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Research Article

Concrete Construction Engineering Management in the Context of the Internet of Things

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Concrete engineering is currently the top priority in China's construction, but its engineering management is still weak. The current method is to use the human model to carry out traditional management and control. The defect is that the form is too singular and cannot be involved in all aspects. To solve these problems, this paper proposes the application of Internet of Things technology in concrete engineering management, aiming at studying the quality management method of concrete prefabricated buildings. Through the experimental process of constructing a refined quality management model of prefabricated buildings based on wireless sensor network and BIM technology, BIM technology can help design technical processes and build operation and maintenance systems. The results show that, after the establishment of the information sharing platform, the safety of concrete has been controlled to a certain extent and the accident rate has been reduced from 49% to 36%. Such results show that the use of IoT technology to help concrete engineering management is very effective.

1. Introduction

Compared with cast-in-place concrete building production and construction methods, prefabricated concrete buildings have the characteristics of factory production of components, short construction time, and high resource utilization. The advantages of China's construction industry in the promotion and application of prefabricated buildings are obvious. Therefore, in recent years, China has gradually increased its support for prefabricated buildings and issued relevant national policies. It can be seen that the combination of prefabricated buildings and information technology has also ushered in a more optimistic development trend in the refinement of the quality management model. Although prefabricated buildings have brought a new dawn to the development of China's construction industry, the quality problems in the current construction process cannot be ignored. These problems not only adversely affect the construction quality, but also lead to prolonged construction period and increased construction costs.

Based on literature research and expert interviews, this paper sorts out and analyzes the current quality management problems of prefabricated buildings and uses factor analysis to determine the common factor and verify it, to improve the accuracy of later research. It provides a strong basis for solving the quality problems of prefabricated buildings. Determine the main research direction to improve building quality; use the visualization and parameterization characteristics of wireless sensor network technology to determine the 3D model of prefabricated parts, build a family library, and improve the accuracy of component production and construction. Using the characteristics of wireless sensor network technology information sharing, it can achieve the integrated management of all participants and links, optimize the management system, and realize the precise management of people and things, to achieve the overall refined management of the quality of prefabricated buildings.

This paper applies the refined management theory to the quality management of prefabricated buildings. It refuses to refine everything in the management process but highlights the key points of management, so that the core content of quality management is refined, which is conducive to promoting the healthy development of prefabricated buildings. Then, combine wireless sensor network technology, prefabricated building, quality management, and refined management concepts. It is a new attempt of wireless sensor network technology based on existing research, a new development of prefabricated buildings based on the current situation in China, and a new exploration of refined management concepts based on the construction industry.

2. Related Work

Concrete is a general term for engineering composite materials in which aggregates are cemented into a whole by cementitious materials. It is widely used by major research institutes. Concrete engineering occupies a large proportion in green buildings for a long time, but the resource consumption is large, the labor intensity is high, the quality of the project is difficult to guarantee, and major safety accidents occur from time to time. The construction management methods are in urgent need of innovation. The following are the research proposals put forward by various scholars on this issue. The primary objective of the Mauricio study was to use the HIPERPAV Wisconsin software to evaluate the predicted time-to-sale (TOS) for cold-weather concrete laying when using Class C fly ash [1]. Araldi et al.'s research aimed to analyze the influence of different curing conditions on the development of concrete compressive strength from the perspective of construction management. It is well known that humidity and temperature conditions are the main factors affecting the strength behavior of concrete. Therefore, modifying these parameters directly affects the behavior of the material and thus the construction management [2]. The main aim of Pellegrino and Costantino was to understand whether the learning effect explaining productivity gains in subsequent cycles of a given repetitive construction process is primarily attributable to pure worker learning [3]. Mahakud et al.'s project deals with the reuse of concrete blocks dismantled from C&D waste in the form of recycled coarse aggregate (RCA), which is replacing natural coarse aggregate in concrete and is used in the construction industry [4]. In Dimitriou et al.'s paper, the widely recognized feedforward artificial neural network (FFANN) intelligence is used to process real-world data from 68 concrete highway bridges and provide an alternative model for accurate Bill of Quantity (BoQ) estimation [5]. However, the above research is only at the theoretical stage at this stage, and the practicality is not too strong.

The extension and expansion of the Internet of Things based on the Internet are a large network formed by combining various information sensing devices on the network. The Internet of Things is used in the following major areas. Razzaque et al. present the characteristics of IoT, including hyperscale IoT, heterogeneity at the device and network level, and the large number of events that arise spontaneously from these things. These will make developing diverse applications and services a very challenging task [6]. Lin et al. proposed the fact that IoT based on fog/edge computing becomes the future infrastructure for IoT development. To develop IoT infrastructure based on fog/edge computing, the architecture, enabling technologies, and issues related to IoT should be studied first, and then the integration of fog/edge computing and IoT should be explored [7]. Mosenia and Jha attempted to provide a comprehensive list of vulnerabilities and countermeasures at the edge layer of IoT, including three layers, namely, edge node, communication, and edge computing. To achieve this, it first briefly describes three well-known IoT reference models and defines security in the context [8]. Zhang et al. proposed a novel RTLS using active RFID, iLocate, which can locate objects with high precision up to 30 cm through ultra-long-distance transmission. To achieve fine-grained localization accuracy, iLocate proposes the concept of virtual reference labels [9]. Collier proposed building the Internet over the next 63 years to meet the world's need for cheap and clean energy. The Internet originated from revolutionary advancements in electronics, telecommunications and information technologies, devices, and applications [10]. However, at present, the Internet of Things technology and concrete project management still do not get rid of the traditional content and thinking. There is a lack of in-depth discussion of IoT technology. This also hinders the further combination and advantages of IoT technology and concrete project management. To tap the potential of the Internet of Things, improve the teaching ecology, and improve the management level still need to be further explored.

3. Wireless Sensor Networks in the Internet of Things

In recent years, in the process of assembled building construction, it is difficult to accurately control some details of prefabricated components in the production stage leading to problems such as deviation in size and large construction joints at a later stage; the amount of grouting is not accurately controlled and improper connection operations lead to cracks on the connection surface between components; and, due to improper personnel management, finished products are damaged during transportation and storage and other quality management problems. These problems not only adversely affect the quality of construction but also lead to longer construction period and higher cost.

The purpose of this paper is to collate and analyze the current quality problems in various aspects of assembled buildings and then sort out and summarize the main factors affecting the quality of assembled buildings, so as to determine the main research directions for improving the quality of buildings; using the visualization and parameterization characteristics of wireless sensor technology in the Internet of Things, the 3D model of prefabricated parts is determined, and the home library is constructed to improve the accuracy of the production and construction process of parts. Using the characteristics of information sharing of wireless sensor technology in the Internet of Things, we can achieve integrated management of each participant and each link, optimize the management system, and achieve precision in the management of people and things, so that the overall quality of assembled buildings can be finely managed.

