Digital Intelligent Management Platform for High-Rise Building Construction Based on BIM Technology

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Abstract—**In this study, the digital intelligent management platform of high-rise building construction based on BIM technology is used for real-time monitoring and management of construction progress and quality. In the data acquisition and processing layer, construction site data is obtained through RFID technology. After processing such as cleaning and integration, it is input to the BIM model layer to dynamically generate various real-time BIM models, and these real-time BIM model information is input to the application layer to query, monitor and correct the construction progress and quality. The results are presented by the display layer. The actual application results show that the real-time BIM models generated by the platform have clear details and can realize the query, monitoring and correction functions for the construction progress of high-rise buildings, and effectively correct the construction progress according to the construction progress monitoring query results to achieve the unification with the planned progress. It can effectively realize the visual measurement of the size of each component in construction and monitor the construction quality in real time.**

Keywords—BIM technology; high-rise building construction; digitization; intelligent management; BIM model; RFID technology

I. Introduction

With more and more complex high-rise construction and longer construction cycle in recent years, it makes the control of construction progress and quality more and more difficult. Therefore, the collaborative management of construction progress and quality of high-rise buildings has become a very important research topic in the field of engineering construction [1]. Many studies have been done by scholars at home and abroad for this purpose. At present, most of the studies are exploring the working principles of management and platform for comprehensive monitoring of progress and quality implementation in the construction phase. However, such management platforms lack specific responses in case of changes in project construction and are not effective in ensuring that high-rise buildings proceed as planned [2, 3]. Therefore, there is a need to create a platform that can adapt to this change.

J. Zhang et al. (2021) study the project critical chain schedule monitoring method based on project resource segmentation, and determine the early warning state value by multi-objective fuzzy comprehensive evaluation method, solve the overdue minimization objective function, and finally use BPNN to predict the next phase of the project so as to deal with the problems in the project implementation process in a timely manner. In order to realize the monitoring and management of project progress, this monitoring method of construction project progress can effectively predict the project risk situation and has good effect on reducing the overdue completion rate and overcapacity rate, but it does not implement monitoring and management of construction quality of the construction project [4]; Zhou, C et al. (2020) proposed that the digital construction management platform in EPC mode is mainly from EPC mode starting from the EPC model to solve the key problems in the digital construction of large enterprises, so as to analyze the necessity of applying the EPC model in digital construction. Although this platform can realize the basic digital management in construction, it lacks the function of real-time correction and adjustment according to the plan in the actual construction process [5]; Ma, G et al. (2019) proposed an engineering construction schedule optimization model based on improved genetic algorithm, constructed the overlapping strategy decision model of engineering schedule, combined with the optimization algorithm to output the overlapping strategy with precise overlapping rate, and obtained the overlapping strategy in meeting the premise of schedule requirements, the optimal schedule plan is obtained. This model can achieve the optimal management of project construction schedule, but does not have the ability to control the project construction quality [6]. In recent decades, information simulation technology has been widely used in the construction industry, especially the Building Information Modeling (BIM) technology. This technology is considered as an essential tool for construction project management. All project participants can share and exchange information with each other with the help of BIM technology platform, which is also an upgrade of CAD technology. In a real sense, it realizes industrialization, refinement, digitization, informatization, and intelligence in the construction industry [7, 8]. It not only reflects the geometric information of building entities, but also shows a large amount of building information such as structure type, material type, manufacturer, construction quality, etc. during the whole life cycle of a construction project. It not only provides a unified data and information source for the collaborative management of all project participants, but also promotes the reform process of building construction progress and quality management [9]. Obtaining 3D models through BIM technology can enhance the interactivity of manual models [10]. However, due to the large volume and high investment in the construction of high-rise

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buildings, the wide range of specialties and long period, the impact on the surrounding environment and complex construction organization and other challenges. Therefore, in the construction process of high-rise buildings, we need to adopt BIM technology to solve the problems of construction progress and quality management in real time. For the pre-processing of the data, RFID technology is required. This technology, also known as radio frequency identification, is a communication technology [11]. This technology allows the identification of specific targets and the reading and writing of relevant data through wireless communication without the need to establish mechanical or optical contact between the identification system and the specific target.

Based on the above analysis, this paper innovatively proposes a digital intelligent management platform for high-rise building construction based on BIM technology. The digitalization of construction progress and quality in the construction process of complex high-rise buildings is visually and intelligently monitored and managed, which improves the comprehensive management level in the construction process of high-rise buildings and ensures the construction progress and quality of high-rise buildings. Firstly, RFID technology is used for data collection, and then the data is input into the BIM model proposed in this study.

II. Digital Intelligent Management Platform for High-Rise Building Construction

A. *Overall Architecture Design of the Platform*

Architecture design of the digital intelligent management platform for high-rise building construction based on BIM technology. The key objective of the platform is to realize the visual digital intelligent management of the construction progress and quality of high-rise buildings, as well as to ensure the construction quality and progress. The overall architecture design of the platform is shown in Fig. 1.

