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Application of 5G Wireless Communication and BIM Technology in Management of Construction Projects

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With today's advancement of science and technology, people's demands for energy saving and environmental protection are increasing. The construction industry has huge carbon emissions and high energy consumption. Hence, technological transformation and industrial upgrading have always been the focus of social attention. From the "Eleventh Five-Year Plan" to the "Thirteenth Five-Year Plan", China has established specific targets for energy conservation and emission reduction, albeit with little significant effect. As a new technology, BIM provides the best entry point and reform direction for the transformation of China's construction industry. At present, the research and application of Building Information Modeling (BIM) technology is still in the emerging stage. In the construction stage, especially in large and complex construction projects, the BIM technology has not been fully applied. However, given the current development trend, the application of BIM technology in the field of construction may become a mandatory requirement for industrial development and national construction. Therefore, in this paper, we propose the application of 5G wireless communication and BIM technology in the management of construction projects. This paper first introduces 5G communication technology and MIMO-D2D coexistence system. Then, it conducts in-depth research on its precoding technology algorithm and, finally, the experimental part analyzes the trend of China's construction industry using BIM technology to research and analyze various aspects of construction such as building safety and completion speed. The experimental results show that the application of BIM technology can speed up the laying of bricks by up to four times or more compared to the traditional method. Ultimately, this means that BIM technology will greatly influence the speed with which the whole construction process can be completed.

Keywords: BIM Technology, Construction Project Management, 5G Wireless Communication, D2D Communication Technology

1. INTRODUCTION

In 2015, the total output value of the national construction industry reached 18.0757 trillion yuan, accounting for 7.03% of the GDP, a sharp decline from 10.2% in the same period in 2014, while the total output value of the construction industry fell to single digits for the first time. In order to survive and develop in a fiercely competitive market, construction companies need to drastically change their production and management methods that have been applied in the traditional construction industry. This transformation requires the adoption of new technological methods and tools. Since the advent of BIM (Building Information Modeling), as an innovative tool and management method, its great value has been consistently proven by numerous applications in developed countries in Europe and America.

China's current construction management model has been unable to meet the requirements of construction projects, and information technology has become increasingly essential to the current construction industry. BIM has great advantages as it facilitates information transmission and

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sharing, collaborative work, the improvement of management efficiency and reduction of costs. Moreover, its emergence just meets the requirements of informatization development.

First, the paper briefly introduces 5G communication technology and the MIMO-D2D coexistence system, and discusses its precoding algorithm in detail. Then, China's national conditions in terms of safety on construction sites, construction progress, and other aspects of this industry were analyzed. The innovation discussed in this paper is the adoption of the latest 5G technology to conduct in-depth modeling in the algorithm part, and to optimize it. In the experimental section of the paper, the application of the BIM technology that is applied in other countries is examined, confirming its usefulness.

2. RELATED WORK

The need to use BIM to minimize construction and demolition waste (CDW) is well documented, but most existing CDW management tools still lack BIM capabilities. Therefore, Akinade assessed stakeholder expectations regarding the use of BIM for CDW management [1]. The construction site of Beijing subway station faces several challenges: there are many important buildings in the vicinity, there is a complex system of underground pipelines, the construction itself is difficult, and it requires a high level of management. In order to ensure the safety of the construction site, settlement monitoring is required. Zeng used BIM technology to build a 3D subway model, an unusually-structured model and many other detailed models of subways [2]. The traditional mode of managing the progress of a construction project is restricted by the natural environment, the objective and subjective environments, and other factors, all of which can hamper the engineering aspect of construction. In actual engineering, Li managed the construction process by adopting an auxiliary BIM model and BIM5D software [3]. The analysis of the settlement effects of deep foundation excavations and the planning loads of buildings is based on the guidelines contained in the ITB standards. Based on a simplified and detailed method of numerical analysis, Szwarkowski introduced the results of vertical ground deformation near existing objects. He presented results for the vertical deformation of the ground adjacent to existing objects [4]. Although BIM technology was adopted for construction management, its effectiveness was not analyzed in the era of network communication.

It is critical to ensure the ultra-reliable and low-latency communication (URLLC) for 5G wireless networks and beyond, and this area is currently receiving significant attention from academia and industry. Bennis' overarching goal is the first step in addressing this research gap. To achieve this vision, after providing definitions of latency and reliability, the various contributing factors of URLLC and their inherent trade-offs have been carefully studied [5]. Most major mobile network operators see IoT-enabled machine-to-machine (M2M) communication networks as an important source of new revenue. Dhillon discussed the need for wide-area M2M wireless networks, especially short packet communication to support a large number of IoT devices [6]. Luong conducted a recent literature review of works on economic analysis and pricing models for data collection and wireless communication in the Internet of Things (IoT). A wireless sensor network (WSN) collects data from the environment and transmits the data to sink nodes, and is the main component of IoT [7]. These scholars mentioned above introduced the application of BIM technology in construction projects under the wireless network, but they did not conduct in-depth analysis of it, nor did they make suggestions. Hence, it was not a perfect solution.

3. 5G WIRELESS COMMUNICATION ALGORITHM DECONSTRUCTION

3.1 5G Wireless Communication Technology

The rapid development of wireless mobile communication is now a mainstream trend in contemporary society, and mobile communication covers many hot technologies that meet the needs of developing markets [8]. Today, the fourth-generation mobile communication technology (4G-LTE) has reached maturity and is being used in the industrial sector. Its core technologies are Orthogonal Frequency Division Multiplexing and Multiple Input Multiple Output (MIMO). With the development of IoT and mobile internet services, mobile broadband traffic will increase by 1,000 times in the next 10 years. Obviously, 4G technical support alone cannot meet the resource utilization and transmission rate requirements of the future information society. Therefore, fifth-generation mobile communication (5G) has become the focus of mobile communication research [9–10].