3.1. Overview of Wireless Sensor Networks. Time synchronization technology in wireless sensor network is one of the important auxiliary technologies in wireless sensor network because it is the basis for ensuring the cooperative work between nodes, realizing multisensor node data fusion, and assisting the positioning process. The limited energy and node computing power of wireless sensor networks pose a large challenge to the design of distributed network time synchronization [11]. Its structure diagram is shown in Figure 1.

It can be seen from Figure 1 that the sensing, processing, and communication capabilities of each sensor node are very limited. However, through the collaboration and information aggregation among sensor nodes in the network, tasks over a wide geographic range can be accomplished. It can be seen from the above overview that the combination of wireless sensor node monitoring and manual monitoring forms a data source. With the material supply unit, supervision unit, construction unit, and other participants as the data nodes, the quality supervision department, and the construction unit as the data terminal, based on the Internet of Things technology, the whole process and all-round management of the concrete project are carried out.

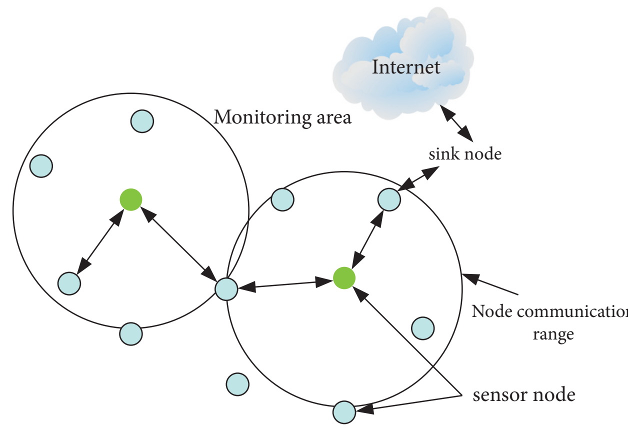

Figure 1: Wireless sensor network structure diagram.

3.2. Clock Model for Time Synchronization in Wireless Sensor Networks. In a wireless sensor networks, each node has its own internal clock, and each clock is composed of an oscillator that generates periodic signals and a counter. The counter increases its countervalue on the rising or falling edge of the output waveform of the crystal oscillator until it reaches the preset threshold and then generates an interrupt and saves it to the register [12]. An ideal oscillator would produce the following sine wave formula:

$$s(t) = V_0 \cos\left(2\pi f_0 t + \varphi_0\right). \quad (1)$$

Among them, f_0 is the ideal frequency of the oscillator, φ_0 is the initial phase at time $t = 0$, V_0 is the tuning voltage, and $s(t)$ represents the output of the oscillator. However, in the actual environment, affected by the quality of the oscillator, the power supply battery of the node, temperature, pressure, humidity, and device aging, the frequency of the oscillator will show instability, which will cause the drift of the clock. Moreover, the clock drift rates of the clocks of different nodes are also different. Therefore, the clock frequency $f_A(t)$ of node A is time-varying as

$$f(t) = \left(1 + \delta_A(t)\right) f_0. \quad (2)$$

Among them, $\delta_A(t)$ represents the frequency offset of a node A relative to the ideal clock in the formula, that is, the clock frequency offset of the node A [13]. $1 + \delta_A(t)$ represents the clock rate of node A. The clock function model of the node A can be obtained by a simple operation:

$$c_A(t) = \frac{2\pi\left(1 + \delta_A(t)\right) f_0 t + \varphi_0}{2\pi f_0}, \quad (3)$$

$$c_A(t) = \beta_A(t) + \theta_A. \quad (4)$$

Among them,

$$\beta_A(t) = \delta_A(t) + 1. \quad (5)$$

The clock running rate of a node A is represented by formula (2), θ_A represents the initial clock offset of node A, and $\delta_A(t)$ represents the clock frequency offset of node A. It is a time-varying variable, and its value is affected by many factors, such as changes in device internal temperature and external ambient temperature, atmospheric pressure, and hardware aging [14]. In the case of low requirements on synchronization accuracy, a first-order clock model that only considers the clock skew is often used, as shown in

$$c_A(t) = t + \theta_A. \quad (6)$$

3.3. Discrete Clock Model. It can be seen from the above that the clock model described in this paper is formula (2), which is expressed as the integral form of β_A, as follows:

$$c_A(t) = \int_0^t \beta_A(\tau) d\tau + \theta_A. \quad (7)$$

Time synchronization between nodes is usually achieved through the exchange of timestamps, and time cuts can be regarded as discrete samples of continuous time. Assuming that the sampling period is t, the discrete clock model of the node is

$$c(n) = \sum_{k=1}^{n} \beta_A(k)\tau_0 + \theta_A, \quad (8)$$

$$c_A(n) = n\tau_0 + v_A(n-1) + \left(\beta_A(n) - 1\right)\tau_0. \quad (9)$$

Among them, $VA(n)$ represents the cumulative clock offset and $\beta_A(k)$ represents the instantaneous clock frequency offset at the kth sampling. According to the analysis of the literature, the time-varying clock frequency offset

$\beta_A(n)$ can be described by the Gauss-Markov model; namely,

$$\beta_A(n) = \beta_A(n-1) + u_A(n). \tag{10}$$

Among them, $u_A(n)$ is Gaussian noise with mean 0 and variance $\sigma_{u_A}^2$. On the other hand, according to the definition of the accumulated clock skew in the above formula, the recursive formula of $v_A(n)$ can be written:

$$\begin{aligned} v_A(n) &= v_A(n-1) + (\beta_A(n) - 1)\tau_0, \\ v_A(n) &= v_A(n-1) + \tau_0\beta_A(n-1) + \tau_0 * u_A(n) - \tau_0. \end{aligned} \tag{11}$$

It can be supposed that

$$x(n) = [\beta_A(n)v_A(n)]^T. \tag{12}$$

According to the above formula, the clock parameter evolution model of a node A can be written in the following matrix form:

$$x_A(n) = \begin{bmatrix} 1 & 0 \\ \tau_0 & 1 \end{bmatrix} x_A(n-1) + \begin{bmatrix} u_A(n) \\ \tau_0 u_A(n) \end{bmatrix} + \begin{bmatrix} 0 \\ -\tau_0 \end{bmatrix}. \tag{13}$$

3.4. Local Timestamp Measurement Model. In order to establish a clock relationship between two adjacent nodes, this chapter adopts a bidirectional mechanism to exchange time information. In the bidirectional information exchange model between node *A* and reference node *R*, since the time to complete the information exchange cycle is very short, it is assumed that the clock parameters remain unchanged during the information exchange cycle [5]. First, the clock model is represented by a reference clock and accumulated clock offset:

$$\begin{aligned} c_A(t) &= \int_0^t \beta_A(\tau)\mathrm{d}\tau + \theta_A, \\ c_A(t) &= t + v_A(t). \end{aligned} \tag{14}$$

