j \in Q} m_j \frac{B''_j}{\sigma(X'_j)} - p \quad (19)$$

The concrete balance principle of bid section is explained as follows: if there are Q bid sections for the dam, the concrete quantity of each bid section is WQ, the current cumulative concrete quantity is WQ, and the concrete quantity of warehouse surface is WLQ, then:

$$wLQ = wQ(k) = [\zeta_1 c_1(\delta) + \zeta_2 c_2(WQ) + \zeta_3 c_3(WQ) + \zeta_4 c_4(WQ) + \zeta_5 c_5(k) + \zeta_6 \mu_{ik}] \quad (20)$$

Among them:  $\delta$  compare the quantities of different bid sections with bid section 1 as the reference,  $\varepsilon$  It is an adjustable proportion. At the same time, the first bin in the comprehensive index is taken



as the reference position. By adjusting the bin surface that does not meet the overlap ratio index, if there are bins that do not meet the overlap ratio limit, the pouring sequence is kicked out

$$wLQ_{gain}(Y) = \frac{\sigma(Y) - avg(\sigma(Y'), \sigma(Y'))}{\sigma(Y)} \quad (21)$$

$$Y = \frac{2k}{k+1} + \frac{2c_1 + c_2 + 3et - 2et\zeta}{3} \quad (22)$$

The selection of the cable crane is to configure the cable crane according to the position of the pouring bin and the state of the cable crane, the safe distance of the cable crane under the complex environment and other factors, and select the deployment scheme of the cable crane as the pouring scheme according to the minimum clock of the cable crane in the matching scheme

$$wLQ(d_i, w_j) = P(d_i)P(w_j | d_i); P(w_j | d_i) = \sum_{k=1}^K P(w_j | z_k)P(z_k | d_i) \quad (23)$$

$$\frac{B\Delta H}{k} \sum_{i=1}^k \max_{j:i} \left\{ \frac{D \text{int} ra(Ci) + D \text{int} ra(Cj)}{D \text{int} er(Ci, Cj)} \right\} \quad (24)$$

In the construction simulation of cement mixing pile, the pouring duration of dam block will affect the change of cable crane state and dam block state. This paper decomposes the construction process of concrete production and transportation in each link of the cable crane warehouse surface of the mixing plant transport vehicle (unloading platform), and uses the laws of each link of monitoring and analyzing the concrete production and transportation process based on the Internet of things, combined with the mechanical operation efficiency of the warehouse surface, the dam block pouring time can be calculated.

### 3. CONSTRUCTION QUALITY CONTROL

#### 3.1 Model Scheme

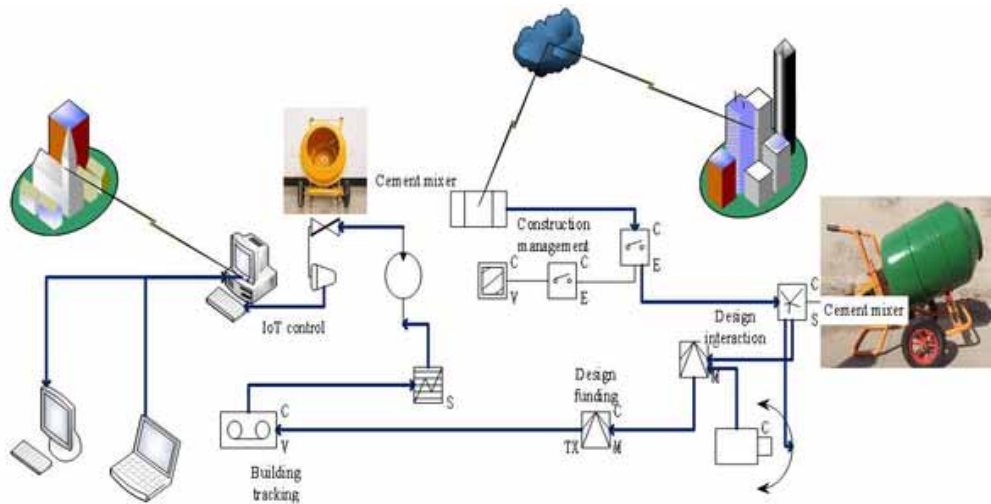
This paper constructs IOT cement mixing pile construction quality control model iotcmp (Internet of things cement mixing pile) based on BIM. This model integrates IOT microdevices, connects equipment detection and detection modules based on the original cement mixed pile, and connects to construction projects through 5G communication scheme, overall construction project management and control department. The Internet of things management and control model in this paper is implemented in the form of web, which uses various data type interfaces including Python and PHP scripts, as well as functional business interfaces of system development.