As is generally known, in the traditional cellular network, the bandwidth resources are very limited. Therefore, given the increasingly greater communication requirements, the current spectrum resources are gradually becoming scarce. As a new type of short-distance communication service, D2D communication enables two users to communicate directly in a multi-channel network. Its structure is shown in Figure 1. When D2D communication is introduced into traditional cellular communication, the frequency band occupancy rate of the current system can be significantly increased, thus expanding the communication capacity of the entire cell. In addition, the D2D technology layout is relatively simple, and there are no special requirements for the central processor and application fields. There is no need for manual operation by users, and automatic connection can be made with the assistance of the base station [11]. In a word, D2D technology in cellular communication has certain research value and application prospects.

Gradually, 5G technology will penetrate all aspects of daily life, including work and leisure5G will support various business needs in scenarios with extremely high traffic density and link density, and very specific mobile characteristics, and will also provide users with the ultimate application experience such as ultra-high-definition video [12]. It will meet diversified market demands in various industries such as transportation, medical care, and urban construction, and truly realize the IoT [13–14].

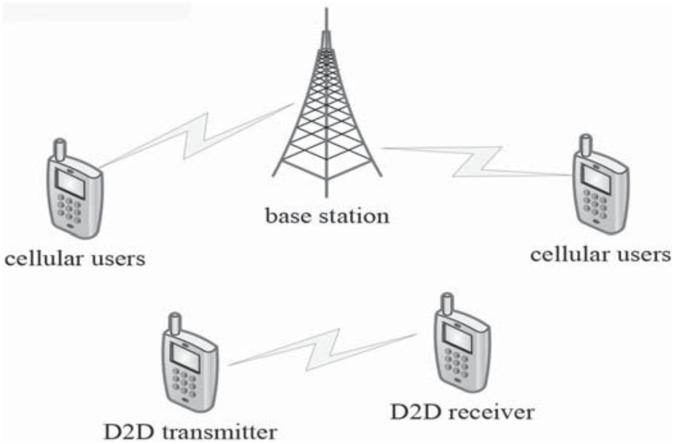

Figure 1 Schematic figure of D2D communication network structure.

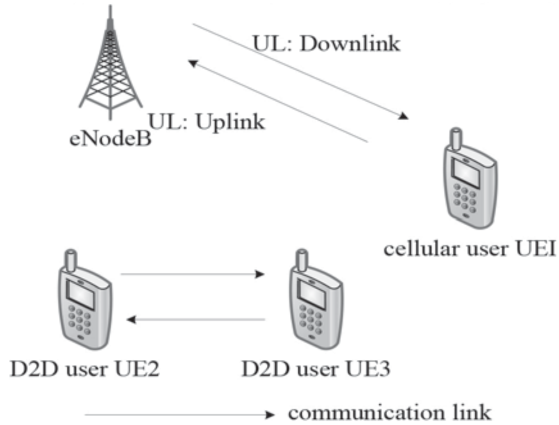

Figure 2 Multiplexing Orthogonal Resource Scenario figure.

3.2 Basic Theory of Interference Management in MIMO-D2D Coexistence System

When D2D communication is included in a traditional cellular network, the resource usage mode of D2D users can be determined according to the current spectrum of resource usage and data service requirements. If there are too many D2D users, the base station will be overloaded, and the transmission rate will be reduced. In this case, D2D users utilize the non-orthogonal resource-sharing method. This allows the base station to provide high-speed transmission for all users without participating in the forwarding, which saves a large amount of spectrum resources, expands the system throughput and the amount of intelligent device access, and has a positive impact on the overall system performance. However, when this communication method is introduced into the cellular network and the MIMO system, it will cause co-channel interference to the original cellular communication [15]. In response to this kind of interference, domestic and foreign institutions have proposed a variety of related interference-suppression technologies.

(1) Resource sharing method in D2D communication

There are two types of resources-sharing that enable the full use of wireless resources and the lightness of the base station load: orthogonal sharing and multiplexing sharing. In traditional cellular networks, the spectrum resources allocated to each user are perpendicular to each other. This resource allocation method causes almost no interference between users; however, the resource utilization rate is not high, and therefore cannot allow access to an increasing number of users. When D2D communication is introduced into the frequency band used by cellular users, the two users will use the same wireless resources, that is, the D2D users utilize the multiplexing mode. As shown in Figure 2, this mode is suitable for situations where the heavy load of the cell leads to a shortage of spectrum resources. However, flexible transitions between these two modes are also possible. For example, D2D users in orthogonal mode can switch to multiplexing mode when the distance between the transmitter and the receiver increases or the interference they receive suddenly becomes stronger [16–17].

(2) Main technologies of D2D interference coordination

When there are D2D users communicating in a multiplexed manner in the network, there will be serious interference problems in the heterogeneous system. In order to make the introduction of D2D communication more effective and improve the system capacity and overall performance of the entire network, it is necessary to carry out reasonable and effective interference control and interference cancellation in D2D heterogeneous networks [18].