According to the clock model of formula (3), the message exchange process described by formulae (5) and (6) can be rewritten as follows:

$$\begin{aligned} T_{2,t} - v_A(t) &= T_{1,t} + d + X_t, \\ T_{3,t} - v_A(t) &= T_{4,t} - d - Y_t. \end{aligned} \tag{15}$$

Among them, d is the deterministic delay in the message transmission process, and X_t and Y_t are the nondeterministic delays in the message transmission process. Then,

$$z_A(t) \triangleq T_{2,t} + T_{3,t} - T_{1,t} - T_{4,t}. \tag{16}$$

Then, by sampling, a discrete local time measurement model can be obtained, as shown in the following formula:

$$z(n) = H^T x_A(n) + V_n. \tag{17}$$

Among them, $ZA(N)$ is the observed value, and it is easy to observe that the two formulations transform the estimation problem of clock parameters into a Gauss-Markov estimation problem with unknown states.

The Internet of Things technology takes a single building or a group of buildings as the research object and forms a complete data chain by setting up signal collection sources, data transmission networks, data processing centers, etc., changing the traditional management mode of building users' declarations and management department filing. There is three-dimensional management mode in which data nodes collect data and transmit data in LAN, and the management department analyzes and processes data, changes from passive to active, and realizes all weather and whole process management in the operation and maintenance stage of concrete projects. It can not only improve the running state of concrete projects, but also provide a reference for the secondary development of concrete projects.

4. Refinement Management of Prefabricated Concrete Building Quality Based on Internet of Things Wireless Sensor Network Technology and BIM Technology

4.1. BIM Technology. BIM technology is an inevitable product of the application of information technology in construction. It creates building models from informative data about the entire construction project by digitally simulating all real building information. This building model provides owners, builders, designers, and other employees with convenient and reliable multifaceted performance data [15]. Researchers then delved into BIM technology, and understandings of BIM technology vary widely. The application value of BIM is shown in Figure 2.

By studying the concept of wireless sensor network recognized in the construction industry, this paper analyzes it from two aspects: narrow and broad. In a narrow sense, the concept of wireless sensor network refers to the analysis from the perspective of technological tool changes. Design tools have developed from traditional CAD technology to wireless sensor network software represented by Revit as a new technical means [16]. In a broad sense, wireless sensor networks have created a possibility for information sharing among different disciplines of construction engineering. It is an information sharing model established and improved by various majors on the basis of wireless sensor networks. It can realize the change of a certain parameter in the model, and the corresponding data in other majors can also be updated in time, reducing the redundancy of dubbing information.

4.2. Design Process Management Based on Wireless Sensor Network Technology. In the current common design stage workflow, the design stage mainly carries out scheme design, preliminary design, and construction drawing design, to determine the prefabricated building structural system and the type of prefabricated components, carries out plane, elevation, and section design, proposes interior decoration plans, etc., as shown in Figure 3.

Although there is a step of optimizing design, the effect on the detailed design of prefabricated buildings is not obvious, and it is generally limited to design error

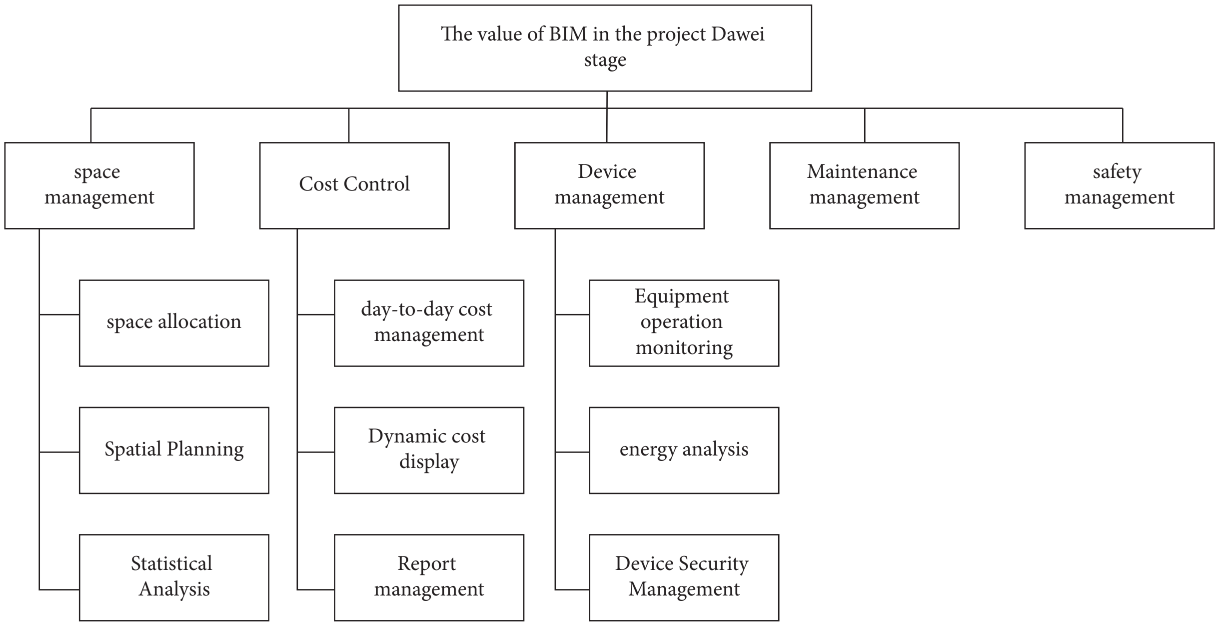

Figure 2: The application value of BIM technology in the engineering operation and maintenance stage.

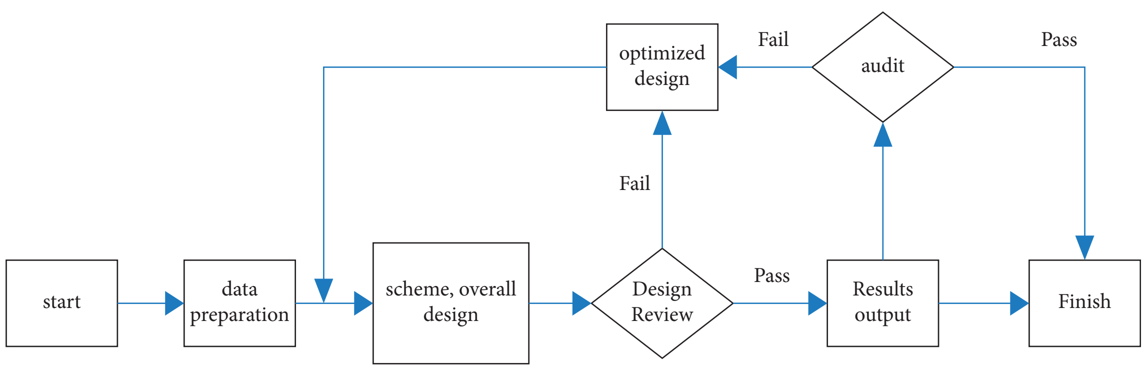

Figure 3: Common design phase workflow.

correction. At the same time, in the embodiment of the output of the results, it is also limited to the professional construction drawing design documents, calculation books, detailed drawings of nodes, detailed drawings of components, etc.