#### 3.2 Construction Quality Control Model and Construction Design

On the basis of previous studies, this study summarizes the risks of each stage, designs and establishes the overall structure of cement mixing pile monitoring based on the Internet of things according to the

key and difficult points and risks of each stage, and establishes corresponding solutions for each stage. The framework of cement mixing pile monitoring based on Internet of things is shown in Figure 1.

Figure 1. Internet of Things cement mixing pile management and control project



In the design stage, through the collaborative design based on the Internet of things, the cement mixing pile monitoring is used to carry out the design control and design interaction, so as to eliminate the information islands and communication barriers of the design parties; In the procurement phase, the material procurement tracking process based on the Internet of things model components and cement mixing pile monitoring is carried out to track the procurement process in real time and reduce the transportation risk; In the construction stage, through the monitoring of cement mixing pile, BIM based construction management is carried out to provide information interaction and processing means in the construction management process, improve the construction management density, and assist in progress control, quality control and safety control.

On the basis of unifying the direction and standard through the management means, each professional design process should be able to carry out real-time collaboration and mutual control, so as to optimize the pipeline design process into an overall orderly and synchronous real-time collaborative design mode. In this mode, all the disciplines participating in the design will reduce the slow down time as much as possible, and can carry out the interpenetrating work earlier, which greatly shortens the overall design cycle. On the other hand, the design data applied by each unit is uniformly managed through the information platform, and the approved, unified and up-to-date control data is always used by each unit to ensure the convergence of information. At each stage, take full advantage of the collaborative benefits of designing under the Internet of Things control mode. Secondly, cement mixing pile monitoring can provide the way of information interaction between all parties. Naturally, it can also use the Internet of things model as the communication carrier of all parties. Every designer in the design process can perceive the existence of other majors, and can communicate to a certain extent. Cement mixing pile monitoring uploads synchronous design model and drawing data. Designers can view and review the conflicts between their own professional or regional design model or drawing and other designers on the platform, and point out design problems and feed them back to relevant personnel through the information interaction process provided by the platform, try to reduce or eliminate the adverse impact on the design work due to the communication

barriers of all parties. Moreover, through the integrated management of the information platform, the general contractor can set various permissions on the design data and design results, which greatly improves the data security. At the same time, through the effective analysis of the designer's account behavior, we can analyze the performance of the design unit to a certain extent, and take corrective measures in advance.

## 4. RESULTS AND DISCUSSION

### 4.1 Problems in Construction Quality of Cement Mixing Pile

Both at home and abroad attach great importance to the research on the mechanism of cement mixing pile management and control model of the Internet of things, and agree that intelligence is the development trend. However, the modeling research on how to integrate intelligence, how to improve intelligence, and how to evaluate intelligence is still lack of integrity, systematicness, and mathematics, especially under the threat of diversified Internet of things cement mixing pile use security, the mechanism research of Internet of things cement mixing pile intelligent management and control, such as security, interpretability, trustworthiness and so on, is even less.