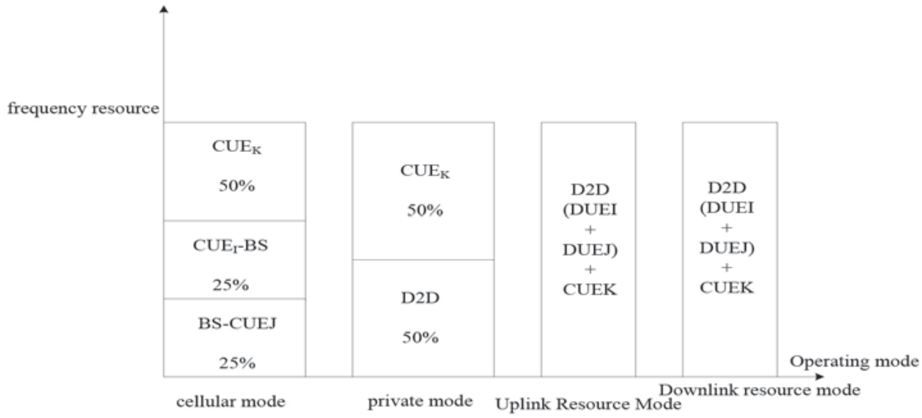

Figure 3 Resource utilization of D2D in different working modes.

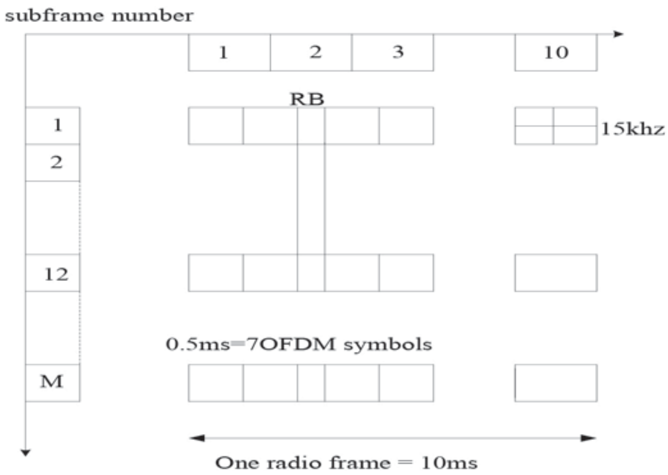

Figure 4 Slot resource figure in LTE system.

With the increasing scarcity of wireless spectrum resources, how to improve system throughput and idle resource occupancy through effective measures has become a key research focus in the communications industry. The selection of mode in D2D communication is one of the main methods used to improve the overall performance of the network. The resource utilization of D2D in different working modes is shown in Figure 3.

The use of resources is vertical, so there is no interference. Both D2D and cellular mobile phones can use the maximum transmission power to communicate, and can achieve better communication quality. The disadvantage is that this communication method does not solve the problem of scarcity of spectrum resources, and even imposes a more serious load on the base station when the data rate requirement is high [19–20]. Therefore, this method is suitable only when the base station is relatively idle and the distance between D2D users is large.

(3) Resource allocation

When working in the cellular mode or the dedicated mode, there is no interference between the D2D user and the original cellular user, but in these two modes, the introduction of D2D communication will be meaningless. Therefore, D2D communication is introduced into the LTE-A system, as shown in Figure 4. However, a large number of current studies have shown that reasonable allocation of resources is an important way to suppress interference. At the same time, different resource allocation schemes have different impacts on system throughput and system performance.

(4) MIMO system model

MIMO technology is essentially an abstract mathematical expression of multi-antenna mobile communication systems. In previous communication systems, the multipath effect is a factor that has a negative impact on system performance. However, in MIMO systems, multipath becomes a positive factor. It can obtain multiple data streams between devices and make information transmission more accurate [21–22]. The schematic figure of the MIMO system is shown in Figure 5.

As shown in Figure 5, the MIMO system adopts a multi-antenna transmission and reception system, and transmits the binary data information to be sent out through the sending end. After the transmitted data passes through the multipath channel, the reception and restoration of the data can be achieved by corresponding space-time detection processing at the receiving end. Unlike smart antenna technology, the wireless channel correlation between any two antennas in a MIMO system is very small. If the parameters of each antenna channel are independent of each other, multiple parallel channels are allowed to transmit and receive information in a MIMO system. When the data is transmitted independently

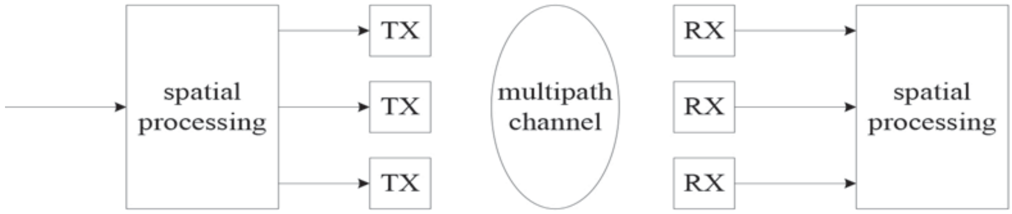

Figure 5 Schematic figure of the MIMO system.

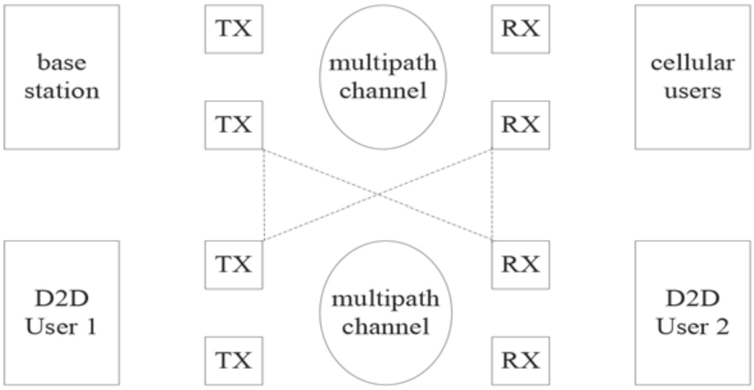

Figure 6 MIMO system communication model.

of each other on the parallel space channel, the rate of transmission can be greatly improved.