The intelligent management platform is mainly composed of data acquisition and processing layer, BIM model layer, application layer and display layer. The data of high-rise building's construction site is collected through the data acquisition and processing layer. After processing the collected data, the BIM model layer uses the processed high-rise building's construction site data to build terrain BIM model, high-rise building's BIM model, high-rise building's construction information BIM model, construction machinery and equipment's BIM model and the 4D BIM model of high-rise building construction. Various BIM models are introduced into the application layer to prepare the progress plan and progress report of high-rise building construction, monitor and correct the construction quality and progress in time, simulate and optimize the construction process, and present various application results in the application layer to the construction manager in real time through the display layer, so as to complete the digital intelligent management of high-rise building construction progress and quality.

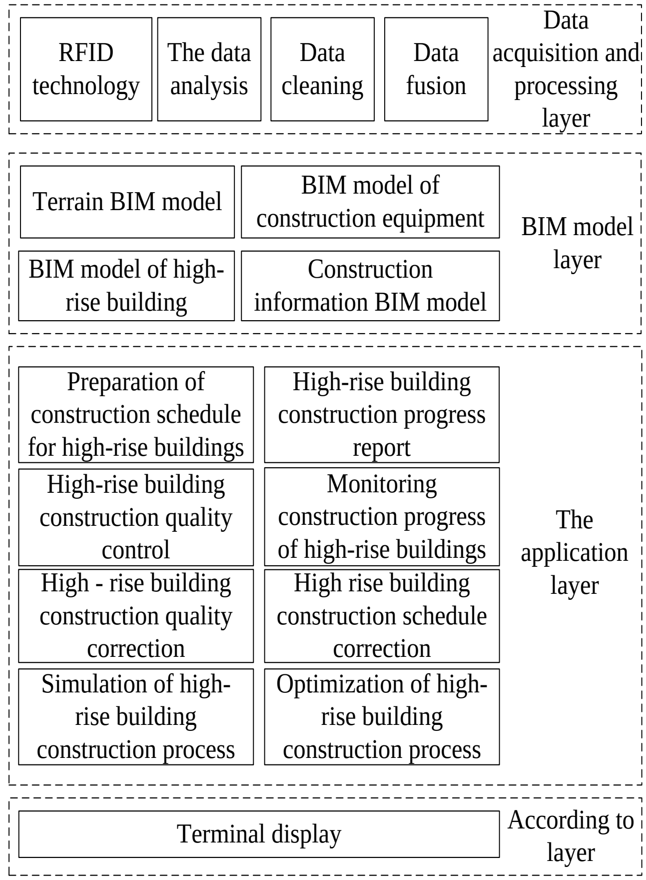


Fig. 1. Overall architecture diagram of digital intelligent management platform for high-rise building construction based on BIM technology

B. *Design of Data Acquisition and Processing Layer in Digital Intelligent Management Platform for High-Rise Building Construction*

In the digital intelligent management platform for high-rise building construction designed in this paper, the data acquisition and processing layer mainly realizes the collection and processing of building and mechanical equipment data on the high-rise building construction site. Therefore, this layer can be divided into two parts: data acquisition and data processing. The key contents of the two parts are as follows:

1) Data collection part: mainly using RFID technology to collect construction site data of high-rise buildings in real time. It provides strong data support for the realization of digital intelligent management of the building. In terms of applicability, RFID technology has technical advantages in the field of building management. Its superior non-contact reading and writing function can be used to quickly identify information such as high-rise building construction [12]. In this study, RFID technology is used to quickly identify and collect information from each instrument and equipment in high-rise buildings and construction, and to complete the storage and transmission of the collected information. Its structure is shown in Fig. 2.

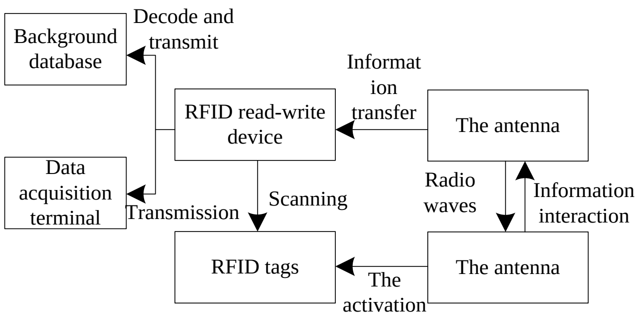


Fig. 2. Structure diagram of data acquisition part of RFID technology

The realization process of RFID technology in the data acquisition part is as follows: i) identification and information acquisition of buildings and mechanical equipment: the RFID technology in the data acquisition part is mainly composed of RFID tag, RFID reader and antenna. In the on-site construction process, RFID tag is generally placed in mechanical equipment, and RFID reader and writer are placed in each floor of buildings; when the RFID reader scans the RFID tag, the antenna of the RFID reader transmits radio waves, and the antenna of the RFID tag receives the transmitted radio waves, activates the RFID tag, and collects the existing building and mechanical equipment and other information, such as building and mechanical equipment ID; for mechanical equipment with motion range on the construction site, RFID can not only collect its construction information, but also realize the accurate positioning of mechanical equipment according to the collected information. ii) Information storage and transmission of buildings and mechanical equipment: after the RFID reader obtains the actual construction information of buildings and mechanical equipment on the construction site in real time, it can write the information into the RFID tag, decode it and transmit it to the RFID background database for storage by GPS or wireless network, or directly to the data acquisition terminal.