Figure 2. Local settlement of cement factor

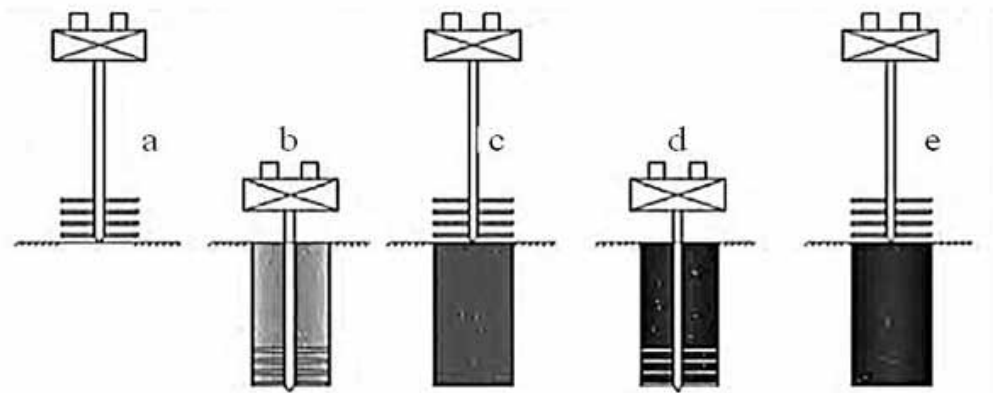


(Some pictures are from Bing)

As shown in Figure 2, at present, due to the poor construction quality of cement, some projects have quality problems. In particular, with the increasingly urgent demand of the electromagnetic Internet of things cement mixing pile war, the bottleneck problem that restricts the management of Internet of things cement mixing pile for a long time has been broken through. It has become a consensus to promote the transformation or change from the static closed artificial Internet of things cement mixing pile management mode to the dynamic collaborative and efficient Internet of things cement mixing pile intelligent management and control mode.

## 4.2 Construction Quality Control of Cement Mixing Pile

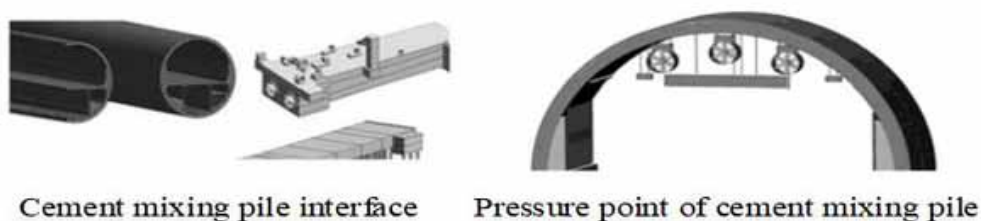
Figure 3. Cement mixing pile state



(Some pictures are from CNKI)

As shown in Figure 3, the integrated automatic simulation technology of schedule simulation evaluation optimization and resource allocation driven by simulation boundary and automatic parameter update is the core of the transformation of schedule simulation from static to dynamic and from scientific research to application. The transformation logic and data interaction mode of each internal link are studied, and the evaluation and optimization resource allocation is incorporated into the simulation system under the IOT management and control simulation architecture to make it a whole.

Figure 4. Cement mixing pile home point and interface



(Some pictures are from CNKI)

The home point and interface of cement mixing pile are shown in Figure 4. In this structure, the cement density, cement content, construction time and other indicators can be evaluated. Based on the study of construction quality control process, this paper designs a quality control framework for civil engineering construction period based mainly on quality control modules and develops costs, schedules, materials and other modules. The quality module is designed completely according to

the process content, and combined with the mature three-dimensional visualization platform, the construction data and analysis results are displayed in the platform.

Table 1. Intelligent management and control system model for cement mixing piles

Item	Construction time	quality of work	Stealing situation	Head pile diameter
Slurry volume	3.4	4.98	1.18	3.4
depth	3.36	3.35	4.75	1.03
density	2.35	4.1	4.92	4.49
Ash amount	2.91	1.51	1.22	6.68

Starting from the relationship between the whole and the environment, the whole and the part, and the structure and function, the intelligent management and control system model of cement mixing pile in the Internet of things is constructed, which is composed of environment model, function model, physical model and mathematical model, as shown in Table 1. Starting from the characteristics of openness and purpose of the system, this paper analyzes the function and interface relationship among material system, cement mixing pile monitoring system of Internet of things, cement mixing pile reasoning system of Internet of things and cement mixing pile decision system of Internet of things. On this basis, the interaction rules of elements and systems, systems and systems, systems and environment in the IOT cement mixing pile management and control safety system are further refined, and the basic characteristics of the intelligent frequency management system, such as structure, hierarchy, relevance, coordination, timing and safety, are deeply studied.

