Short Research Article

Application of BIM based information management technology in prefabricated buildings

Abstract: Under the background of industrial transformation and green development of construction industry, prefabricated building has become an important means to promote the development of construction industrialization and environmental protection. In the period of new and old construction mode change, the construction links of in-depth design, component production, component transportation and assembly construction are added to the prefabricated building, which has higher requirements for the unity of the whole process of the construction project. BIM platform can unify the information of the whole process and coordinate the management of the whole process of the project. This paper expounds the application of information management technology based on BIM in the three processes of in-depth design, component production and transportation management of prefabricated building. Through the analysis and comparison of actual cases, it is concluded that the prefabricated building combined with BIM Technology has more advantages than traditional construction in design, management, capital, environmental protection, etc.

Keywords: Prefabricated building; information management; transportation management; BIM Technology

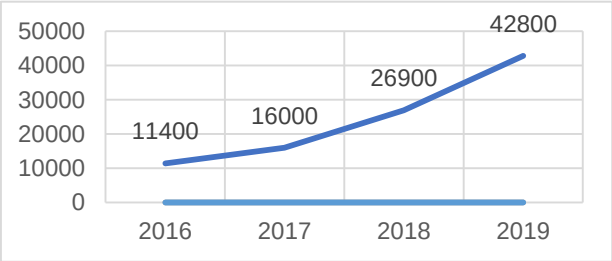
0 Introduction

The common building construction method in China is cast-in-place reinforced concrete. However, there are a lot of problems to be solved in the traditional construction mode under the modern green development environment: a lot of construction waste, long construction period, low production efficiency and the rising cost of construction site.

Under the background of industrial transformation of the construction industry, prefabricated construction has become a new choice to upgrade the construction mode. According to incomplete statistics [1], China's provinces and cities have issued more than 150 policy documents related to prefabricated construction, and all regions actively promote prefabricated construction projects. In 2019, the newly started prefabricated building area in China will be 420 million m^2, an increase of 45% over 2018. On the whole, prefabricated building has a good development trend in China. Graph 1 shows the newly started areas of prefabricated buildings in China in recent four years.

Graph 1: New construction area of prefabricated buildings in China from 2016 to 2019

（ten thousand m^2）



Some domestic scholars have studied and analyzed the feasibility of BIM application in prefabricated buildings. Zhang Hao[2]proposed that the QR code identification generated by BIM model can be bound to the prefabricated components, and the information about the production, transportation and installation of prefabricated components can be queried and mastered through the code scanning form of intelligent devices, thus realizing an efficient management mode. Wei Dong quan[3]thinks that the application of BIM information model in assembly component processing and production can meet the needs of enterprise management, improve enterprise production efficiency and reduce enterprise operation cost. Chen Min[4] believe that the BIM based prefabricated construction project management improves the efficiency of project management to a great extent, and realizes the comprehensive information management in the aspects of component deepening, transportation management, quality inspection, whole process control, etc.

On the basis of practical engineering cases and related research, this paper discusses the construction mode of prefabricated building with BIM information management as the carrier, analyzes the difficulties existing in the prefabricated building project according to the unique attributes of prefabricated building, and puts forward relative solutions.

1 Prefabricated building information generation

Compared with traditional buildings, prefabricated buildings add more links in the project process, which makes the project operation and management more complicated. The construction process of prefabricated buildings is a chain process, which is connected with each other. A more systematic management mode is needed to make each link more precise. However, each link will produce a large amount of information and data, which need to be transmitted and exchanged by all parties.

There are differences in project process between traditional construction and prefabricated building, which produce a lot of data. The data generation stage in the new links of prefabricated building includes design stage, component deepening stage, component production stage, component transportation stage and component hoisting stage. The above added links involve the exchange, transmission and extraction of information, and the traditional construction technology is difficult to manage the generation of a large number of new information. Based on the theory of BIM intelligent construction site[5], the information is managed by means of Internet of things and big data, and the management mode of assembly information model is established.