2) Data processing part: the data processing part is the intermediate filter layer for effective information transmission from the data acquisition part to the BIM model layer. The amount of information collected by RFID technology in the data acquisition part is huge and miscellaneous. It must be further processed by data analysis, data cleaning and data integration, so as to provide efficient data information flow for the management of high-rise building construction. Since a large amount of complex data will be generated during the construction of high-rise buildings, NoSQL, Sybase, Oracle and other databases can be selected for data storage of the information of buildings and mechanical equipment on the construction site obtained by RFID technology in the data acquisition part [13]; At the same time, due to the non-standard data form, data conflict, data duplication and other situations in the obtained information, in order to effectively manage the construction progress and quality of high-rise buildings in the digital intelligent management platform, it is necessary to analyze and clean such complex and diverse information data. Through the statistical analysis and network analysis of such information data, the classification and standardized processing of such information can be realized [14]; The cleaned and re selected data cannot be directly applied to the intelligent management platform. It is necessary to sort out such data forms through data integration, so that the BIM model layer in the intelligent management platform can directly extract and use these data, and use these data to obtain various corresponding BIM models, so as to lay a foundation for the application and implementation of the management platform.

C. Design of BIM Model Layer in Digital Intelligent Management Platform for High-Rise Building Construction

1) Structure Design of BIM Model Layer

Based on its own characteristics, if the traditional construction management mode is adopted, the management efficiency is not only low, but also easy to cause the loss of information and other problems. In this paper, the BIM model layer is designed by using BIM integration technology in the digital intelligent management platform of high-rise building construction, which can effectively solve the above problems. According to the digital intelligent management requirements of high-rise building construction, the BIM model layer structure of the digital intelligent management platform for high-rise building construction is designed. This layer uses different software to build three-dimensional terrain’s BIM model, high-rise building’s BIM model, construction machinery and equipment’s BIM model, high-rise building’s construction information BIM model and the 4D BIM model of high-rise building construction. Through the application layer of the digital intelligent management platform of high-rise building construction, the integration and application of this BIM model are realized, so as to realize the digital visual intelligent management of high-rise building’s construction progress and quality. The structural design of BIM model layer is shown in Fig. 3.

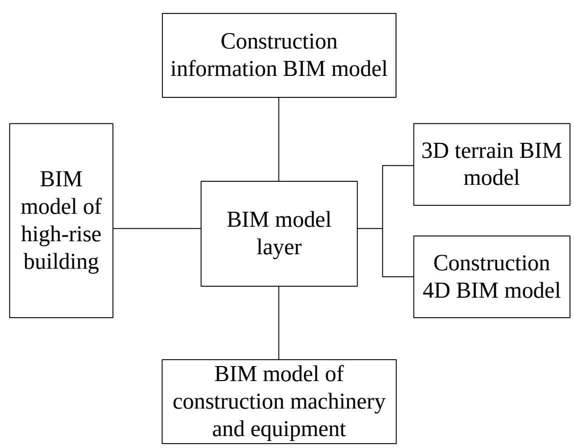


Fig. 3. Structure design drawing of BIM model layer

Various BIM models in the BIM model layer are described as follows:

a) Three-dimensional terrain's BIM model: this model is a three-dimensional real scene model, which can well reflect the terrain and geomorphic characteristics of the high-rise building's construction area. It is intuitive, vivid and realistic. The model is composed of terrain mapping data and real image. After collecting the terrain image of the area where the high-rise building construction is located, the three-dimensional digital model of surrounding buildings, terrain and geomorphic vector data and other information, it is imported into BIM software for processing, to obtain the three-dimensional BIM model of terrain and landform.

b) BIM model of high-rise building: in order to maximize the coincidence between the construction simulation and the actual construction process, taking the construction process of high-rise building as the goal and based on the construction scheme plan, the construction project of high-rise building is divided into different construction areas for modeling. The model is the basis of realizing digital intelligent management of high-rise building construction. It integrates physical and functional characteristics, including the spatial location, shape structure and material properties of high-rise building's construction projects. BIM model construction of high-rise building mainly includes two parts: terrain surface solid model and high-rise building's partition solid model. Whether it is terrain surface solid model or high-rise building's partition solid model conforming to partition, the multi-level of detail accuracy of components generated by BIM component assembler directly determines the accuracy of partition solid model of high-rise building construction [15-17]. BIM software editor can be used to improve the overall accuracy of generated components. The specific process is shown in Fig. 4.

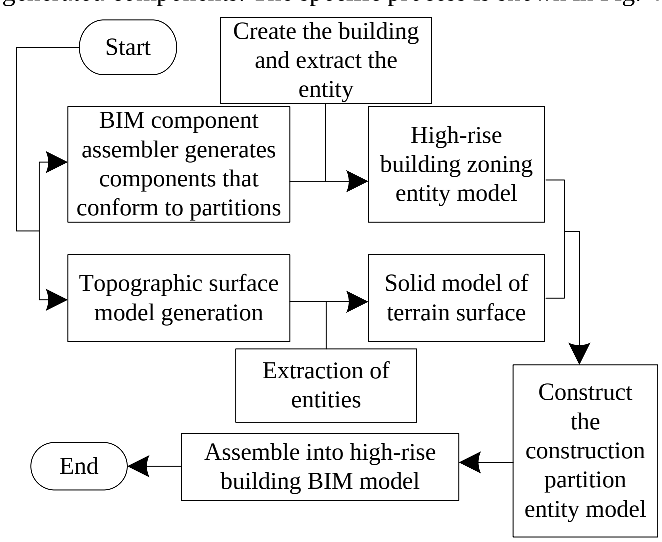


Fig. 4. BIM model assembly flow chart of high-rise building

c) BIM model of high-rise building's construction information: the BIM model of high-rise building's construction information based on BIM technology mainly includes construction progress and construction quality information, which has better visibility. This model can be created with the help of Microsoft Project (MSP), and the bar chart of on-site construction progress can be prepared according to the created model.