3.3 Introduction to Precoding Technology

(1) MMSE precoding algorithm

Compared with the ZF precoding algorithm that considers only co-channel interference and ignores channel noise, the MMSE precoding algorithm takes into account both co-channel interference and channel noise. A compromise is found between the two using the minimum mean square error criterion. Although the inter-user interference is not completely suppressed, the overall performance of the system is improved. Compared with the ZF precoder, the complexity of the algorithm is also greater. Applying the minimum mean square error theory, the precoding matrix of the target user can be obtained:

$$\begin{aligned} u^{opt} &= \arg\ \min Z\left[\left\| w - \hat{w} \right\|_G^2\right] \\ &= rg\ \min Z\left[\left\| w - \frac{1}{\varepsilon}(Fuw + \varphi)\right\|_G^2\right] \end{aligned} \tag{1}$$

$$Zww^G = MD\varphi^2 \tag{2}$$

According to the above formula, the optimal precoding matrix can be obtained:

$$u^{opt} = \varepsilon G^G (G^G + M_0 J)^{-1} \tag{3}$$

Then the power adjustment factor ε in the MMSE precoding algorithm can be expressed as:

$$\varepsilon = \sqrt{\frac{Md}{dk(u^*_{opt}(u^*_{opt}))^G}} \tag{4}$$

Since the MMSE precoding algorithm considers not only the co-channel interference but also the channel noise when solving the channel pseudo-inverse, this algorithm finds the optimal balance point for suppressing the co-channel interference and the channel noise. The advantage of this algorithm is that it can achieve good performance regardless of whether there is a high or low signal-to-noise ratio.

(2) Maximum SLNR precoding algorithm

The ZF and MMSE precoding schemes have certain restrictions on the number of antennas at the transmitting and at the receiving ends. In contrast, the scheme based on the maximum SLNR has no limit on the number of antennas, and its application is not limited by the characteristics of a scenario. The formula for the signal-to-leakage-to-noise ratio can be expressed as:

$$\begin{aligned} WZMK_r &= \frac{\|G_r u_r\|_H^2}{\|\tilde{G}_r u_r\|_H^2 + \mu^2} = \frac{\|G_r u_r\|_H^2}{\sum_{j=1, j\neq r}^{R} \|G_j u_r\|_H^2 + \mu_r^2} \\ &= \frac{dk(u_r^G G_r^G G_r u_r)}{dk(u_r^G(\tilde{G}_r^G \tilde{G}_r + \mu_r^2 J)_r)} \end{aligned} \tag{5}$$

Its corresponding generalized eigenmatrix can be expressed as:

$$(G_r^G G_r)\vec{m} = \varphi(M_k \mu^2 J + \tilde{G}_r^G \tilde{G}_r)\vec{m} \tag{6}$$

(3) MIMO-D2D system model

Compared with the single-antenna D2D heterogeneous system, the MIMO technology can bring more spatial benefits and diversity to the D2D heterogeneous system.

Figure 6 depicts the system model of MIMO-D2D. Since both the base station and the user terminal are equipped with multiple antennas, the transmitted signal of the base station can be more accurately aimed at the cellular user through the multipath channel. At the same time, the signal of D2D communication can also be more accurately transmitted to the target D2D user. Therefore, the combination of MIMO technology and D2D communication can significantly increase the throughput to the mobile communication system, and solve the problem of scarcity of spectrum resources caused by the increasing number of smart devices. At the same time, compared with D2D communication, the interference in the network combining MIMO technology and D2D communication will be more complicated. Therefore, the effective management of co-channel interference is the key to whether the combined MIMO and D2D technology can be effectively utilized.

The signal transmitted by the cellular user to the base station can be expressed as:

$$b_z = G_z U_z W_z + G_{yz} U_t W_t + \beta_z \tag{7}$$

Similarly, the signal received by D2D user 2 can be expressed as:

$$b_z = G_t U_t W_t + G_{yt} U_z W_z + \beta_t \tag{8}$$

The signal-to-interference-noise ratio received by the cellular user can be expressed as:

$$WIMK_z = \frac{\|G_z U_z\|_H^2}{\|G_{yz} U_t\|_H^2 + M_0} \tag{9}$$

The signal-to-interference-to-noise ratio received by the receiver of the D2D user can be expressed as:

$$WIMK_t = \frac{\|G_t U_t\|_H^2}{\|G_{yz} U_z\|_H^2 + M_0} \tag{10}$$

In the case of high signal-to-noise ratio, co-channel interference accounts for the main interference and, in general, the transmit power of the base station is relatively large. Therefore, in the downlink communication process, the suppression of the interference of the base station with the D2D communication becomes the main problem to be solved in the D2D-MIMO heterogeneous network.

