

Application of Intelligent Construction Techniques in China

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Abstract. Intelligent construction techniques refer to the use of advanced technologies and systems to improve the efficiency, productivity, and safety of construction projects. The application of intelligent construction technology in China is gradually becoming a new trend in the construction industry. Starting from the concept and characteristics of intelligent construction technology, this article explores its application in the Chinese construction field. By analyzing the advantages of intelligent construction technology in improving construction efficiency, reducing costs, and enhancing quality, it reveals its positive impact on the Chinese construction industry. At the same time, this article also discusses the challenges and development prospects that intelligent construction technology may face in practical applications in China, providing foresight of future trends regarding the integration of Artificial Intelligence (AI), Big Data, Building Information Modeling (BIM), Robotics, sustainability, and other innovative and advance technology with intelligent construction techniques, and recommendations for helping accelerate the development of intelligent construction techniques by means such as enhancing education and training programs and establishing industry standards and regulations.

Keywords: Intelligent construction, construction industry; big data.

1. Introduction

Intelligent construction techniques refer to the use of cutting-edge systems and technology to improve the efficiency, productivity, and safety of construction projects. These techniques integrate various technologies such as Artificial Intelligence (AI), Big Data, Internet of Things (IoT), and Robotics to accelerate, automate, and optimize construction processes.

Intelligent construction techniques have gained significant attention in recent years, particularly in the construction industry in China. With the rapid advancement of technology and the increasing demands for efficient and sustainable construction practices, the application of intelligent construction techniques has become a key focus for many construction companies and researchers in China. From early 2000s, the Building Information Modeling (BIM) and Geographic Information Systems (GIS) techniques was first introduced, and Big Data, AI, and IoT were followed later. Other advanced techniques, for example 3D printing, drones, and virtual reality, are going to be integrated in the future. This paper aims to provide an overview of the background and current situation of intelligent construction techniques in China, highlighting the challenges and opportunities facing the industry.

2. Background Research

2.1. Intelligent Construction

The components of intelligent construction techniques include:

1) AI

AI refers to the ability of machines to perform tasks that normally require human intelligence. In the context of construction, AI can be used for tasks such as project planning, scheduling, and monitoring. AI algorithms can analyze large amounts of data to identify patterns and make predictions, helping construction companies make informed decisions and improve project outcomes.

2) Big Data

Big data refers to the large volume of data that is generated in construction projects. This data can come from sources such as sensors, drones, and construction machinery. By analyzing this data, construction companies can gain valuable insights into their projects, such as identifying bottlenecks, predicting equipment failures, and optimizing construction schedules.

3) IoT

IoT is a network of physically connected objects with data exchange capabilities. IoT devices in the construction industry, like wearables, drones, and sensors, can gather data in real-time on a variety of project parameters, like worker activity, temperature, and humidity. Utilizing this data will enhance safety, track project progress, and allocate resources as efficiently as possible.

4) Robotics

Robotics refers to the application of automated machinery to construction projects. Robots can be used for tasks such as bricklaying, welding, and demolition, which are repetitive or dangerous for human workers. By using robots, construction companies can improve efficiency, reduce labor costs, and enhance safety on site.

5) BIM

BIM is a digital representation of the physical and functional characteristics of a building. BIM software allows construction companies to create 3D models of their projects and simulate construction processes before they begin. This helps to identify potential conflicts or errors in the design, optimize construction sequences, and improve collaboration among project stakeholders.

In conclusion, intelligent construction techniques leverage advanced technologies to enhance the efficiency, productivity, and safety of construction projects. By integrating AI, big data, IoT, robotics, and BIM, construction companies can improve project outcomes, reduce costs, and stay competitive in the rapidly evolving construction industry.

2.2. Development History of Intelligent Construction in China

2.2.1. Overview

The application of intelligent construction techniques in China can be traced back to the early 2000s when the government began to prioritize the development of smart infrastructure, and have undergone significant development over the years, reflecting the country's commitment to innovation and technological advancement in the construction industry.

The development of intelligent construction techniques in China can be divided into several key stages. In the early 2000s, the focus was primarily on the introduction of advanced technologies such as BIM and Geographic Information Systems GIS to improve the efficiency and accuracy of construction projects. These technologies allowed for better planning, design, and management of construction projects, leading to improved quality and reduced costs.