2 Application of BIM Technology in assembly project

BIM is a platform based on the whole life cycle of the project, which should be lean designed according to the characteristics of prefabricated buildings to improve management efficiency.

2.1 Project overview

The project is the relocation project of Nantong Party school, which adopts BIM management

platform and assembly technology. The background of the project is composed of 5 floors of teaching building (height: 22.05m), 3 floors of administration building (13.50m) and 2 lecture halls The building is composed of three storeys (height: 17.45m), 15 storeys (height: 54.950m) of canteen and student apartment building, 2 storeys (height: 17.8m) of culture and Sports Center, and 23000 m^2 basement. Except that the culture and sports center is located outside the basement, the rest are the superstructure of the basement, with a total building area of 65000 m^2. The building structure is prefabricated integral frame cast-in-place shear wall structure. The type of prefabricated components: precast beam, precast slab and precast building The assembly rate is 51%.

2.2 Application of BIM Technology in the design stage of prefabricated building

The difficulties of this project lie in many specialties, short project cycle and many technical difficulties. BIM management platform can coordinate various specialties, manage the whole process of the project, and deal with the problems encountered in the construction in advance.

The assembly project is managed based on BIM platform. BIM information model management platform is an efficient platform to achieve common information. Designers of different specialties can design and modify synchronously in a multi-user way. Under the condition of collaborative design (Fig.1), conflicts between specialties can be found in time.

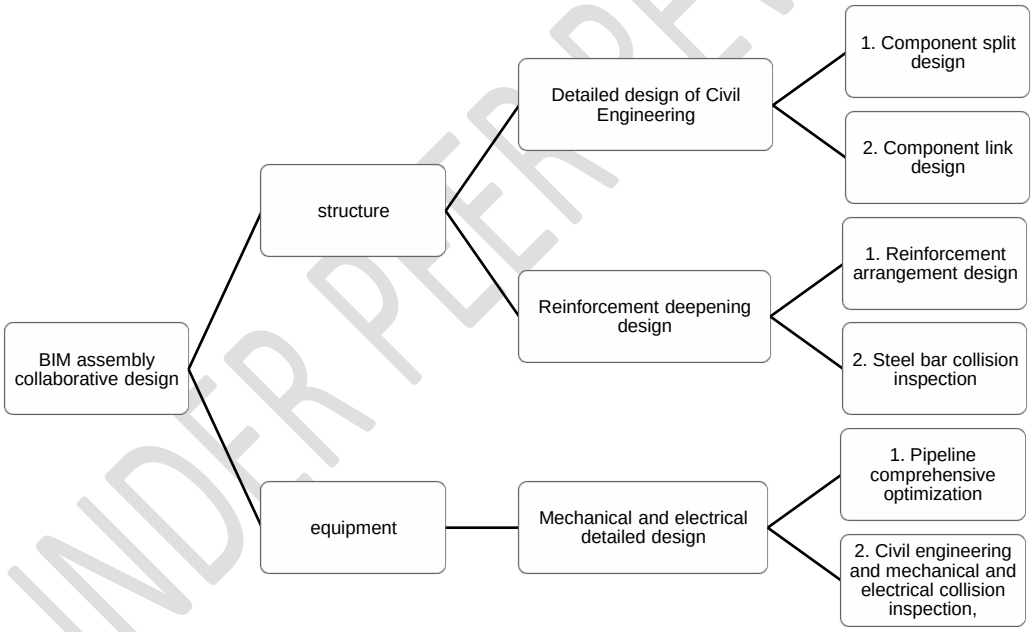


Fig.1. BIM assembly collaborative design

（1）BIM platform is used to establish the initial model of prefabricated architecture and structure (Fig.2 and Fig.3 are BIM models of architecture and structure);