(4) Resource Allocation Algorithm

Shannon's formula is expressed as:

$$Z(z_m, t_n) = Y \log_2 \left(1 + \frac{q_{zm}^r h_m}{q_n^r h_{n,m} + M_0}\right) \tag{11}$$

The D2D user must satisfy the following conditions for selecting the multiplexed resource block r for n:

$$\gamma_{n,r} = \begin{cases} 1, & r = \arg\min\{Z(z_m, t_n) - Z_{\min}\} \\ 0, & else \end{cases} \tag{12}$$

$$\min\{Z(z_m, t_n) - Z_{\min}\} = \max\{Z(z_m, t_n) - Z_{\min}, 0\} \tag{13}$$

The D2D user SNR meets the following conditions:

$$\varphi_{Tn}^r = \frac{\sum\limits_{n\in N} \beta_{n,r} q_n^r h_n}{q_{zm}^r h_{m,n} + M_0} \geq D \arg et\varphi_T \tag{14}$$

Only when this condition is met can the throughput of the system be improved.

$$0 \leq \sum_{r\in R} \beta_{n,r} q_n^r \leq q_{\max} \tag{15}$$

D2D users can select only one resource block to demultiplex, as follows:

$$\sum_{r\in R} \beta_{n,r} = 1, \ \forall n \in N \tag{16}$$

The throughput of D2D user n on resource block r is:

$$K_n^r = Y \log_2(1 + \varphi_{Tn}^r) \forall r \in \{1, 2, \ldots R\} \tag{17}$$

The goal of this current study is to maximize system throughput:

$$Z_r = \max \sum_{r=1}^{r} \sum_{n\in N} \beta_{n,r} K_n^r \tag{18}$$

$$w.d\ x \ \ \beta_{n,r\in\{0,1\}}; \sum_{r\in R} \beta_{n,r} = 1 \tag{19}$$

$$y \ \ \frac{D \arg et\varphi_T (q_{zm}^r h_{m,n} + M_0)}{h_n} \leq \sum_{r\in R} \beta_{n,r} q_n^r \leq q_{\max} \tag{20}$$

4. APPLICATION OF BIM TECHNOLOGY IN MANAGEMENT OF CONSTRUCTION PROJECTS

4.1 Status Quo of China's Construction Industry

As is known, the total output value and added value of the construction industry, profits and taxes, output value and profits and taxes, the number of construction units and employees, and the area of construction and completion can all indicate the current status of the construction industry. The analysis of major economic indicators and statistical data for the past five years, as shown in Figure 7, indicates that although the momentum of China's construction industry development has been good in recent years, the growth rate is slow. Compared with the same period of last year in 2014, the growth rate has slowed significantly, even shifting to negative growth, the construction industry has declined sharply, and corporate profits have been shrinking. The domestic construction industry is facing an unprecedented crisis, this period being referred to by some as "the cold winter of the construction industry".

As shown in Table 1, especially since 2014, the number of construction projects has been steadily decreasing, and construction companies are finding it more difficult to survive. BIM is the key to the sharing, management and application of big data in the current construction industry. There is no doubt that BIM has become an indispensable management method.

As shown in Table 2, in the construction stage, BIM technology can improve the collaboration on the project, strengthen the quality and safety of management, reduce the

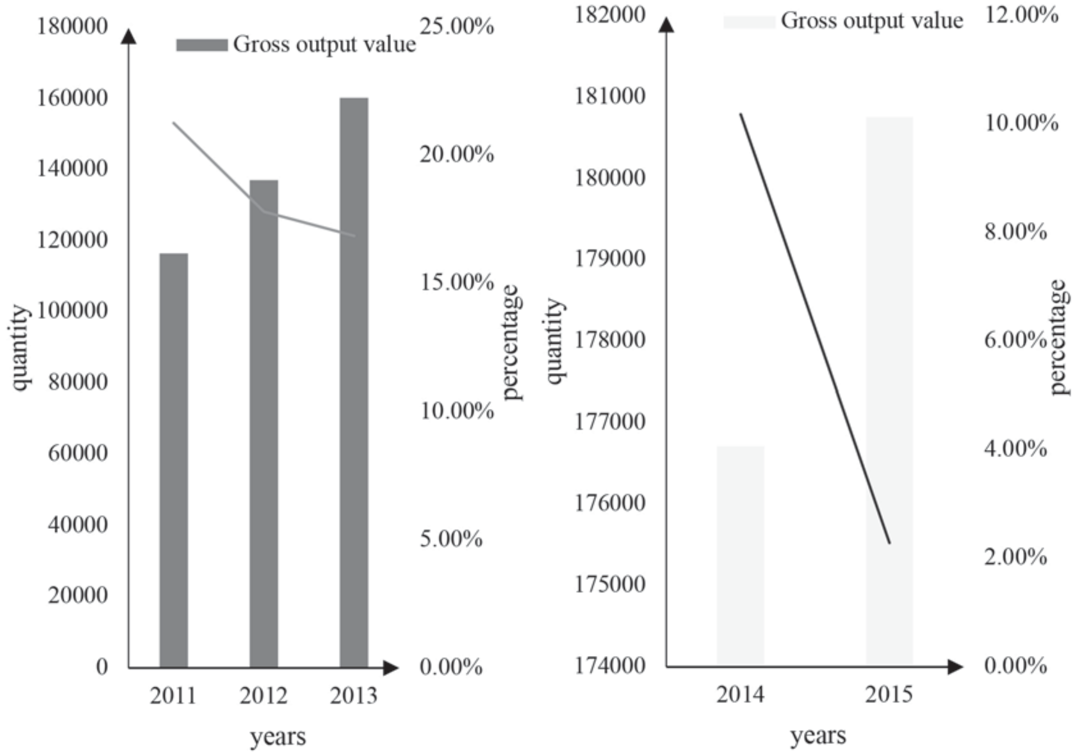

Figure 7 Gross Output Value of Construction Industry 2011–2015.

Table 1 Construction area of buildings in the construction industry.

Years	Housing construction area	Year-on-year increase
2011	851828	20.31%
2012	986427	15.8%
2013	1132002	14.76%
2014	1249826	10.41%
2015	1239717	−0.81%

Table 2 2011–2015 Total Profits of Construction Enterprises.