Figure 5. Status of Cement Mixing Pile of Internet of Things

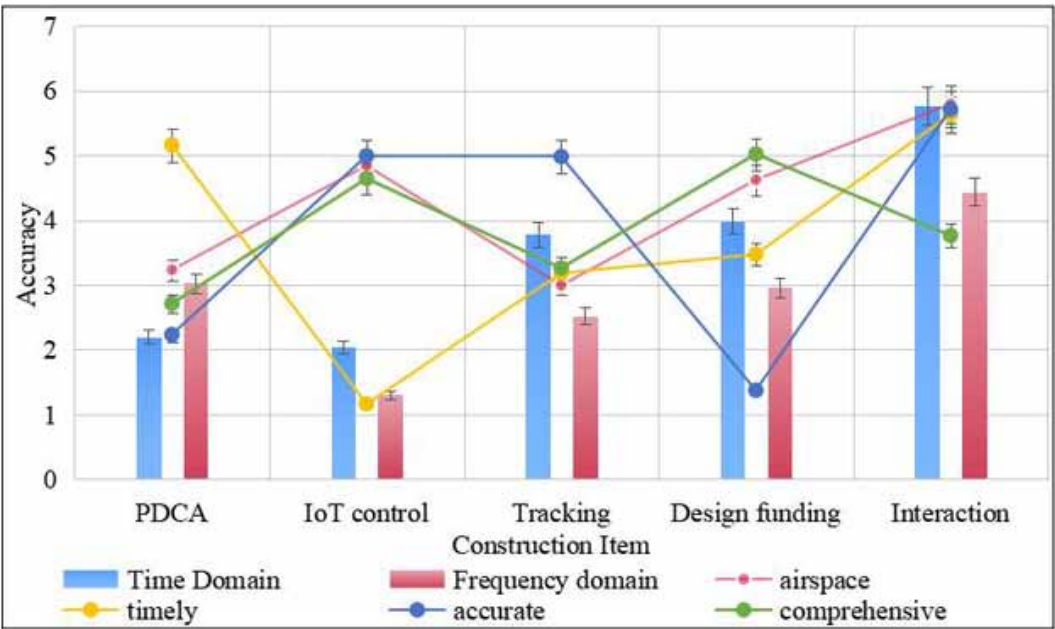


(Some pictures are from CNKI)



As shown in Figure 5, IOT cement mixing pile obtains IOT cement mixing pile status, situation and evolution trend information through situational awareness. The concerned IOT cement mixing pile dimensions include time domain, frequency domain, spatial domain, etc., and the goal is to obtain timely, accurate and comprehensive information. As one of the key technologies of cognitive radio, the early focus of situation awareness of cement mixing pile in the Internet of things is to obtain the busy / occupied information of cement mixing pile in the Internet of things based on a series of statistical signal detection methods.