As China continued to invest in research and development, the focus shifted towards the integration of AI and IoT technologies in the construction industry. This led to the introduction of smart construction equipment and machinery, automated construction processes, and real-time monitoring systems. These innovations not only improved the efficiency of construction projects but also enhanced safety and sustainability.

In recent years, China has further advanced its intelligent construction techniques by incorporating big data analytics, cloud computing, and robotics in the construction process. These technologies have revolutionized the way construction projects are planned, executed, and managed, leading to faster completion times, reduced waste, and improved resource utilization.

Currently, the intelligent construction techniques in China focus on the integration of various technologies to create a seamless and interconnected construction ecosystem. This includes the use of drones for site surveying, 3D printing for rapid prototyping, and virtual reality for project visualization. These technologies not only improve the efficiency of construction projects but also enhance collaboration among stakeholders and provide better decision-making support.

In conclusion, the development of intelligent construction techniques in China has been a result of continuous innovation and investment in research and development. The integration of advanced

technologies has transformed the construction industry, making it more efficient, sustainable, and cost-effective. As China continues to lead the way in intelligent construction, it is expected that the country will set new standards for the global construction industry in the years to come.

2.2.2. Government Support

The Chinese government has recognized the importance of intelligent construction and has implemented a series of support measures and policies.

First and foremost, the Chinese government has established the National Intelligent Construction Engineering Technology Research Center to spearhead research and development in intelligent construction technologies. This center serves as a platform for collaboration between industry, academia, and government agencies to promote innovation and knowledge sharing in the field of intelligent construction.

In addition to research and development support, the government has also provided financial incentives to encourage the adoption of intelligent construction techniques. For example, the government offers subsidies to construction companies that invest in intelligent construction technologies, such as BIM software and equipment. These subsidies help offset the initial costs of implementing intelligent construction techniques and make them more accessible to a wider range of construction companies.

Furthermore, the Chinese government has introduced regulatory policies to promote the use of intelligent construction techniques. For instance, the government has mandated the use of BIM in public infrastructure projects to improve project management and reduce construction waste. By requiring the use of BIM, the government aims to standardize construction practices and improve the overall quality of construction projects in the country.

Moreover, the government has also established training programs and certification schemes to develop a skilled workforce capable of implementing intelligent construction techniques. These programs provide construction workers with the necessary knowledge and skills to operate advanced construction technologies and equipment, thereby increasing the adoption rate of intelligent construction techniques in the industry.

In conclusion, the Chinese government has been actively supporting and promoting the application of intelligent construction techniques in the country. Through research and development initiatives, financial incentives, regulatory policies, and training programs, the government has created an enabling environment for the adoption of intelligent construction techniques in the construction industry. Moving forward, it is essential for the government to continue its support and collaboration with industry stakeholders to further accelerate the adoption of intelligent construction techniques and drive innovation in the construction sector.

2.3. Policies and Regulations

Different government departments provided guidance and regulation for intelligent construction. This section provides an overview of the existing policies and regulations related to intelligent construction techniques in China.

2.3.1. National Development and Reform Commission (NDRC)

The NDRC is responsible for formulating and implementing policies related to economic and social development in China. In 2016, the NDRC issued the "Guiding Opinions on Promoting the Development of Intelligent Construction" to promote the application of intelligent construction techniques in the construction industry. The document emphasizes the importance of promoting the integration of information technology, artificial intelligence, and other advanced technologies in construction projects.

2.3.2. Ministry of Housing and Urban-Rural Development (MOHURD)

The MOHURD is the primary government agency responsible for regulating the construction industry in China. In 2017, MOHURD issued the "Guidance on Promoting the Application of

"Intelligent Construction Techniques in the Construction Industry" to provide guidance on the implementation of intelligent construction techniques. The guidance document outlines the key principles, requirements, and responsibilities for implementing intelligent construction techniques in construction projects.