The application of wireless sensor network technology is more conducive to the quality management of prefabricated buildings and achieves refined quality management. First of all, in the management and control process of each participant of the project, Figure 4 clarifies the responsibilities of each participant in the deepening the design stage. The specific process is shown in Figure 4.

(1) All participants give feedback on relevant issues, further revise and refine the wireless sensor network model, conduct secondary disclosure after review, and determine the production, transportation, and construction plan for prefabricated parts [17].

(2) The design unit and the wireless sensor network consulting unit assist in deepening the design and promote the optimization of the wireless sensor network model. The production and transportation unit and the construction unit will decompose and refine the work by specialty according to the requirements of the construction project and clarify the requirements of each specialty.

(3) Integrate all professional work contents based on the wireless sensor network platform and conduct combined inspections with relevant participants to solve problems such as pipeline collisions in the design stage. If it passes the review, the detailed design will be completed; otherwise, it will be returned to improve it again.

The prefabricated building should take information management as the premise to realize the integrated design. It enables each stage and each link to work together, optimize development, and achieve refined quality management of prefabricated buildings.

Based on the ontology library formed by the structured processing of normative clauses and the building information model management library with the addition of time

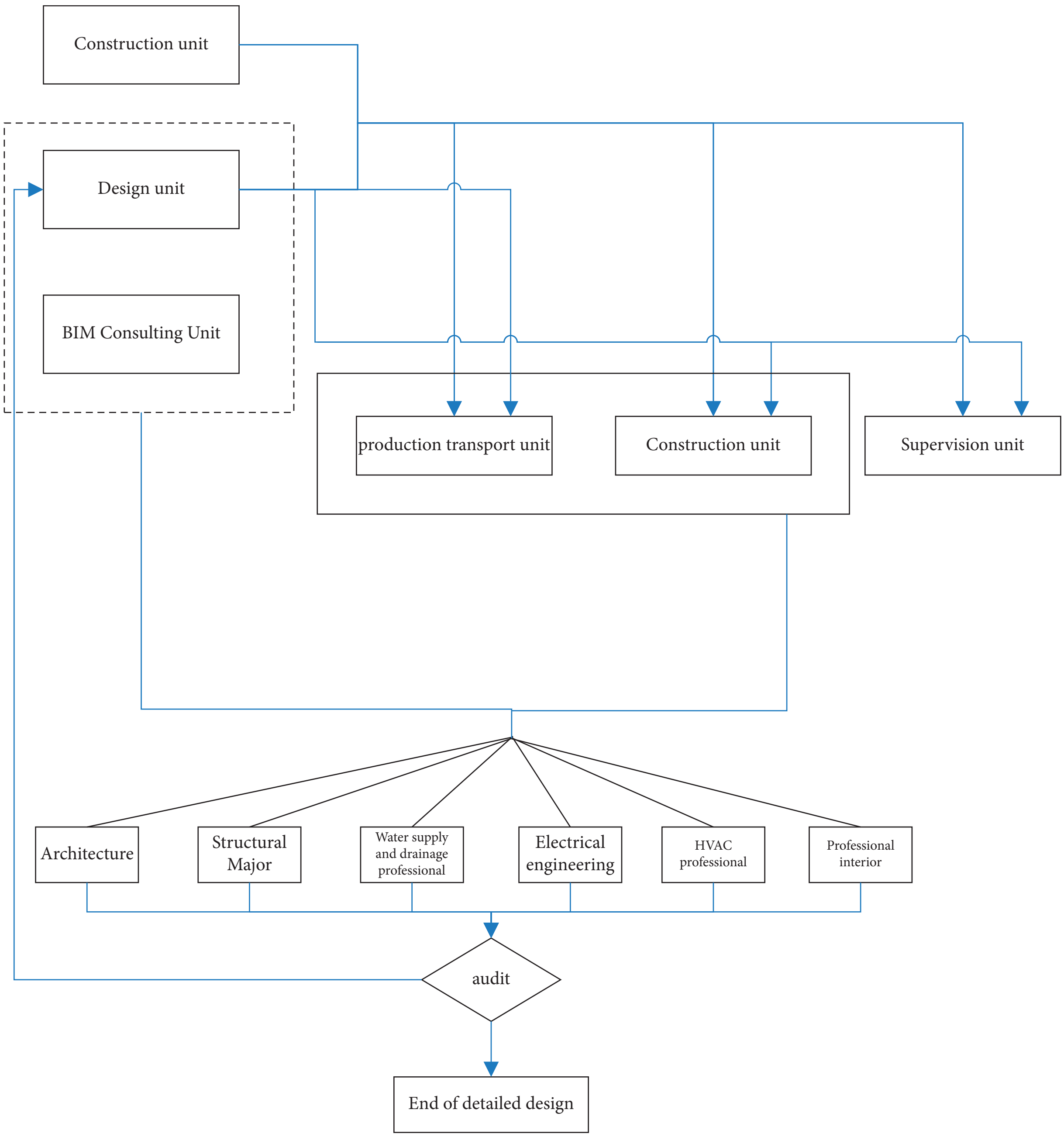

Figure 4: The management and control process of each project participant.

dimension, cost dimension, quality dimension, and lightweight technology, on the premise of clarifying the responsibilities of all parties involved in the project, the design flow figure of the deepening design stage is constructed, and the specific steps are shown in Figure 5.

The first step is to prepare data, including project assignments, topographic maps, and electronic files, and control planning requirements of local departments and other requirements of construction units. In the second step, based on the prepared data, the design information model is established on the wireless sensor network platform after coordinating and professional revising for many times with the participants. In the third step, the model information is output as the basic information of the project, and the review report is formed by performing normative information retrieval in the ontology database of the prefabricated building field, that is, the data reasoning of the two information databases. If it fully complies with the national standard, it will pass the design review. Otherwise, go back to the previous step to further improve and revise according to the review result report. The fourth step is divided into architecture major, structure major, water supply and drainage major, HVAC major, electrical major, and interior decoration major, and BIM design data is exported. These include the 6D model of the entire project cycle, various detailed 2D/3D drawings of components and composition information, and construction simulation animations [18].