Fig.2. Architecture model

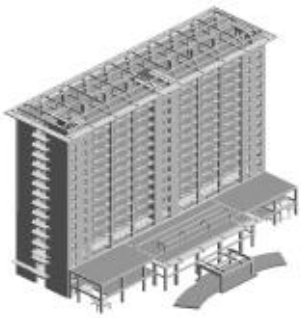


Fig.3. structure model

In the BIM structure model, the nodes are used to arrange the steel bars of the prefabricated components, and the collision checking function of the software is used to adjust the position of the steel bars in collision, and the prefabricated columns, beams and slabs are combined in the model to avoid the steel bar collision of different components for the second time, so as to solve the problem of steel bar collision in the construction site (Fig.4)

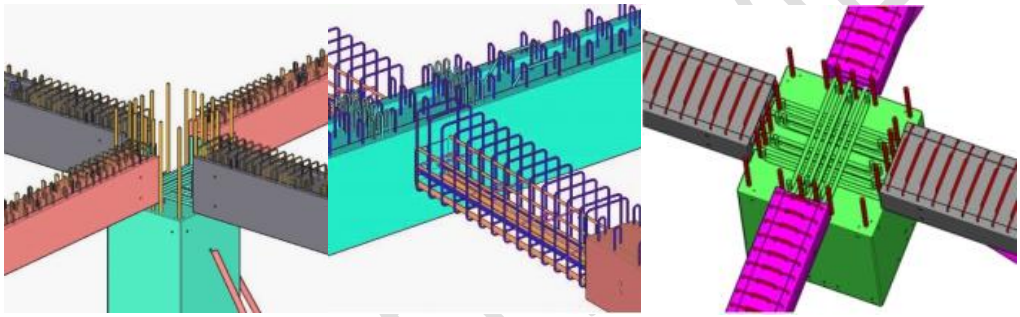


Fig.4. Steel bar collision adjustment

（2）The first mock exam is to build the building, structure and equipment in the same model. The electromechanical equipment can be used as a three-dimensional reference for this model. The electromechanical equipment (Fig.5) is built in the BIM building model, which provides convenience for the electromechanical inspection in the hidden parts of the operation and maintenance in the later stage.

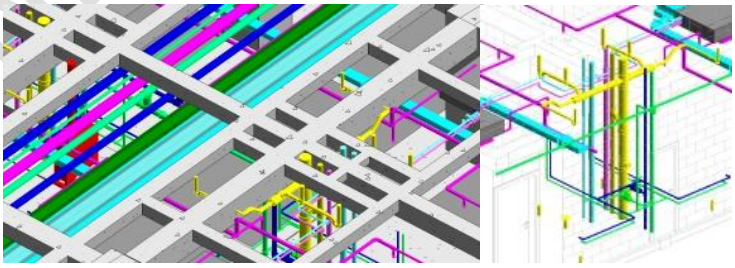


Fig.5. Electrical model

（3）The BIM structure model is used to split the prefabricated components (Fig. 6 and Fig. 7), number the prefabricated components, and generate the QR code of the corresponding prefabricated components (Fig.8). Each QR code contains the data information of the components. Through the

drawing function of the software, the detailed drawing of each component is designed. The detailed drawing includes the size information of the component and the number of reinforcement, and the data is integrated into the QR code (Fig.9)

The construction site can also query the original information of the component through the QR code generated by the prefabricated component in the BIM structure model, so as to confirm the specific location of the component, and also check the component size and reinforcement information. The component processing factory obtains the detailed information of the component through the QR code on the detail drawing, so as to carry out the production of the component.