Years	Total corporate profit	Year-on-year increase
2011	4168	22.27%
2012	4776	14.58%
2013	5575	16.73%
2014	6407	14.93%
2015	6451	0.69%

construction period by about 10% and the rework rate by 60%, and increase the profits of construction companies by 5–10%. BIM technology can be used to produce detailed, accurate and structured construction data, providing a useful reference for future construction and maintenance work.

4.2 Application of BIM Technology in the Construction Industry

In the United States, BIM technology is a world-leading technology. Because the concept of BIM originated in the United States. Hence, BIM technology has gradually become a mature BIM technology after a series of researches and the development of information technology. The U.S. government has implemented a 3D-4D-BIM national plan since 2003, and launched the IFC-based national BIM technology in December 2007. In 2011, AR technology and BIM technology were applied to the management of engineering projects. The proportion of BIM applications in the US construction industry was 71% in 2012 and 28% in 2007, as shown in Table 3.

In this paper, a comparison and summary is made of countries in terms of their application of BIM, reported in the “Wide Application and Obstacles of BIM - BIM2007

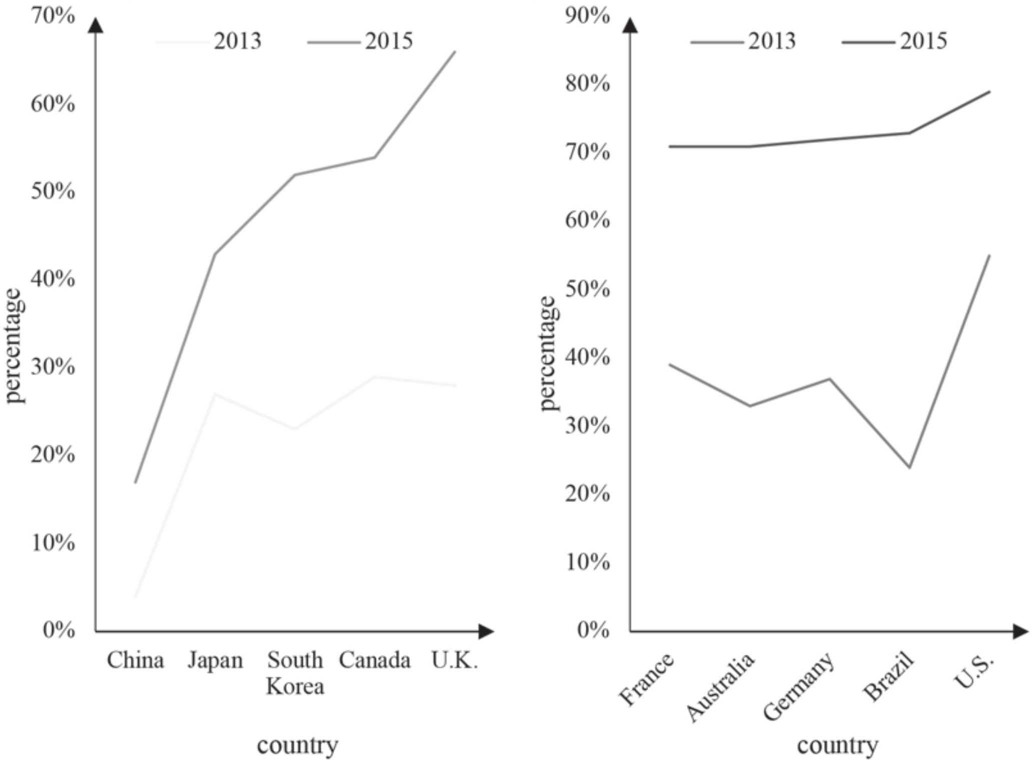

Figure 8 BIM application in the construction industry in typical regions of the world.

Table 3 Penetration Rate of BIM Technology in the United States.

Years	Penetration rate
2007	28%
2009	49%
2012	71%

AISCACCL Information Construction Industry Roundtable Event Report". This information is shown in Figure 8.

Statistics for 2015 show that China, Brazil, and the United Kingdom occupied the top three places in regard to the speed of global BIM technology development. However, in 2013 and 2015, the survey data for the application of BIM in the construction industries of various countries showed that China's construction industry is lagging behind other countries in this regard. There is also a some gap between China and other developing countries such as Brazil. After 2015, its application has been significantly increased in various countries, indicating that the IBM technology has much practical value.

(1) Application of BIM technology in building safety protection measures

China has a large construction industry. However, due to the large amount of engineering, information overload, difficulty in transmitting information, complex technology, substandard quality, failure to complete construction projects on time, industrial accidents, and many other problems, the overall profits of construction companies are less than optimal. An analysis of statistics regarding accidents and deaths in various industrial sectors of China in 2016, is presented in Figure 9:

From the statistics shown in Figure 9, the following conclusions can be drawn:

In terms of the number of accidents, the transportation industry has the most serious, with more than 50% safety accidents, higher than other industries;

In terms of the number of casualties (deaths), the construction industry also has fewer deaths than the transportation sector, and coal mine has much less casualties.

As can be seen from the number of deaths and accidents, the transportation industry has the largest number of deaths among all accidents. Although far fewer people are involved in the construction industry (at the end of 2019, there were 54.27 million employees in the construction industry) than in the transportation industry (there are 623.543 million people in air transportation industry by 2019. Data source: www.ceicdata.com), due to its higher share and higher fatality rates, the construction industry has the greatest potential risk of any industry. Therefore, in this context, the application of BIM technology to engineering safety, quality, progress management and other construction-related issues can help to improve the level of engineering management.