d) BIM model of construction machinery and equipment: the information data of various construction machinery and equipment on the high-rise building's construction site obtained and processed by the data acquisition and processing layer in the platform is used to import into the BIM software to generate the real-time BIM model of construction machinery and equipment in the operation of the construction site.

e) 4D BIM model of high-rise building construction: the 4D BIM model of high-rise building construction is the integration of BIM model and high-rise building's BIM model of high-rise building's construction information.

2) Design of Dynamic Modeling Process in BIM Model Layer

The accuracy of traditional manual modeling methods cannot be guaranteed, and it is time-consuming and laborious. It costs a lot in practical application. Due to many uncontrollable factors in the intermediate process of automatically creating BIM model, it is easy to miss or deviate from the model. Therefore, in the digital intelligent management platform of high-rise building construction, the dynamic modeling process of BIM model layer combines time series and planning model to realize the dynamic generation of various BIM models. In the design stage before the construction of high-rise building project, the pre generated BIM model corresponding to the construction plan of high-rise building project [18] is the planning model. According to this planning model, various BIM models can be dynamically created, which can make full use of the planning model to complete the verification of the real-time creation model, ensure the accuracy and integrity of high-rise building construction, and reduce the complexity of automatic modeling.

The dynamic modeling method used in the BIM model layer in this paper is to obtain the spatial position and orientation of each model component in the actual high-rise building's construction project by using the processed on-site construction data on the basis of the data acquisition and processing layer, and change the planning model to obtain various actual BIM models according to this kind of actual information. This way of creating the actual BIM model based on the planning model can not only ensure the accuracy of the BIM model, but also reduce the complexity and workload. For the convenience of description, U_a is defined as the actual BIM model generated by the BIM model layer, and U_b is defined as the plan model. Then the relationship between the two is:

$$U_a = \delta(U_b) \quad (1)$$

Where, δ represents the model change function, which aims to transform the planned model components according to the information of the actual high-rise building's construction site, such as rotation, clipping, spatial position movement and so on. The planning model U_b can be described by a series of elements C_b and the relationship H_b between elements, that is:

$$U_b = \langle C_b, H_b \rangle \quad (2)$$

Therefore, only a certain transformation of C_b and H_b is needed to generate U_a. The transformation equation used here is:

$$\max^l \left[fit\left(B, U_b^l\right) \right] \rightarrow \tilde{U}_b \sim U_a \quad (3)$$

Where, B represents the characteristics of the obtained construction site data; U_b^l represents the BIM planning model modified by l iterations; $fit\left(B, U_b^l\right)$ represents a function for calculating the similarity between B and U_b^l; $\tilde{U}_b$ represents an approximate solution of U_a and the optimal solution of fit function. This dynamic modeling method of real-time generating BIM model based on planning model not only has high modeling efficiency, but also has high precision, and can reconstruct the covered part. The dynamic modeling process of BIM model layer combining time series and planning model is shown in Fig. 5.

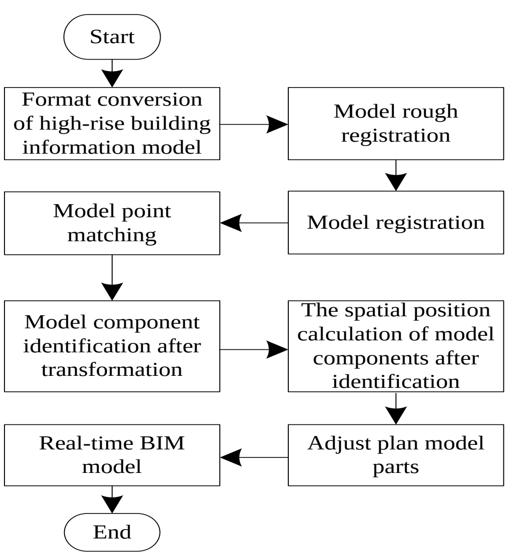


Fig. 5. Dynamic modeling process diagram of BIM model layer combined with time series and planning model

The detailed steps of dynamic modeling process of BIM model layer combining time series and planning model are as follows:

1) Format conversion of high-rise building's information model: in order to obtain the detailed information in the BIM model, it is necessary to convert the irregular geometry in the BIM model into triangles, that is, convert the parametric BIM model into STL data format [19]. Relatively complex planes or surfaces can be represented in detail by triangles.

2) Rough model registration: rough registration of the converted model is carried out based on the spherical coordinate system. The converted model is an entity to be pseudo scanned in the coordinate system. In the matching process, it is necessary to select the datum points of high-rise building's construction engineering facilities to obtain more than three point pairs, and then rough registration is carried out.