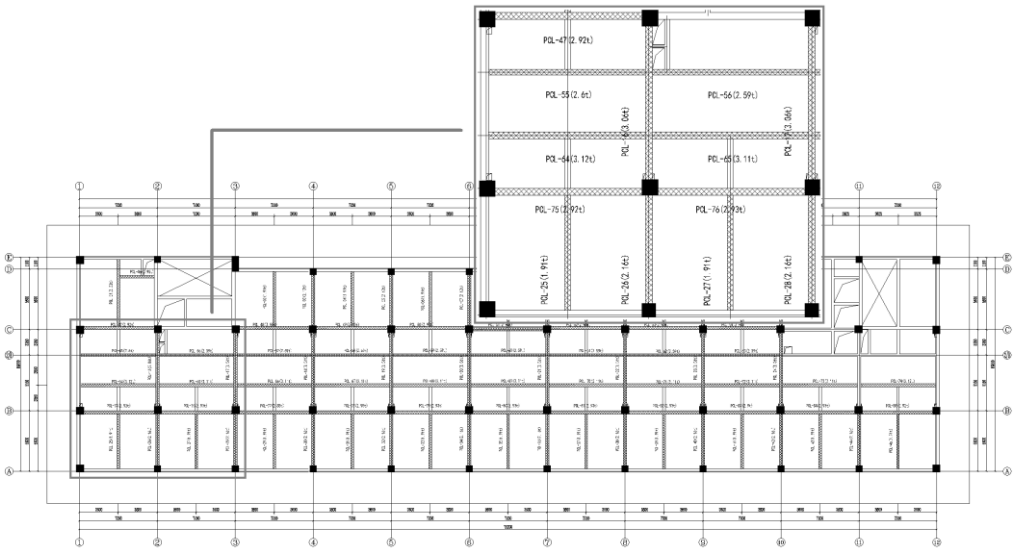


Fig.6. Splitting of precast beam

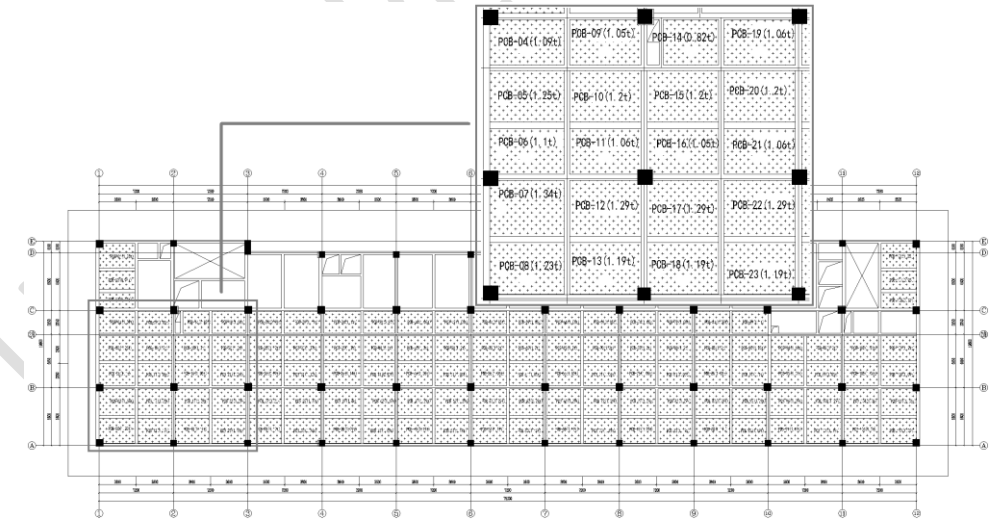


Fig.7. Splitting of Precast slab

Fig.8. QR code of prefabricated components

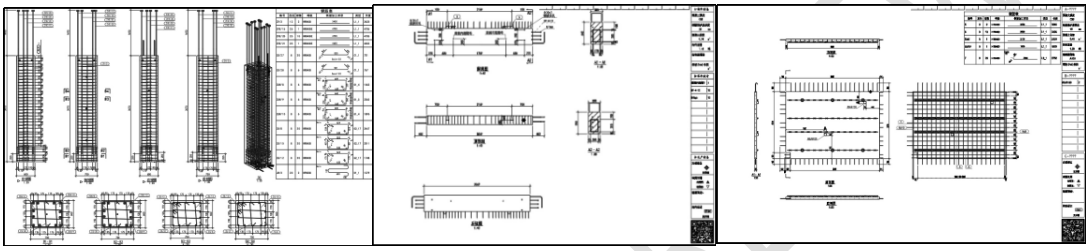


Fig.9. Detail of prefabricated components

3 BIM Technology is used for information standardization processing of fabricated components

BIM software is used to build assembly standard library. Each component is parameterized to form a standardized component information database. For production management and construction management. Taking prefabricated components as an example, some statistical data of precast beams, precast slabs and precast columns are listed(Table.1).

Table.1. **Prefabricated component database**

Precast beam								
type	Component size（mm）			Concrete quantity	Bulk density	weight	number	Total amount of concrete
	length	width	height	（m^3）	(t/m^3)	（t）		（m^3）
PCL-01	250	460	6520	0.7498	2.5	1.8745	2	1.50
PCL-02	250	460	3120	0.3588	2.5	0.897	4	1.44
PCL-03	400	700	5970	1.6716	2.5	4.179	1	1.67
PCL-04	400	700	5920	1.6576	2.5	4.144	1	1.66
PCL-05	400	700	6070	1.6996	2.5	4.249	1	1.70
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Precast slab								
type	Component size（mm）			Concrete quantity	Bulk density	weight	number	Total amount of concrete
	length	width	height	（m^3）	(t/m^3)	（t）		（m^3）
PCB-01	5020	2920	60	0.88	2.5	2.20	2	1.76

PCB-02	2920	1470	60	0.26	2.5	0.64	2	0.52
PCB-03	3370	1870	60	0.38	2.5	0.95	1	0.38
PCB-04	3120	1570	60	0.29	2.5	0.73	2	0.59
PCB-05	3145	1570	60	0.30	2.5	0.74	8	2.37
……	……	……	……	……	……	……	……	……

Precast column								
type	Component size（mm）			Concrete quantity	Bulk density	weight	number	Total amount of concrete
	length	width	height	（m^3）	(t/m^3)	（t）		（m^3）
PCZ-01	800	1000	3680	2.94	2.50	7.36	1	2.94
PCZ-02	800	1000	3680	2.94	2.50	7.36	3	8.83
PCZ-03	700	700	3680	1.80	2.50	4.51	11	19.84
PCZ-04	800	800	3680	2.36	2.50	5.89	1	2.36