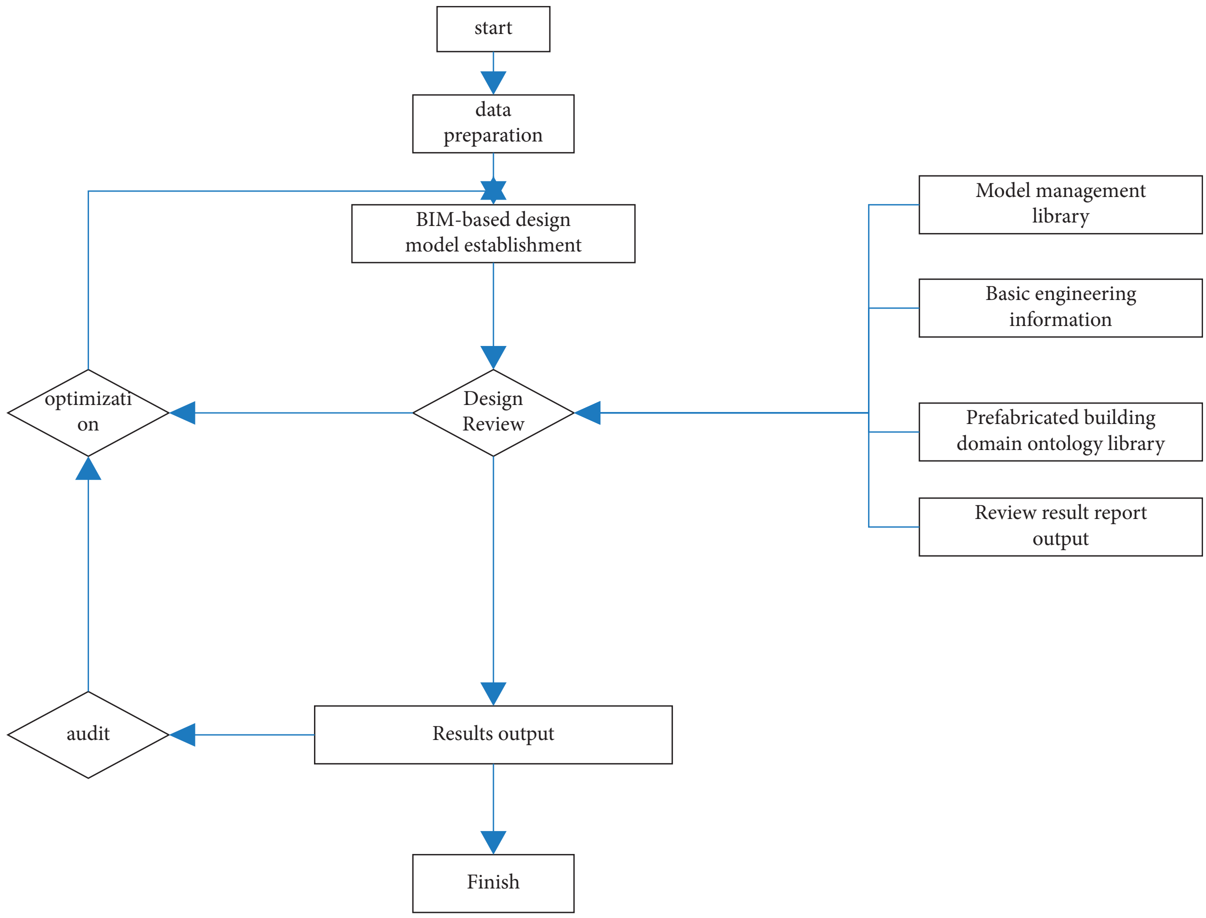

Figure 5: Design flow figure of the detailed design stage.

4.3. BIM-Based Operation and Maintenance Management System. Operation and maintenance management is the last stage in the entire construction project cycle and is an indispensable link. The longer the duration of operation and maintenance is, the more important it is to reflect the value of the building. However, judging from the current situation, most of the operation and maintenance systems just stop at the simple processing of data and do not use it. As a result, the management efficiency is not high, and the utilization rate of resource data is low, resulting in the waste of resources. However, judging from the current situation, most of the operation and maintenance systems just stop at the simple processing of data and do not use it. This results in inefficient management and low utilization of resource data and thus wasted resources. The operation and maintenance stage is faced with the complexity of big data processing in various equipment tools, space, energy consumption, and other aspects. Therefore, the informatization application degree of the operation and maintenance system should be continuously improved, as shown in Figure 6.

4.3.1. Equipment and Facility Management. The virtual 3D building data possessed by the BIM model is conducive to the efficient management of the operation and maintenance party and can realize the real-time status of the three-dimensional dynamic observation equipment. And it can provide a convenient visualization environment for complex pipeline systems, so that maintenance personnel can more clearly grasp the whole figure of the building. Facility and equipment management is mainly carried out through three aspects: asset inventory, daily management, and report management, as follows.

(1) *Daily Management.* The operation and maintenance provider conducts planned maintenance, formulates a list of quarterly and monthly planned maintenance tasks, and decomposes the plan and assigns the maintenance tasks to the weekly and daily plans. The above work can be carried out directly through the BIM information management platform, the quality plan formulation in the construction and assembly stage is synchronized, and information such as work content, executors, people in charge, acceptance people, and planned completion date is sent to relevant personnel for review and task notification. At the same time, the electronic maintenance feedback form is sent to the households and tenants who have applied for maintenance in a targeted manner, to verify the maintenance information and realize the refinement of the service.

(2) *Report Management.* Relevant participants can directly export relevant asset reports, financial reports, maintenance statistical reports, user feedback reports, etc., from the BIM operation and maintenance management