Figure 6. Construction quality under the information monitoring method

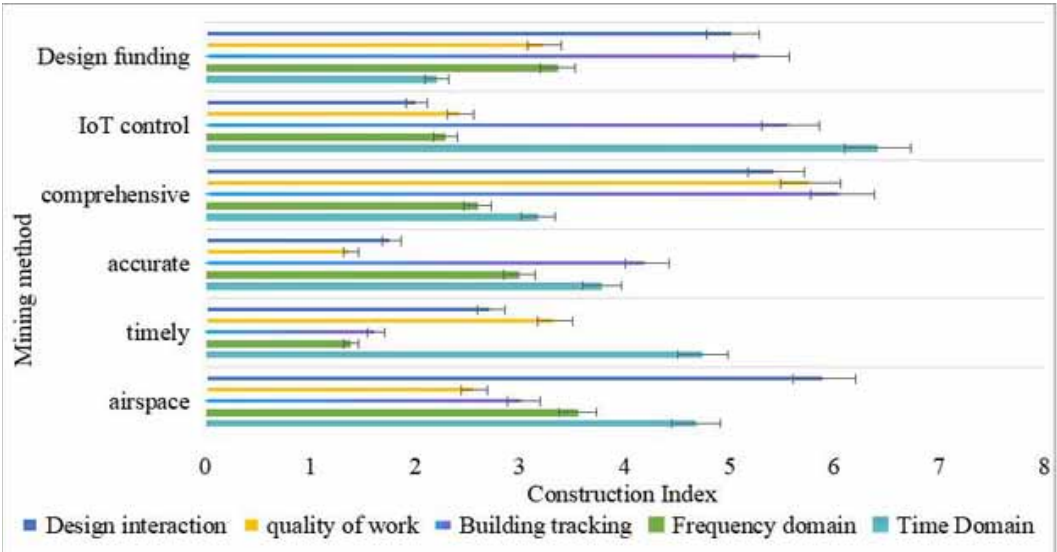


As shown in Figure 6, the process is designed in strict accordance with the iotcmp method, and the information monitoring method is integrated into the mode. The construction quality inspection is mainly based on information, supplemented by traditional methods. If the results obtained through data analysis are normal and within the value set in the specification, the project quality of this part can be considered as qualified. If the result of analysis is abnormal, it is necessary to carry out quality inspection in combination with manual inspection under the condition that abnormal monitoring such as monitoring instrument damage cannot be ruled out. Finally, if a problem is found in the inspection, it needs to be handled. If the problem is properly solved after being handled, it needs to re develop the solution and re conduct the quality control process until the problem is solved.

In order to facilitate the browsing of the system at any time and the query and maintenance of data, the earth building system is designed with B / S (Browser / server) architecture, so that the management and control department can operate the system by logging in the browser at any time. The indicators are shown in Figure 7. Take data access interface, database access driver, control department interface, HTML, CSS, Web browser data interaction Python script earthwork construction quality control platform monitoring data model data web server cloud server GPRS data transmission module HTTP request websocket operation interaction presentation layer business logic layer data layer data

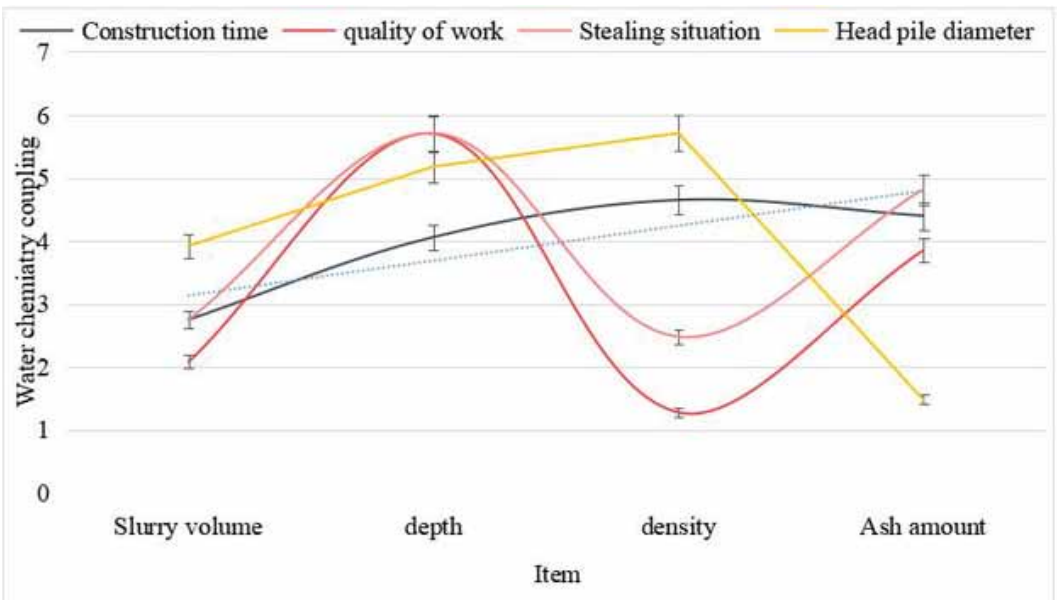
acquisition layer basic information base engineering construction management system management  
visualization control platform deformation temperature stress pressure.