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The concept of prefabricated building is to divide the traditional concrete structure into "parts" of the individual, and process these "parts" in the factory in advance, and then transport them to the construction site. Under the construction concept of the same as cast-in-place, the single structural members are assembled together by the method of combined connection. After the construction drawing design is reviewed, the deepening department will carry out the deepening design of the building structure. The common floor, beam, column, stair and wallboard will be split according to the industry standard; secondly, the optimal scheme of steel bar will be considered. Therefore, a large amount of component data, which is different from the traditional design, will be produced in the process of component splitting. Therefore, the standardization of components is an important factor in the information management of prefabricated buildings.

Traditional design usually shows the relationship between building location and elevation through construction drawings, which is an "integration" of information. However, prefabricated components decompose this "integration" of information and produce a lot of secondary information. If the splitting method is "personalized", it is bound to cause a lot of difficulties to the subsequent process sequence. Therefore, the standardization of component information is an inevitable requirement in the early stage of prefabricated building information management.

Prefabricated components usually adopt the design concept of "more combinations, less specifications", which can reduce the production cost of the factory, improve the production efficiency of components, and reduce the assembly time on the construction site. Therefore, mass production of building components contains a large number of component properties, which are precast beam parameter information: volume parameters, quality parameters, accessories parameters, steel specification parameters, material parameters. Only by means of information management, can we manage the assembly components accurately and efficiently in the design stage.