3) Fine model registration: for each scanning point in the data generated after laser scanning of the solid parts of the converted model, the model points of the corresponding parts can be found in the planning model after mapping, to record the included angle in the horizontal direction and the inclination angle in the vertical direction when the laser scanner scans the solid parts of the converted model. These two angles can determine the direction of the ray for the pseudo scanning of the converted model; Then, by calculating the intersection and distance between the triangular surface of a part in the planning model and the previously determined ray, the obtained intersection is the model point matching the scanning point; The vertices and corresponding intersections of STL triangles in the converted model need to be represented by spherical coordinate system, so the horizontal included angle and vertical inclination of the boundary of each triangle element can be identified.

4) Model point matching: in the construction of high-rise buildings, each model point of each component can be matched with the corresponding scanning point. The previous coarse registration and fine registration ensure that each model point has the same angle with the actual scanning point. Therefore, it only needs to compare the distance ΔD between the model point and the scanning point to determine the relationship between this distance and the preset threshold ΔD_{max}. If $\Delta D \leq \Delta D_{max}$, it is considered that the two-point pairing is successful. Therefore, the definition of D2 directly determines whether the automatic matching can be successful. ΔD_{max} is defined as:

$$\Delta D_{\max} = \varepsilon_1 + \bar{\varepsilon}_2 \quad (4)$$

Where, ε_1 represents the acceptable construction error in the actual high-rise building construction; $\bar{\varepsilon}_2$ represents the average value of registration error.

5) Recognition of model components after conversion: for the point matching method, as long as a certain number of point pairs are judged to match, it can be considered that the components are recognized, but its stability depends on the number of point pairs sought [20]. Here, a method with higher stability is combined to judge whether the object is recognized more effectively. The process of the method is as follows: i) define parameter A_e as the surface area of the model, that is, the sum of the areas formed by the equal division of the distance between adjacent discrimination points. ii) Define the model's surface area threshold S_e as:

$$S_e = n \tan\alpha \tan\beta \,\mathrm{dist}_{\max}^2 \quad (5)$$

Where, n represents the minimum number of model recognition point pairs; $\tan\alpha$ and $\tan\beta$ represent the tangent functions of the horizontal included angle and vertical inclination of the model components respectively; $\mathrm{dist}_{\max}^2$ represents the highest distance function of the distance between adjacent discrimination points. The accuracy of component identification is guaranteed by setting an appropriate threshold S_e. When the threshold S_e is less than or equal to A_e, the component can be considered to be successfully identified.

6) Spatial position calculation of model components after identification: after the components of the converted model are successfully identified, the position and orientation of such components need to be calculated. After the third step of fine registration, the converted model will be paired with the real-time high-rise building's state data points, so that the spatial position information such as the position and orientation of the components that have been successfully identified can be calculated. According to the spatial position information of such actual components, various real-time BIM models in high-rise building construction can be obtained by adjusting the parts of the plan model, such as rotation and clipping.

D. Construction Progress and Quality Monitoring Process of Application Layer in Digital Intelligent Management Platform for High-Rise Building Construction

In this paper, the application layer of the digital intelligent management platform for high-rise building construction mainly realizes the functions of construction progress planning, report generation, monitoring, correction, construction quality monitoring, and the optimization and simulation of the whole construction process, etc. Among them, construction progress monitoring and construction quality monitoring are particularly keys. Therefore, the design is implemented for the monitoring process of high-rise building's construction progress and quality. Fig. 6 shows the details.

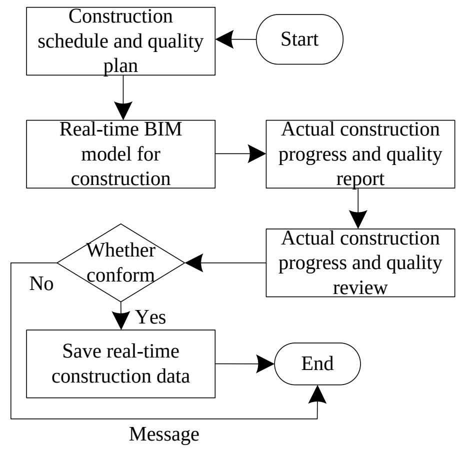


Fig. 6. Monitoring process diagram of construction progress and quality

Construction progress and quality monitoring is based on the construction plan. The BIM model layer is used to import various BIM models in the actual construction of high-rise buildings in the application layer, so as to visually and intelligently supervise whether the actual construction progress and quality of high-rise building projects under construction are consistent with the construction plan, so as to achieve the purpose of digital intelligent management of high-rise building's construction progress and quality. The management of high-rise building's construction progress and quality realizes the input of time nodes and construction tasks of high-rise building's project construction. In the management process, the generated construction progress chart and construction quality model chart can be reviewed to observe whether they meet the construction requirements, and the construction progress and quality can be checked and recorded in real time.

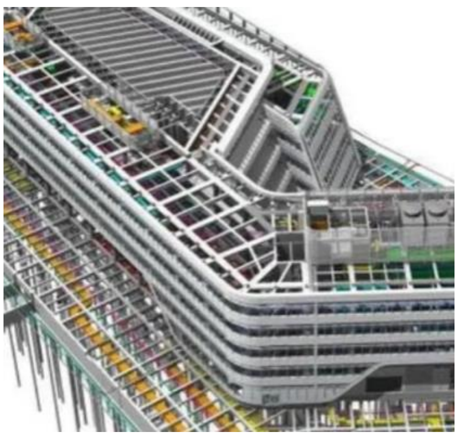
In the digital intelligent management platform of high-rise building construction, the construction progress and quality report is generated according to different time periods. Through the comparative analysis of the current construction progress and quality and the planned construction progress and quality, the report is formed and output through the display layer to realize the supervision and reminder of high-rise building's construction progress and quality; At the same time, it can query the completion of high-rise building's construction tasks according to the time, content, cycle and other keywords of construction tasks, and adjust the construction progress and quality of high-rise buildings in real time to avoid the waste of time, manpower and economic cost. So far, the design of digital intelligent management platform for high-rise building construction based on BIM technology has been completed.