2.3.3. Local Government Regulations

In addition to national-level policies and regulations, many local governments in China have also introduced their own regulations to promote the application of intelligent construction techniques. For example, the Shanghai Municipal Government has issued the "Shanghai Municipal Regulations on the Promotion of Intelligent Construction" to encourage the adoption of intelligent construction techniques in construction projects in the city. Similarly, the Beijing Municipal Government has introduced the "Beijing Municipal Action Plan for Intelligent Construction" to promote the use of intelligent construction techniques in the capital city.

2.3.4. Industry Standards

In addition to government policies and regulations, industry standards play a crucial role in shaping the development and adoption of intelligent construction techniques in China. The Chinese Construction Industry Association (CCIA) has developed a series of standards related to intelligent construction techniques, including standards for BIM, smart construction equipment, and digital construction management systems. These standards provide guidance and best practices for the implementation of intelligent construction techniques in the construction industry.

2.3.5. Funding and Incentives

To further incentivize the adoption of intelligent construction techniques, the Chinese government has also introduced various funding programs and incentives for construction companies. For example, the Ministry of Finance has launched the "Intelligent Construction Technology Development Fund" to provide financial support for research and development projects related to intelligent construction techniques. Additionally, local governments may offer tax incentives, subsidies, and other financial support to companies that invest in intelligent construction technologies.

In conclusion, the regulatory environment for intelligent construction techniques in China is evolving rapidly, with a range of policies, regulations, and incentives in place to promote the adoption of these advanced technologies in the construction industry. By complying with these regulations and leveraging the available funding and incentives, construction companies in China can enhance their competitiveness and drive innovation in the sector.

3. Case Studies

3.1. Case Study 1: Smart Construction Site Management

Smart construction site management refers to the use of information and intelligent technology to improve the efficiency and quality of construction management, and it has several benefits.

The first benefit is improvement of management efficiency. Through the application of smart construction sites, it aims to improve the efficiency of construction project management, including personnel management, safety management, quality management, production management, etc.

The second one is better safety and quality control. Smart construction site technology introduces better construction safety and quality management by different methods. For example, during the construction process, portable equipment could be used to collect safety management related data and transmitted them to smart construction site management platform database to monitor the current operating status and identify potential risks [1].

The third benefit is that smart construction site management grants environmental monitoring and green construction. Smart construction site technology can monitor environmental indicators such as PM2.5 and noise, and implement environmental protection measures such as sprinkler systems and

misting cannon machines, resulting in less environmental impact caused during construction process [2, 3].

Along with all the benefits, smart construction site management can encounter certain challenges and difficulties. From real project experience, inconsistent data standards and system integration difficulty are major complaints about smart construction site management.

Conclusively, intelligent construction techniques encourage the construction industry to pursue technological innovation, efficiency improvement and sustainable development in construction management.

3.2. Case Study 2: BIM in Building Construction

Different projects include exhibition center, transportation hub, and pre-fabricated machine rooms are studied. All those projects faced difficulties caused by the complexity site conditions, and implemented BIM techniques to integrate different professions to increase productivity and facilitate the construction. Those projects emphasize the importance of BIM technology in improving the efficiency of architectural design, construction and management, and combine BIM with other intelligent systems, such as AR, AI, and RFID.

3.2.1. Technology application and innovation

BIM+AR technology: Through augmented reality technology, automatic matching of paper drawings and BIM models is achieved, improving the visualization and explanation efficiency of the construction site. As shown in Fig. 1, BIM technology was applied to simulate the design and construction process in a commercial building development project to save time and resources, improve efficiency, and reduce amount of mistakes [4].