4 Application of BIM Technology in production and transportation of prefabricated buildings

In the material purchasing stage, the specification parameters and material parameters of steel bars can be extracted in batches by the data information stored in BIM model. Including: reinforcement, concrete, filling materials, concrete admixtures, connectors, embedded parts, etc.

The information involved in the production stage includes the external dimension of the component, the grade length and quantity of the reinforcement, the concrete grade, the type and quantity of the embedded parts, and the position of the parts contained in the component. The information involved in the assembly component drawing will be summarized into two-dimensional code, and the two-dimensional code will be scanned by the machine in the component production, and all data can be processed automatically.

In the design phase, each component will have its own unique "identity" information after splitting. By scanning the QR code bound on the prefabricated components with intelligent devices, the transportation situation of prefabricated components can be mastered. Through the combination of RFID[6](radio frequency identification) technology and BIM information data model, the prefabricated components can quickly find the road matching with the size of prefabricated components on the network map, calculate the optimal route, and simulate the most suitable site location for component placement on the construction site through BIM model.

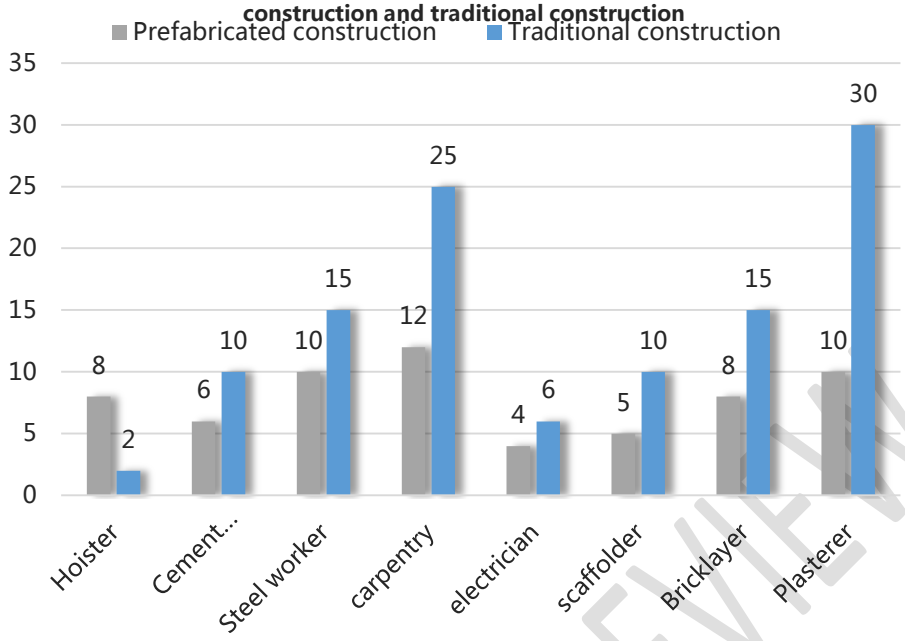
The BIM visual monitoring platform is associated with the on-site construction progress, and the time management node is added to the spatial model to directly reflect the construction process of the whole project. The construction progress can be adjusted with the actual progress of the project, the construction resources can be optimized and the site layout can be carried out scientifically, the construction progress, resources and construction quality of the whole project can be controlled uniformly, so as to improve the construction efficiency, reduce the cost and improve the construction quality.

5 Comparative analysis of prefabricated buildings and traditional projects based on BIM platform

As a new form of construction, prefabricated building is not mature in many aspects, such as the high cost of prefabricated components, the lack of on-site professional prefabricated construction personnel, and the difficulty of assembly construction quality inspection and control. Now the prefabricated project is compared with the traditional project. The prefabricated project adopts the canteen and student apartment building of the project; the traditional building adopts the 15 storey apartment building. In order to reduce the differences in different regions, the two projects are local projects in Nantong.