III. Analysis of Experimental Results

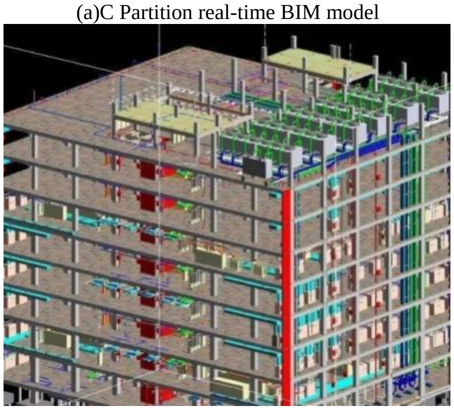
Taking a high-rise building project under construction in an area as an example, this platform is applied to the construction management of the high-rise building project to test the practical application effect of this platform. The high-rise building project is divided into 10 partitions, each partition is numbered a ~ j. Digital intelligent management is implemented for the construction progress and construction quality of each partition through the platform of this paper. The specific inspection process and results are analyzed as follows:

A. *Construction Progress Management Process and Result Analysis*

Firstly, two partitions c and f are randomly selected from the 10 partitions of the experimental high-rise building project, and the real-time BIM models of the two selected partitions are obtained through the platform in this paper. The presentation results are shown in Fig. 7.



(a)C Partition real-time BIM model



(b)F Partition real-time BIM model

Fig. 7. Real-time BIM model of each partition of experimental high-rise building presented by this platform

It can be seen from Fig. 7 that the real-time BIM model of each partition of the experimental high-rise building presented by the platform in this paper can show the internal information and layered information of the building in detail, and the visualization effect is clear, which is convenient for users to view and monitor the construction progress in real time, so as to realize the digital intelligent management of high-rise building construction.

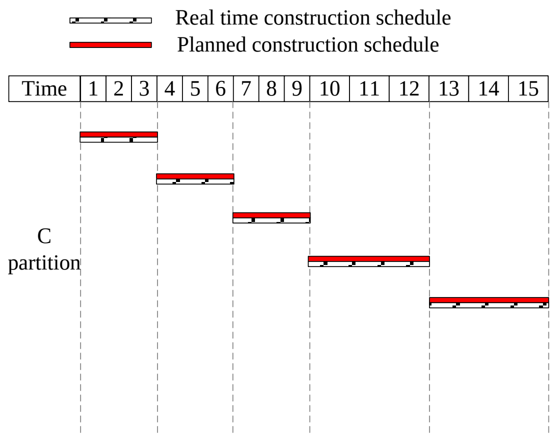
The real-time construction progress of partitions c and f of the experimental high-rise building is obtained through the platform in this paper. The deviation between the obtained real-time construction progress and the planned construction progress is compared and analyzed to realize the real-time monitoring of the construction progress. The bar chart of deviation comparison and analysis is shown in Fig. 8.

According to the analysis of Fig. 8, the real-time construction progress of each partition of the experimental high-rise building can be obtained through the platform. After comparing the implementation deviation between the real-time construction progress of each partition obtained by the platform and the planned construction progress, it is found that the real-time construction progress of partition c of the experimental high-rise building is basically consistent with the planned construction progress, and there is almost no deviation; The real-time construction progress of partition f is different from the planned construction progress, and the deviation between the two is obvious. The actual construction progress of the partition is one day later than the planned construction progress. Therefore, the platform in this paper can monitor the actual construction progress of experimental high-rise buildings in real time, so as to provide guarantee for correcting the construction progress in time and ensuring the completion of the overall construction on schedule.

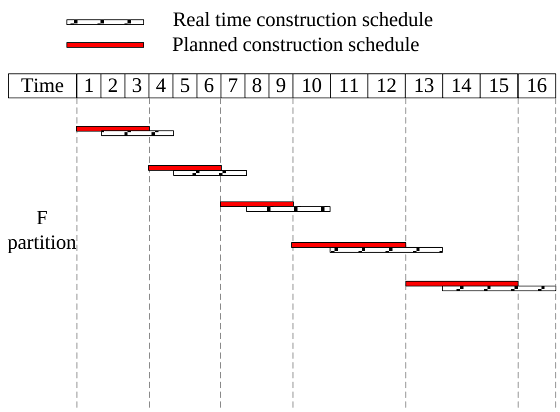
Through the platform in this paper, the real-time construction progress of all partitions of the experimental high-rise building is obtained according to the above methods, and compared with the implementation deviation of the planned construction progress of each partition respectively, the obtained data are stored in the background database of the platform in this paper, and the number of each partition is used to query the planned and actual construction progress data of each partition to complete the construction progress query task. The query results are shown in Table I.