Figure 7. Data access interface to detect construction quality



As shown in Figure 8, in the visualization platform, the loaded earth building model is loaded in blocks, and each block is a file. All the files constituting the model are loaded into the 3D scene by calling the Internet of things monitoring method. Each dam block is attached with information

Figure 8. Cement mixing pile data processing



related to construction quality. Through GPRS network transmission technology and socket monitoring technology, the data monitored by various sensors are transmitted to the database for storage, and different types of data are classified and stored in different databases, mainly including business data and model data of earth building.

Table 2. Scope of quality management

Item	IoT CMP	IOT Control	Tracking	Design Funding	Interaction
Time Domain	2.2	2.04	3.78	3.99	5.77
Frequency Domain	3.03	1.3	2.52	2.96	4.44
Airspace	3.23	4.84	2.99	4.62	5.79
Timely	5.16	1.16	3.18	3.47	5.63
Accurate	2.23	4.99	4.98	1.37	5.71
Comprehensive	2.71	4.64	3.26	5.02	3.76

As shown in Table 2, some function pages of quality management are designed completely according to the quality control process mentioned above, forming a quality management closed loop. The module is the specific application of the quality management process proposed in this paper. According to the construction requirements of soil construction engineering, the system is designed and developed into three modules, namely visual general control platform, engineering construction management and system management. Each module contains multiple sub modules, which together constitute the quality control platform of soil construction engineering construction period, to ensure the safety and smooth progress of engineering construction.

(Some pictures are from Google)

The construction status of cement mixing pile is shown in Figure 9. The IOT monitoring system is used to show the management and control department some of the most needed functions in the construction period of geotechnical engineering, so that the management and control department has the most intuitive feeling. Therefore, the key information of other modules in the system will also be integrated into the visualization platform. The integration of important information into the platform relies primarily on data and model binding. The model mounted on the platform can adapt well to the terrain, and the mounting process uses a lightweight loading method. Each part of the model is bound to quality, cost, progress, and some other important information related to engineering construction to achieve data visualization. At the same time, some specific functions are added in the visualization platform, such as model positioning, site analysis, engineering calculation and so on. Project construction management module contains a wide range of content, are some specific practical functions. The specific report includes quality, material information, construction schedule management, etc.

As shown in Table 3, primitively renders the bottom layer of the engine, and loads and draws the Internet of things model file to realize the rendering and display of the model in the cesium environment and the loading of the visual scene. In fact, the loading process is the fusion process of IOT model in cesium platform. BIM model and terrain are fused, and the data information between them is compatible and coexisting, and there is no loss phenomenon. The final visualization interface is in line with the actual situation of the project.



Figure 9. Construction status of cement mixing pile



Table 3. Internet of Things Cement Mixing Pile Model File

Item	Cesium	Timely	Accurate	Comprehensive	IoT control	Design funding
Time domain	4.68	4.74	3.78	3.17	6.41	2.2
Frequency domain	3.55	1.38	2.99	2.59	2.28	3.36
Building tracking	3.03	1.62	4.21	6.07	5.58	5.3
Quality of work	2.56	3.33	1.38	5.77	2.43	3.23
Design interaction	5.9	2.72	1.77	5.44	2.01	5.03

As shown in Figure 10, when the cement dosage of the cement mixing pile is set to fluctuate by 15%, the water cement ratio under the control of the Internet of things is 0.62, the texture of the mixed cement product is clear, the average compressive strength is 2.65mpa, and the average number of standard penetration blows in this case is 38. It can be seen that it is feasible to use the Internet of things equipment to monitor the cement mixing pile in real time and evaluate the overall benefit. The construction data information is provided by the project construction management module. By

associating the information with the dam section, the management and control department will see the information in the visual interface, which can realize the perfect integration of the model in the three-dimensional scene and the additional data source, which is convenient for the management and control department to grasp and guide the construction process and quality in time, and lays the foundation for the quality control of the construction process.