The comparison of labor index between prefabricated construction engineering and traditional engineering includes lifting worker, cement worker, steel worker, carpenter, water electrician, scaffolder, masonry worker and plasterer. Young people are reluctant to go to the construction site because of the aging of workers. Site employment has become an urgent problem to be solved at the construction site. Therefore, the amount of labor can reflect the differences between prefabricated buildings and traditional buildings, and the amount of labor between different types of jobs in prefabricated buildings can be screened out through BIM data model. The traditional amount of labor needs to be counted by the project manager. The comparison results are shown in Graph 2.

Graph2. Comparison of labor consumption between prefabricated construction and traditional construction



Through the comparison of the above indicators, it is found that the labor amount of prefabricated construction workers is only higher than that of traditional construction in terms of personnel hoisting, and other indicators are lower than that of traditional construction.

Table 2and table 3show the comparison between prefabricated building and traditional building engineering in terms of project single index and cost data. Through the comparison in the above table, it can be seen that compared with traditional buildings, the consumption of steel and concrete in prefabricated buildings is higher, and other indicators are lower. The cost of prefabricated buildings is 15.8% higher than that of traditional buildings.

Table.2. Comparison of single index between prefabricated construction engineering and traditional construction engineering

Serial number	Entry name	Unit	Prefabricated building	Traditional architecture
1	Concrete index	m^3/m^2	0.41	0.39
1.1	PC component Concrete	m^3/m^2	0.19	0
1.2	Cast in place component concrete	m^3/m^2	0.22	0.39
2	Reinforcement index	kg/m^2	45.5	43.78
2.1	PC component reinforcement	kg/m^2	21.5	0
2.2	Cast in place component reinforcement	kg/m^2	23.98	43.78
3	Brick masonry	m^3/m^2	0.04	0.15

4	Internal wall plastering index	m^2/m^2	0.38	1.99
5	Ceiling plastering	m^2/m^2	0.48	0.65
6	Template	m^2/m^2	2.09	3.65
7	Exterior wall painting base	m^2/m^2	0.81	1.65
8	Tower	One day's work/m^2	0.03	0.03

Table.3. Comparison of cost data between prefabricated building and traditional building engineering

Serial number	Entry name	Unit	Prefabricated building	Traditional architecture	Serial number
1	building structure	rmb/m^2	2915.85	2518	397.85
1.1	Assembly part price	rmb/m^2	300	/	/
1.2	Cast in place part price	rmb/m^2	2615.85	2518	/

In the national code for design of concrete structures, the design standards for prefabricated structures are designed on the high side, so the amount of concrete and steel will be more than that of traditional buildings. At present, prefabricated building has not yet been popularized. The cost of prefabricated component mold is high, the unit price of component is high, the cost of personnel training is high, and compared with traditional design, the cost of prefabricated building will be higher than traditional building.

Using BIM model, the project information is integrated into a model. Through standardized design, the project can call these information in each stage, reduce the loss caused by trivial information, improve the utilization rate of information, and realize multi professional collaborative work. It provides an intuitive model for later construction and maintenance, and reduces the cost of later construction. Through the information model platform, the information of prefabricated components is integrated, and the reasonable component production plan is made to reduce the loss caused by human factors. Increase the reuse rate of preform mold and reduce the production cost.
According to the national policy, in response to the call of the government, we should increase the scientific research investment in BIM and prefabricated building, and carry out research and development

Develop more energy-saving and material saving construction methods. Vigorously promote the prefabricated construction, make the prefabricated construction market more mature, so as to reduce the market price.

6 Conclusion

Through the method of actual cases and literature summary, this paper expounds that the prefabricated building based on BIM information management has the advantages of efficient management, green environmental protection and common data; from the perspective of management, construction period, capital, manpower and construction loss, it makes a comparative analysis, and concludes that the prefabricated project based on BIM information management model has great advantages over traditional projects, which is of great significance to the future

construction The development of construction industry is of great help. The results can be used as a reference for related projects and make clear the idea of prefabricated building development.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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