TABLE I. REAL-TIME QUERY RESULTS OF CONSTRUCTION PROGRESS OF THE PLATFORM IN THIS PAPER

Partition number	Plan time	The actual time	Schedule analysis	Delays
a	March 10, 2021	March 15, 2021	The required progress has been reached, but the progress is delayed	Delay 5 days
b	March 13, 2021	March 12, 2021	Arrive ahead of schedule	Without delay
c	March 8, 2021	March 8, 2021	According to the original schedule to reach the specified progress	Without delay
d	March 15, 2021	March 18, 2021	The required progress has been reached, but the progress is delayed	Delay 3 days
e	March 20, 2021	March 24, 2021	The required progress has been reached, but the progress is delayed	Delay 4 days
f	March 6, 2021	March 7, 2021	The required progress has been reached, but the progress is delayed	Delay 1 day
g	March 5, 2021	March 5, 2021	According to the original schedule to reach the specified progress	Without delay
h	March 17, 2021	March 18, 2021	The required progress has been reached, but the progress is delayed	Delay 1 day
i	March 1, 2021	March 3, 2021	The required progress has been reached, but the progress is delayed	Delay 2 days
j	March 25, 2021	March 31, 2021	The required progress has been reached, but the progress is delayed	Delay 6 days



(a)Comparison between real-time construction progress and planned construction progress in c partition



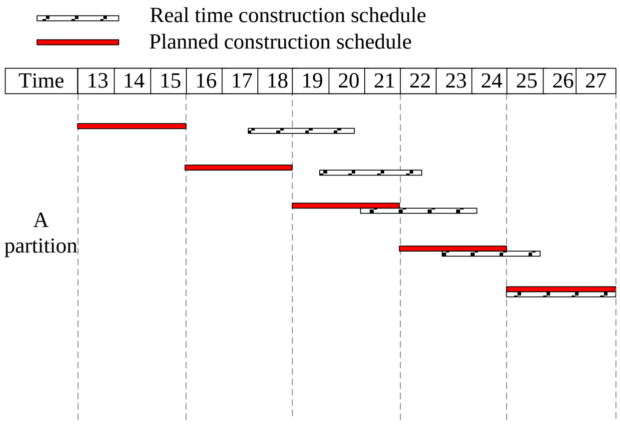
(b)Comparison between real-time construction progress and planned construction progress in f partition

Fig. 8. Horizontal chart of deviation between real-time construction progress and planned construction progress in each partition

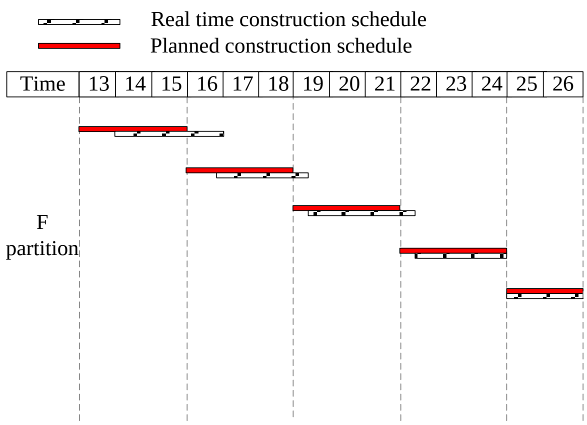
It can be seen from Table I that the platform in this paper can query the actual construction progress of each partition of high-rise building in real time. From the query results, it is known that the actual construction progress of three partitions b, c and g of the experimental high-rise building project is not delayed compared with the planned construction progress, and the construction progress of the other seven partitions is delayed to varying degrees.

Based on the above query results, under the management of the platform in this paper, the construction progress correction is implemented for the seven partitions with construction progress delay. Taking three partitions a, f and j as examples, the bar chart of the real-time construction progress and planned construction progress of each partition after the correction of this platform management is presented to test the correction effect of construction progress management of this platform. The construction progress bar chart of each partition is shown in Fig. 9.

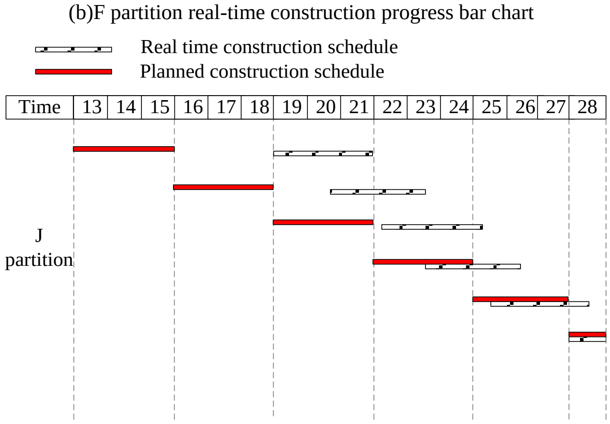
As can be seen from Fig. 9, after the construction progress correction is implemented under the management of the platform in this paper, the actual construction progress and planned construction progress of each partition with construction progress delay in the experimental high-rise building project can be gradually unified. The construction progress management effect of the platform in this paper is remarkable, which can provide effective guarantee for the construction period of high-rise buildings. The data processing efficiency and progress error of this method, digital twin (DT) technology and EPC mode digital building management platform in construction progress are compared and analyzed. The results are shown in Table II.