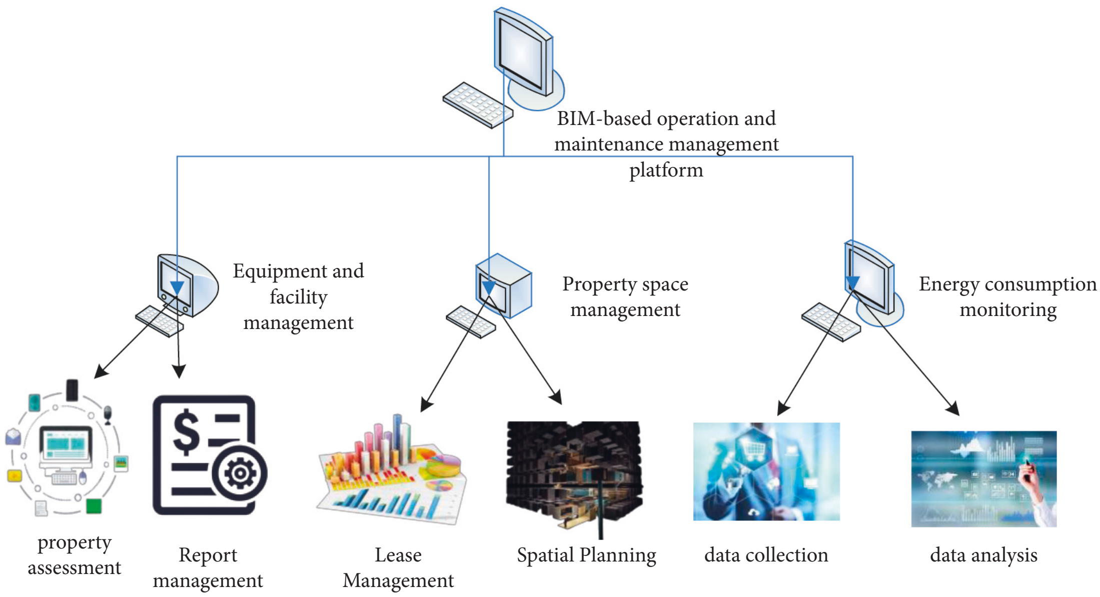

Figure 6: BIM-based operation and maintenance management platform.

center, according to their respective permissions, which is conducive to efficient management during the operation and maintenance period, thereby realizing refined management.

4.3.2. Property Space Management. Property space management is mainly carried out through three aspects: space planning, lease management, and statistical analysis, as follows.

(1) *Space Planning*. Based on the BIM lightweight model formed by integrating building space information by means of information technology, residents can quickly and comprehensively understand the residential community through the panoramic navigation cloud service. And they can track space usage with intelligent systems that integrate databases and BIM models [19]. Based on the planning of the project in the design deepening stage, the operation and maintenance stage can also further rationally plan the existing space through the wireless sensor network operation and maintenance management platform based on the reasonable needs of the owner, which can provide more humanized living experience and business environment for residents and merchants.

(2) *Rental Management*. To strengthen the management of house leasing and maintain the market order, if the house owner signs the lease contract with the lessee and has legal effect, it can make an online report. At the same time, BIM technology is used to manage the space visually, to facilitate the effective management of the property. At the same time, based on the operation and maintenance management platform of the wireless sensor network, shop merchants, parking space tenants, etc., can conduct online payments, consultation, and other related services.

(3) *Statistical Analysis*. Through statistical analysis of space usage and real-time leasing, it can meet space management needs and internal and external reporting requirements and better achieve space resource allocation and efficient processing of related affairs [20]. Under the premise of safety application and economical permission, the space with low utilization rate shall be renovated, and the responsible space shall be managed in a refined manner.

4.3.3. Energy Consumption Monitoring. Energy consumption monitoring is mainly carried out through three aspects: data collection, data analysis, and safety management, as follows.

(1) *Data Collection*. According to the fact that each metering device has an intelligent metering terminal, data acquisition terminal, etc., relevant data information can be entered dynamically. The BIM-based operation and maintenance management platform can classify and read energy consumption data item by item online and monitor the communication status of each metering device and transmission equipment in the system online.

(2) *Data Analysis*. Software such as Green Building Studio and Autodesk Ecotect Analysis can be used for energy simulation analysis to provide a report basis for later energy conservation and automatically save it to the database, to realize the dynamic year-by-year summary and analysis of the total energy consumption and energy consumption per unit area of each category [21].

5. Prefabricated Concrete Structure Design and Safety Investigation

5.1. Comparison of Modal Deconstruction. It can be seen from the above that the idea of fine management of prefabricated buildings based on BIM is very innovative. This chapter is to conduct a security investigation and analysis of a landmark building for refined management, which utilizes the node detection and data analysis capabilities in the wireless sensor network. The ETABS model converted from Revit is recorded as model A; the structural model

Table 1: Definition of load.

	Floor dead load (kN/m^2)	Floor live load (kN/m^2)	Side beam line load (kN/m)
2 layers	1.50	4.00	11
3 floors	1.50	4.00	11
4th floor	1.50	4.00	11
Big roof	4.00 (local 8.00)	3.00	11

established directly using ETABS is recorded as model B. A comparative analysis of the two models was carried out to study the stability and information validity of the structural analysis of the structural model converted from Revit. According to the functional division of the building and the arrangement of the structure, the definition of the structural load is shown in Table 1.

In this paper, a modal analysis was performed using the ETABS program to distinguish the first six orders of structural vibration and to obtain the frequency and period of the natural vibration of the structure. Period analysis and frequency analysis comparison: on the basis of the established structural model, modal analysis is performed on the first 6 rows using ETABS software. The period and natural frequency calculated by the model A are shown in Table 2.

The natural frequency of the model after the third order is clearly smaller than that of the first three orders. The higher the modal order, the smaller the period of the structure and the larger the natural frequency, which is in line with the basic theory of modal analysis [22]. Judging from experience, the first-order period of 1.037 is in line. The period and frequency calculated by model *B* are shown in Table 3.

The first-order period gap is only 0.006, but, with the increase of the order, the reduction rate of the model *A* period is larger, and the model *B* period is smaller. However, in the period of the first 6 orders, the gap is within the allowable range. Therefore, from the comparison of period and frequency analysis, it is feasible to convert from Revit model to ETABS model for structural analysis. The translational and torsional coefficients in the first three modes of the model are shown in Table 4.

It can be seen from Table 4 that the first mode shape translates as a whole along the *Y* direction and the *Y* direction is the vibration control direction of the structure. The second mode shape translates as a whole along the *X* direction, and the *X* direction is the vibration control direction of the structure; the third mode shape is the torsion around the *Z* axis.

Table 2: Model A period and frequency.

Working conditions	Modal	Cycle (sec)	Frequency (cyc/sec)
Modal	1	1.037	0.964
Modal	2	0.934	1.071
Modal	3	0.768	1.303
Modal	4	0.174	5.761
Modal	5	0.165	6.065.
Modal	6	0.15	6.65

Table 3: Model *B* and frequency.

Working conditions	Modal	Cycle (sec)	Frequency (cyc/sec)
Modal	1	1.031	0.97
Modal	2	1.026	0.975
Modal	3	0.891	1.123
Modal	4	0.327	3.06
Modal	5	0.322.	3.103
Modal	6	0.286	3.501

Table 4: Translational and torsional coefficients for the first 3 modes of model *A*.

Modal	1	2	3
Cycle	1.037	0.934	0.765
UX	0	0.975	0.023
UY	0.998	0.003	0.084
RZ	0.005	0.011	0.887

5.2. Structural Dynamics under Response Spectrum Load Cases. In this paper, the response spectrum method is applied to structural dynamic analysis. The relevant parameters of the response spectrum function are determined according to the relevant provisions of the "Building Seismic Design Law." The specific parameters are as follows: the maximum value of the earthquake influence coefficient is 0.08, the seismic intensity (SI) is 7°, 0.01, the characteristic period (Tg) is 0.9, the cyclic reduction ratio is 0.6, and the damping ratio of the function is 0.05. The response spectrum function period and its corresponding acceleration and response spectrum function images are shown in Figure 7.