Figure 10. Cement mixing pile management and control

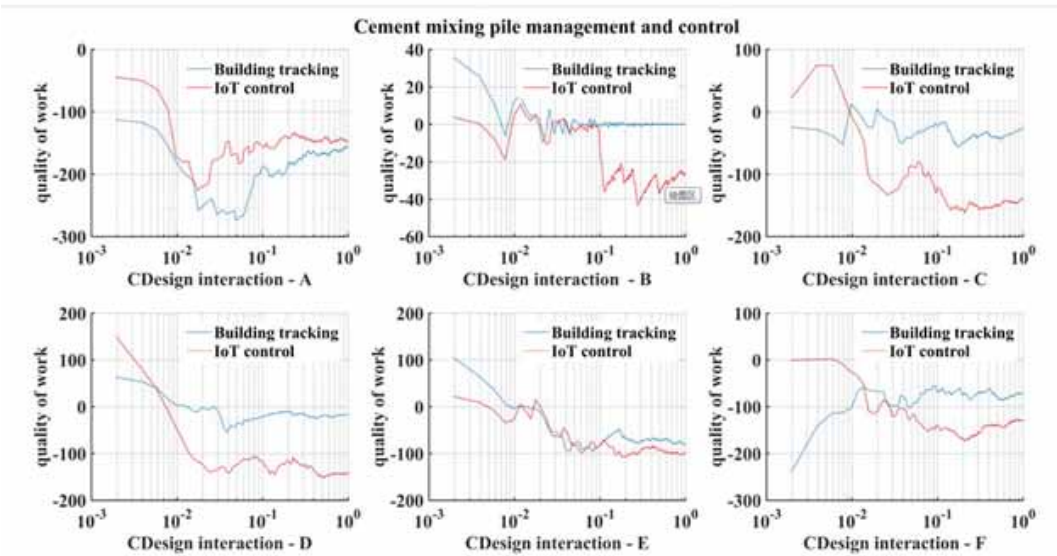
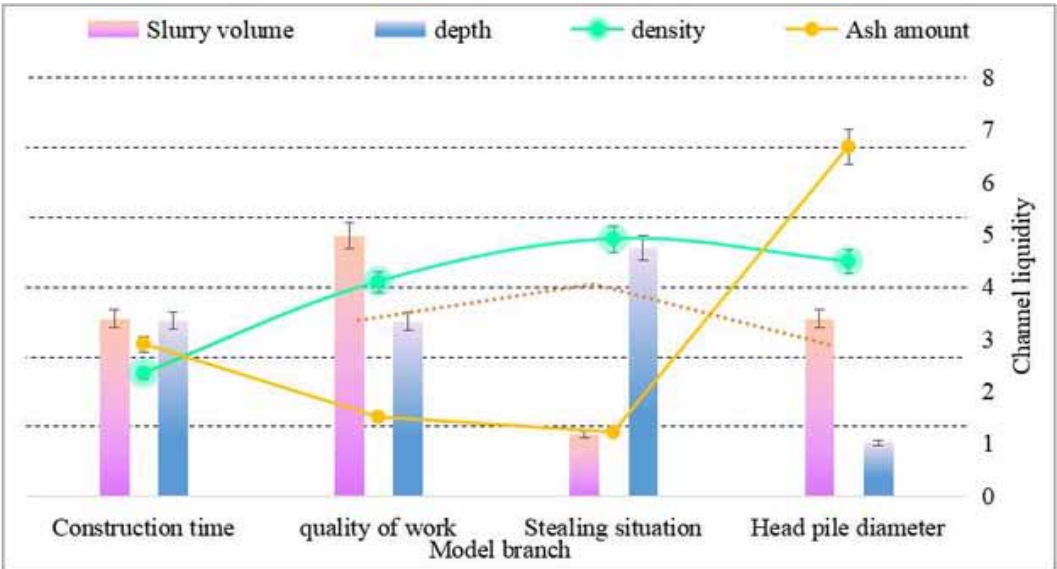


Figure 11. Simulation parameters in traditional schedule simulation



The reliability of cement mixing pile IOT management and control simulation is directly affected by the integrity and accuracy of design, construction and other information resources collection. As shown in Figure 11, the change of simulation parameters in the traditional schedule simulation is weakly related to the law of engineering construction. On the one hand, the lack of information is not enough for knowledge mining to find the law, which leads to the problem of random generation of simulation parameters based on assumptions. Based on the complete information of cement mixing pile, the big data technology is used to mine the laws of each link of engineering construction, which provides the possibility to explore the variation laws of simulation parameters. At the same time, in order to realize the integrated automatic simulation, it is necessary to study the combination mode between the big data analysis of simulation parameters and the schedule simulation system.