(a)A partition real-time construction progress bar chart



(b)F partition real-time construction progress bar chart



(c)J partition real-time construction progress bar chart

Fig. 9. Horizontal chart of real-time construction progress and planned construction progress in each partition after correction of platform management in this paper

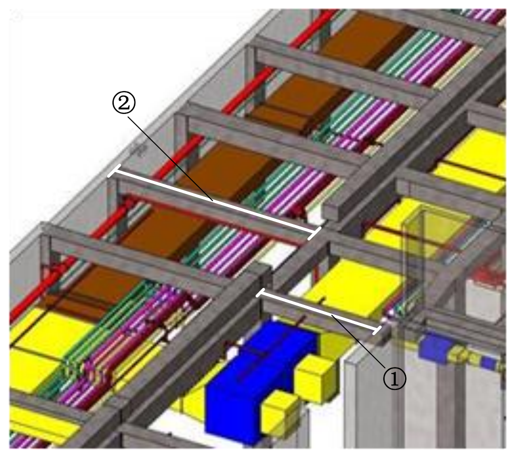
TABLE II. COMPARATIVE ANALYSIS TABLE

Comparison Items	BIM	DT	EPC
Data processing efficiency	91.89%	78.93%	79.97%
Progress advancement error	0.156	0.342	0.459

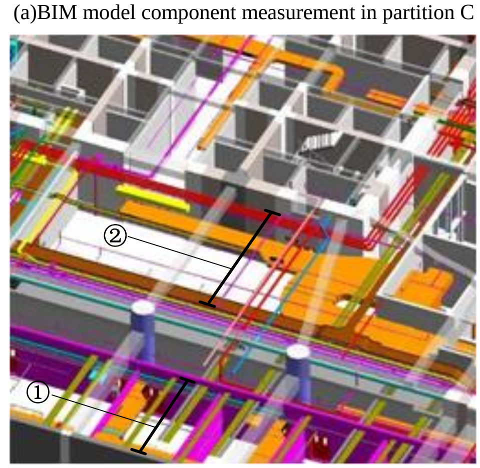
It can be seen from Table II that the data processing efficiency of BIM model is 91.89%, and the progress error is 0.156, which is better than the processing progress of digital twin (DT) technology and digital building management platform under EPC mode. The construction progress management of BIM technology platform has a remarkable effect, which can provide an effective guarantee for the construction period of high-rise buildings.

B. *Construction Quality Management Process and Result Analysis*

Based on the platform in this paper, the parts of the real-time BIM model of the two partitions c and f of the experimental high-rise building are obtained. Using these parts, we can measure whether the size of the internal components in the construction of each partition of the experimental high-rise building meets the construction requirements in real time, so as to achieve the purpose of real-time visual monitoring of the high-rise buildings' construction quality. Taking the random components in the real-time BIM model of partitions c and f obtained by the platform in this paper as an example, the real-time measurement is shown in Fig. 10.



(a)BIM model component measurement in partition C



(b)BIM model component measurement in partition F

Fig. 10. Real-time measurement of BIM model components in each partition of experimental high-rise building obtained by the platform in this paper

As can be seen from Fig. 10, the internal details for the BIM model components of each partition of the experimental high-rise building obtained by the platform in this paper are clear, which can be used to realize the real-time visual measurement of the dimensions of each component in the component, so as to achieve the purpose of real-time monitoring the quality of each component in the construction of high-rise building.

IV. Discussion

This paper mainly analyzes the practical application effect of the platform in this paper from two aspects: the first aspect is the management effect of this platform on the construction progress of high-rise buildings; The second aspect is the management effect of the platform on the construction quality of high-rise buildings. Among them, the management effect of this platform on the construction progress of high-rise buildings is mainly tested through the actual construction progress monitoring, query and correction. The test results show that this platform can realize the functions of real-time progress monitoring, query and correction in the actual construction of high-rise buildings, and has a significant effect on the comprehensive management of construction progress; The management effect of this platform on the construction quality of high-rise buildings is only tested by the quality monitoring in the actual construction. The test results show that this platform can realize the real-time monitoring function of each component quality in the actual construction of high-rise buildings, but it is not verified for other functions of construction quality. This part needs to be further carried out in the future research, in order to improve the verification of the comprehensive management effect of high-rise building construction quality.

V. Conclusion

With the development of science and technology, infrastructure construction is developing rapidly, and also showing the development trend of scale and complexity. In order to ensure that building construction can be put into use properly, it is necessary to ensure that the project can be completed on time as planned. Therefore, this paper proposes a digital intelligent management platform for high-rise building construction based on BIM technology to achieve comprehensive management of progress and quality during high-rise building construction by integrating the processes of data collection and processing, dynamic generation of BIM models, and construction progress and quality monitoring. The application effect of the platform was tested through practical engineering applications. The results show that the data processing efficiency of the BIM model proposed in the study is 91.89%, and the progress error is significantly lower than that of the digital construction management platform model under digital twin (DT) technology and EPC mode, and the application effect in construction progress monitoring, query, correction and construction quality monitoring is significant, which can realize the digital, visualization and intelligent management of high-rise building construction. In the future, we will continue to study the energy consumption and cost management in high-rise construction and further expand the practical application of this platform. This research can track the construction progress and monitor the construction quality in real time, which has significant effect compared with other technologies.

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