The calculation model A defines 6 modal conditions, and the mass participation ratios of model *A* and model *B* are shown in Figure 8.

5.3. Background Investigation on the Safety of the Main Structure of the Building

5.3.1. Economic Survey of Construction Industry. The current booming economic development has gradually increased people's requirements for material life, and the scale of construction has gradually expanded. At the same time, China's economic growth cannot be separated from the contribution made by the construction industry. According to the statistics of the Bureau of Statistics of People's Republic of China, the GDP in 2021 will be 114.4 trillion yuan, a year-to-year increase of 8.1%. The total output value of the national construction industry was 29.3 trillion yuan, an increase of 10.29% over the same period of the previous year. China's construction industry has developed steadily and

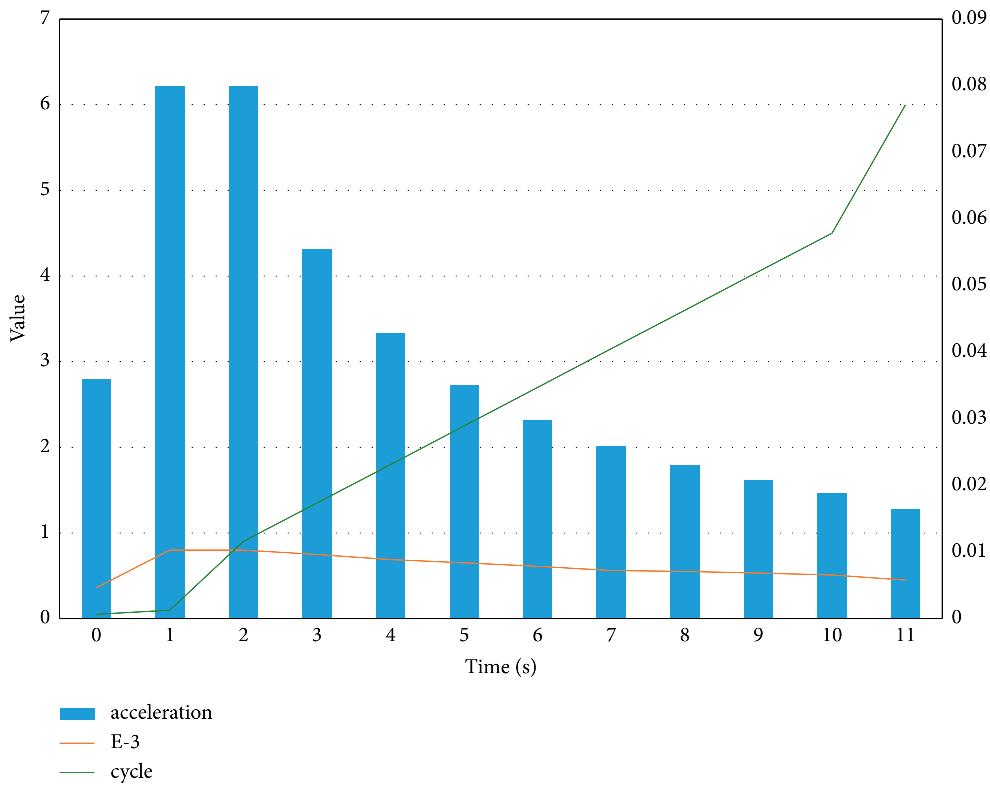

Figure 7: Acceleration vs. response spectral function image.

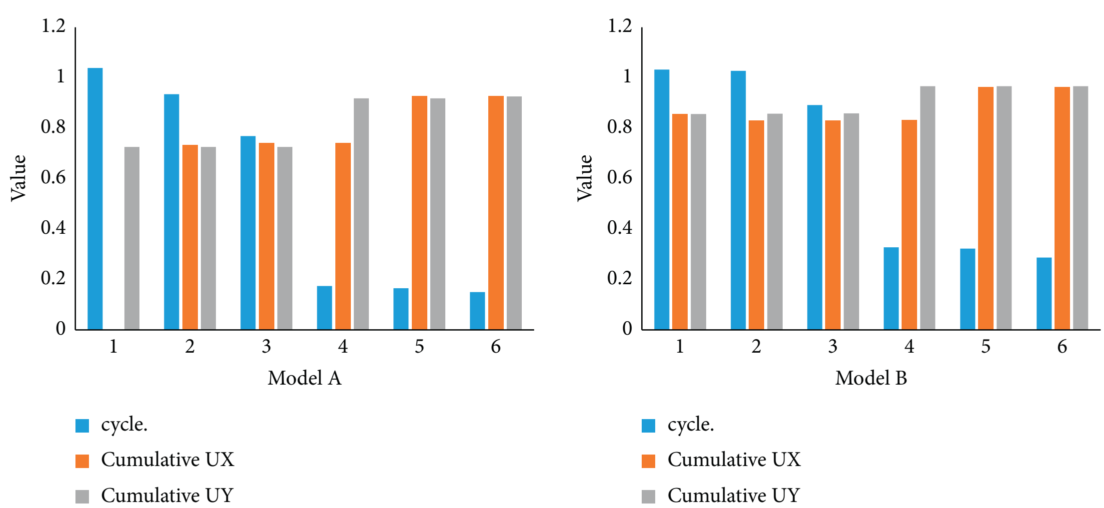

Figure 8: Comparison statistics of model A and model B.

rapidly at a level higher than the average level of various domestic industries, and, at the same time, the number of employees and enterprises in the construction industry has increased year by year in the form of statistical figures. It can be seen that the construction industry has become the backbone of the national economic development and is developing steadily, as shown in Figure 9.

5.3.2. Statistics and Analysis of Accidents in the Main Structure of Buildings. Among the safety accidents in the construction industry, accidents caused by the main structure of buildings frequently occur, which have attracted the attention of the public and need to be strengthened. In this study, due to the difficulty of obtaining accident statistics for large buildings, this paper divides the statistics of home security accidents and the statistics of various experts and researchers on the main structure of buildings. The statistical figure of construction accidents is shown in Figure 10.