Therefore, for collision prevention, BIM technology can be used to effectively solve the issue of spatial relationship. BIM technology can be used to optimize the engineering design of construction projects, thereby reducing the incidence of engineering errors and optimizing the engineering layout. The construction manager can use the optimized collision-prevention construction plan to conduct construction disclosure and simulated construction, so as to effectively improve the quality of the project and enhance the ability to communicate with the land owner. The application of BIM technology to the quality cycle control of PDCA is the

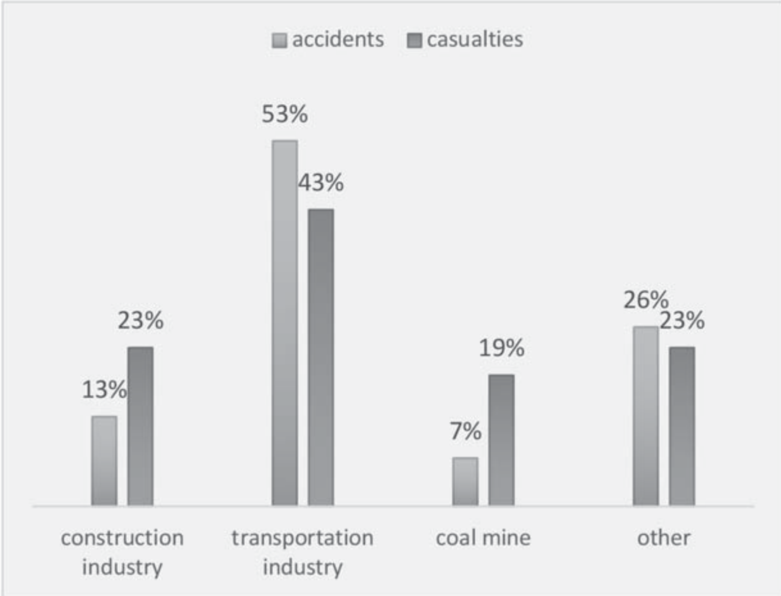

Figure 9 The percentage of accidents and casualties in China in 2016.

result of years of practical application and theoretical research, and is the basis for establishing and implementing quality management. After the application of BIM technology, the effect of PDCA quality cycle is significantly improved, which can provide better services for engineering quality management.

BIM technology is used to establish a reasonable construction schedule, and to control its implementation during the construction process [23–24]. When there is a deviation from the schedule, or when the construction is ahead of schedule, the original schedule can be adjusted. With BIM, the actual progress of the project can be visually and quickly compared with the construction plan anytime and anywhere. Various types of information can be loaded onto the model, enabling all personnel involved in the project to monitor the project in real time. Thus, everyone involved can access information and become aware of any engineering issues.

Effective knowledge management can synchronously save information, knowledge and skills during the process of simulation and construction, and add content to the knowledge base of the construction unit, thereby mitigating problems related to quality, safety, progress etc. associated with the project. The use of BIM technology facilitate the collaboration between participating units, enabling a more efficient exchange of information and feedback. By means of the modular approach, various problems and solutions encountered in an engineering project are made into modular information, which can be directly referenced and applied to other similar engineering projects to accumulate knowledge and reduce workload.

(2) Application of BIM technology in the construction process

By establishing an accurate BIM model and then entering the specification parameters, the arrangement of brick can be quickly established, and the number of whole bricks, and the number and size of cut bricks can be quickly counted. The output report advises on-site workers about pre-cut bricks, thereby improving the efficiency of construction operations and accurately guiding on-site construction.

Depending on the type of walls and local conditions, different BIM software can help save on the cost of materials and improve the construction efficiency, since statistical data for the brick arrangement method and masonry material can be obtained from the detailed design provided by BIM technology. Based on detailed statistical data, the quantity of materials required for all masonry structures can be calculated accurately, even down to individual rooms. Through the linking of the engineering, materials, technology,, finance, and other departments, the time, frequency and quantity of materials can be effectively organized. According to the principle of small quantity and greater frequency, it is ensured that the materials will be delivered to the site within the planned time one day before the current materials run out, which will greatly improve the efficiency of the on-site material stacking. Through continuous communication and collaboration among various departments of the project, material suppliers and logistics, the management process is optimized, and timely construction can be achieved. The paper compared the efficiency of BIM technology and traditional CAD, as shown in in Figure 10:

According to the statistics for masonry and brick arrangement in the section above, to do brick arranging work with an area of 355 square meters between the HP and HQ axes of the outer row columns, a technician using CAD needs a day to work out the brick-laying pattern. However, with BIM technology, it only takes two hours, and most of the time is used to adjust the position of the brick row and the size of the bricks to maximize the utilization of masonry materials. If the integrity of masonry is being considered as well as the efficient use of materials for multiple walls, the adjustment may require a little more time (about one hour) depending on the specific situation. However, compared with the traditional method of arranging bricks, the efficiency achieved by BIM