#### 4.3 Discussion

This paper integrates the data interaction and analysis process into iotcmp method, designs the digital construction quality control process based on iotcmp method, optimizes iotcmp method in informatization, and improves the application degree of iotcmp method in digital and informatization construction process. Based on the quality control process, the construction quality control platform of civil engineering is developed, which solves the problems of difficult interaction and sharing of civil engineering construction data, and ensures the construction quality of civil engineering. Give full play to the role of the Internet of things in the integration of water conservancy and hydropower project construction data, and promote the progress simulation to a higher stage. Schedule simulation is a work with complex boundary conditions and influencing factors, which needs to integrate the ideas, principles and objectives of construction schedule management from different perspectives of all parties involved. Innovative intelligent simulation application mode, the owner, supervision, design, construction, scientific research and other parties jointly participate. According to the optimization suggestions and countermeasures provided by the simulation analysis, participants will find and provide feedback on factors that may limit the actual construction progress in combination with their own situation, and guided intelligent simulation engineering construction. The construction quality management of earth building engineering includes the preparation of quality plan documents, the preparation of supervision related documents, the management of technical scheme, quality inspection, hidden danger rectification, quality acceptance, etc. these contents are also the steps of quality management. The next step begins after the last step is completed, because these documents and data information are stored in the unified database. Data information can be shared, so the next step will be more clear to know when the last step ends, the system can achieve data flow, realize digital quality management.

Through the construction of cement mixing pile monitoring, it provides a communication and coordination medium for all parties in the design stage. After creating a project, the administrator manages the project team and assigns appropriate permissions through management permissions. Create a central file through the platform. So that team members with permissions can access the corresponding model and edit it. Then, it uses its own working set to divide the internal ownership and start cooperation. When there is a need for collaboration with others, a coordination request can be sent to the building owner. The requested person will receive the information immediately, and can borrow the permission to the other party to complete the cooperation. It can effectively solve the dilemma of multi team, cross regional and cross stage coordination of large-scale projects with phased and sub regional design and construction, and also solve the difficult problem of professional subcontracting on site. Taking full account of the potential joint application and operation of design results by multi-disciplinary and Internet of things cement mixing pile management and control construction units, the digital thinking is used to optimize the management and control process in the design stage, create the underlying logic in line with the information management, and integrate it into the cement mixing pile supervision and control, so as to realize the online control of design.

## **5. CONCLUSIONS**

Cement mixing pile monitoring based on the Internet of things can provide multi-faceted collaborative management means for each stage of cement mixing pile management and control project of the Internet of things, so that the participating units can work on the platform; Making full use of the advantages of digital information technology, AI technology and Internet of things technology to eliminate the hidden dangers and even problems of project management caused by information congestion caused by human factors plays an irreplaceable role in assisting the risk management and control in the implementation of Internet of things cement mixing pile management and control project. We should clearly realize that there must be some deficiencies in the digital construction platform at this stage, which is closely related to the management characteristics of enterprises and projects, process system and even the era and industry background. Therefore, when building the digital construction platform, we should fully consider the management characteristics of each enterprise and project, form the basic cognition of platform system mutual reliance and common iteration, and further strengthen the informatization and digital ability of enterprise engineering management. The simulation theory of IOT management and control of cement mixed pile is in the stage of theoretical development and actual research, and should focus on the basic theory, and application mode of IOT management and control simulation. At the same time, in order to make IOT management and control simulation truly serve the engineering construction, we still need to focus on the precision sensing technology, big data technology application, integrated simulation technology and application mode under the guidance of “comprehensive perception, real-time analysis, real-time control” closed-loop intelligent control theory.

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