According to the statistical analysis of accident types, it can be seen that the main structure of the building has a high

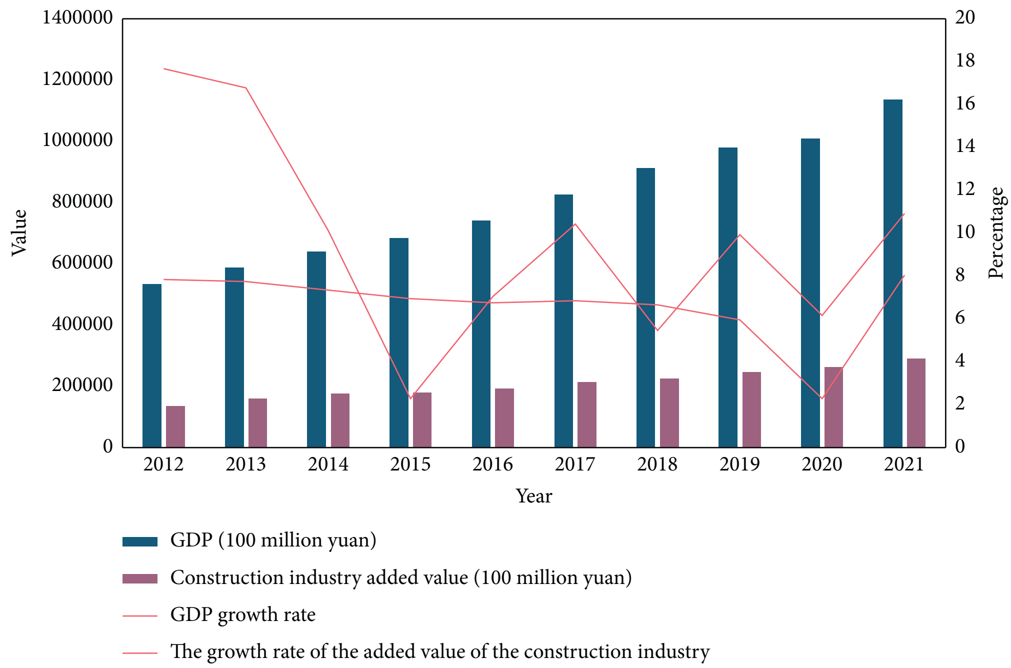

Figure 9: Statistical figures of national GDP and construction industry added value.

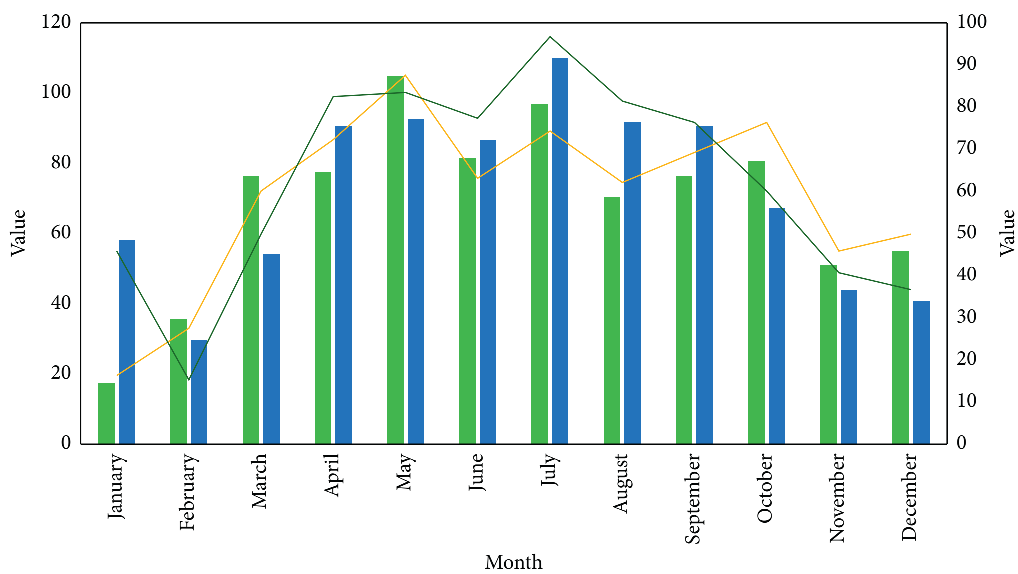

Figure 10: Statistics on the number of fatalities and the number of accidents in the construction industry.

frequency of falling, collapse, and object strikes. At the same time, it can be concluded from the above results that there are many defects in technology and organizational management and the focus is on the mistakes of operation and management of two types of construction groups. To improve the level of building safety management, it can be carried out by increasing technical training, strengthening on-site supervision and supervision, and improving safety management regulations [23]. If the personnel management is simply carried out, the problem of insufficient and comprehensive safety management may be caused due to factors such as experience, knowledge, and technology. Therefore, automatic safety management that does not rely solely on personnel is required at the construction site. Therefore, it is necessary to automate safety management that does not rely solely on personnel at the construction site. It can be seen that the importance of concrete engineering management is based on Internet of Things technology for the current construction industry. It can effectively help improve management efficiency, reduce the influence of human factors, and prevent construction data from being falsified, having a good practical application prospect in concrete engineering management.

In the preliminary project construction, BIM-based quality plan and implementation, the quality master plan of the construction phase of the assembly building is firstly clarified, the nodes of quality management subdivision in the whole process and the responsibilities of their relevant persons in charge are determined, and the information is imported by BIM technology professionals and the progress tracking of the quality plan is carried out online. In order to achieve reasonable arrangement, strict construction and dynamic management of personnel, and solve the problems of uneven number of personnel and irregular operation, the information platform is used to establish the management mode of personnel identification and behavior record. 3D views such as 3D detailed drawings of structures and construction simulation motion drawings are exported from the building information model management library; in addition, the quality plan, responsibility system, and assessment system formulated in advance are educated in advance to the construction site personnel in the preconstruction stage to strengthen the quality awareness of personnel and sign relevant contract agreements offline. BIM technology and RFID technology are combined to collect data, and then face recognition and real-time behavior capture are carried out by filtering and grouping the data.

6. Conclusions

This paper sorts out the theoretical basis and research status of prefabricated building quality management, wireless sensor network technology in the Internet of Things, wireless sensor network technology, and refined management. This paper analyzes the problems existing in the quality management of prefabricated buildings in the development of obstacles and finds out the convergence point between wireless sensor network technology, refined management theory, and quality management of prefabricated buildings. According to the characteristics of the prefabricated building itself, we determine the application direction of wireless sensor network technology and refined management theory in the quality management of prefabricated buildings. Under the theoretical support of refined management, "rejecting cumbersome management and grasping core issues" is the quality management orientation, and "standardization, refinement, and individualization" are the quality management elements. Combine the advantages of wireless sensor network technology visibility, coordination, simulation, optimization, and plotting' to solve the complexity of quality management of prefabricated buildings, build a refined quality management model of prefabricated buildings based on wireless sensor networks, and promote the realization of intelligent construction of the full life cycle of buildings. Therefore, in the future, development in the quality management of the whole life cycle of prefabricated buildings, based on the growth of the number of prefabricated buildings in the future, breaks through the limitations and expands the research ontology to propose a more accurate core content of quality management, for analysis and innovation.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analysed during it.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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