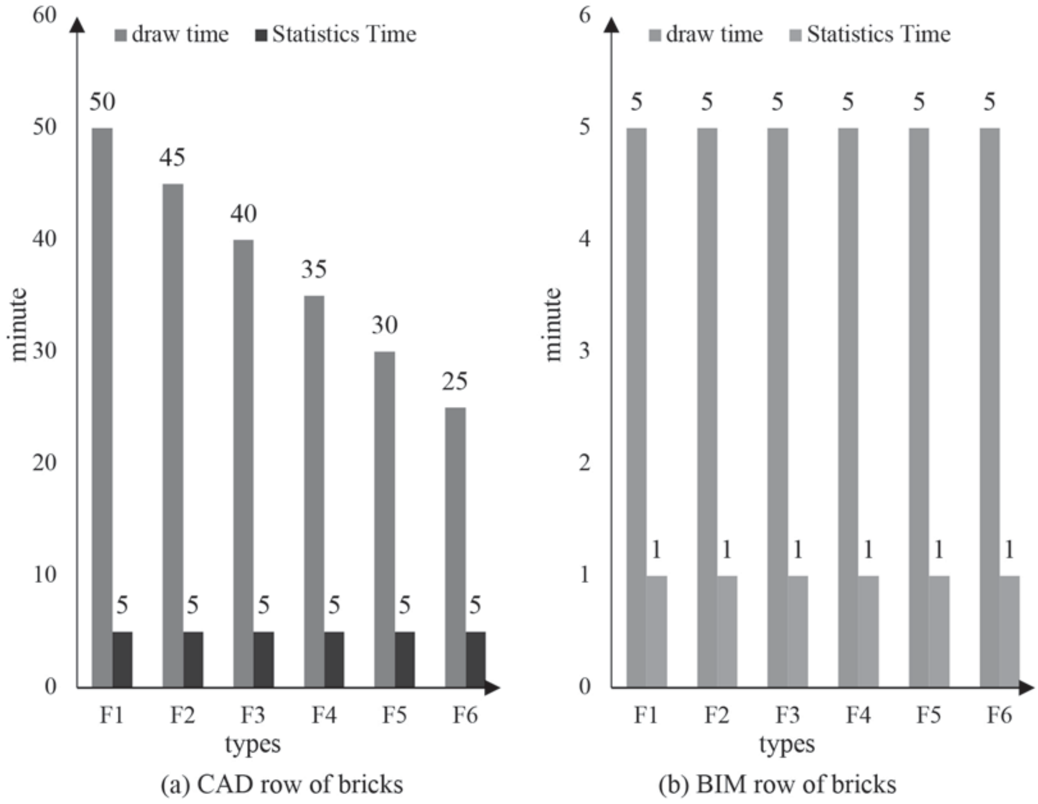

Figure 10 Comparison of BIM technology and traditional methods.

Table 4 Analysis of factors affecting the application of BIM technology.

Participants	Cost of investment	Benefit size	Data processing costs	Technical strength	Contribution
Construction unit	3	3	1	1	1
Design unit	1	1	2	3	3
Construction unit	2	2	3	2	2

technology is four times better. There are more than 400 kinds of masonry walls, even if the statistical classification time is not considered, it takes five technicians at least two months to work out the brick arrangement. With BIM, three technicians can do this in one month, greatly improving the efficiency.

The detailed masonry design based on BIM technology not only solves the problem of saving the consumption of masonry materials by optimizing the arrangement of bricks, but also greatly reduces the turnover of materials and material waste in other areas of construction. The work management method of masonry engineering is similar to the pre-processing of steel bars, and each wall has a blanking figure and blanking list, so that cost savings can be implemented. In both theory and practical application, this decreases the amount of masonry materials required for the construction.

(3) Analysis of the impact of BIM technology on the main participants of the project

When an enterprise encounters a new technology, it usually considers and weighs several factors: investment cost, income and profit, and difficulty of implementation. As a relatively new concept and management method in the construction industry, BIM technology has been used by companies although some departments favor a wait-and-see approach. Therefore, it is also a question worthy of study in which type of inductrial BIM technology is firstly applied. From the perspective of business, the investment cost, benefits, data processing costs and technical strength will be the main factors affecting the adoption of BIM technology. In addition, the modeling process of BIM technology is a gradual one, and can easily lead to the observation that "the predecessors planted the trees and the later people enjoy the shade", so the "contribution degree" of the model will also be taken into account. Each of these influencing factors is now quantified according to three levels with corresponding scores, where "1" represents the smallest degree, "3" represents the largest degree. However, for a business enterprise, the greater the "investment cost", the lower is the possibility of adopting BIM technology. Therefore, "1" in this factor means the largest investment, and "3" means the smallest investment. The results are shown in Table 4.

Through the above analysis of the impact of the three main units involved in the construction project after applying BIM technology, and the data in the table, this paper can draw the following conclusions:

The application of BIM technology by construction units not only has low investment cost and weak technical skills, but also is the biggest beneficiary of BIM technology, but there is a phenomenon of insufficient motivation and low contribution. The design unit needs a skilled technical force in order to apply BIM technology, and is the biggest contributor to the BIM model. However, when there is perceived high investment and low return, there is insufficient motivation to apply BIM. The construction unit is the unit with the greatest motivation to apply BIM technology because its investment is proportional to the income, and the required technical expertise is medium. The order of potential BIM technology adoption is: construction unit > design unit > construction unit. This explains why the penetration rate of BIM technology in construction department is in the leading position in the industry. Based on this, this paper studies the application of BIM technology in the process of project construction management.

5. CONCLUSION

In this paper, the research focus is the application of BIM-based engineering project management. By examining a large number of materials analyses and researches, we can draw several conclusions. Combining multiple viewpoints, we find that the greatest value of BIM is the transmission and sharing of information. By analyzing the concept of BIM, the project management mode and application-driven mode that conform to the maximization of BIM application value are summarized, showing how BIM can be applied to the whole life cycle of construction projects. The overall framework of BIM-based project management applications is constructed. By designing a management structure and workflow, discussing ideas for technical implementation, and analyzing personnel issues, and the soft and hard conditions of BIM application, enterprise owners can better understand the value of BIM to their business operations, and how to maximize this value.

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