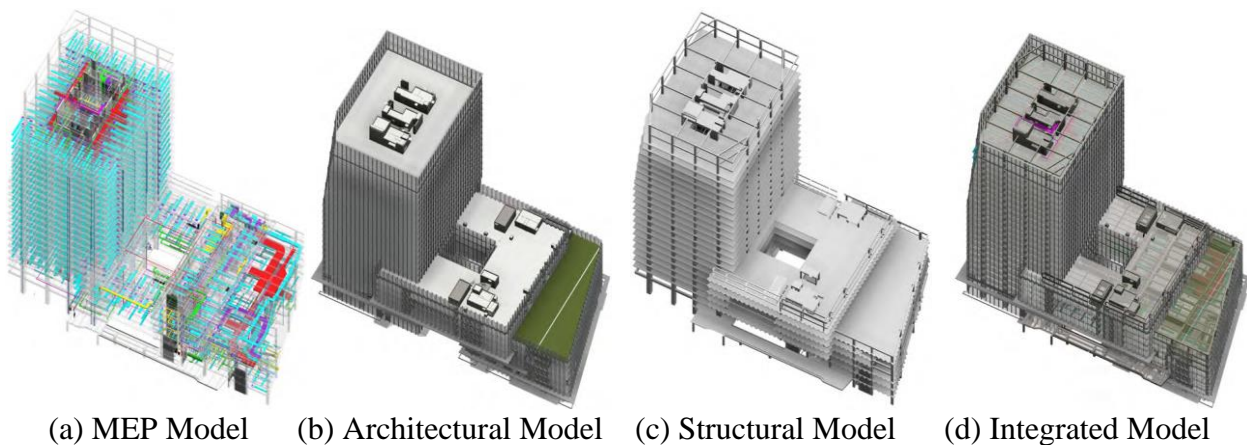


Fig 1. Integrated Different Professions with BIM [4].

BIM+AI technology: The use of artificial intelligence for multi-source information interaction, such as intelligent electronic drawings and atlas technology, improves the accuracy and convenience of construction guidance. For example, schedule optimization algorithms can provide multiple options for project delivery and improve the feasibility of project plans, and image recognition and classification technology can evaluate video data from construction sites [5].

BIM+RFID technology: Radio frequency identification technology is used to track and manage material information to increase the accuracy and efficiency of material management. In the construction of pre-fabricated machine rooms project, the construction team developed an RFID-based on-site material information collection and management platform to help on-site managers collect and update useful information of machines [6].

3.2.2. Construction technology and methods

Modular construction: In prefabricated buildings, high efficiency and quality control of construction are achieved through factory prefabrication and on-site assembly. During the construction phase of a railway station, the project team applied virtual assembly technology to help

eliminate cumulative errors in the processing of individual prefabricated components. This allowed them to successfully cut the construction period by 20 days and save more than 5 million Chinese yuan in rework cost [7].

Smart equipment applications: For instance, orbital robot, 3D printing, VR equipment, laser scanning and intelligent measurement equipment [8]. These technologies are used to improve construction accuracy and train construction personnel. For example, to improve staff management while maintaining personal safety, a project team embedded chips into safety helmets to display the daily schedule, time, and location of various staff members right on site layout drawings [9].

Smart construction site platform: Integrate BIM, Internet of Things, cloud computing and other technologies to achieve digital, online and intelligent management of the construction site. As shown in Fig. 2, on-site information, on-site personnel, mechanical equipment, production process, tower cranes monitoring, and other on-site information can be easily obtained through smart construction site platform [10].



Fig 2. Smart Construction Site Location Planning Map [10].

3.2.3. Conclusion and outlook

Benefit and value: The application of BIM technology in construction projects not only improves the quality of design and construction, but also achieves cost savings and resource optimization.

Future directions: Although there are technical and management challenges in the implementation process of BIM technology, through the joint efforts of all parties in the industry, it is expected to further promote the development and innovation of BIM technology.

4. Key Findings

The application of intelligent construction techniques in China has brought about significant changes in the construction industry, leading to improved efficiency, safety, and sustainability. Through the case studies conducted in various projects across China, several lessons have been learned and best practices identified.

4.1. Emphasis on Planning and Design

One of the key lessons learned from the case studies is the importance of thorough planning and design in implementing intelligent construction techniques. Projects that had a well-defined plan and design from the beginning were more successful in integrating intelligent technologies seamlessly into the construction process. This highlights the need for early collaboration between all stakeholders, including designers, engineers, contractors, and technology providers, to ensure that the project objectives are clearly defined and achievable.

4.2. Integration of Technologies

Another important lesson learned is the significance of integrating various intelligent technologies to maximize their benefits. The case studies revealed that projects that utilized a combination of technologies, such as BIM, IoT, and AI, were able to achieve higher levels of efficiency and productivity. This integration allowed for better coordination between different construction activities, improved communication among project teams, and enhanced decision-making processes.

4.3. Training and Education

The case studies also highlighted the importance of providing adequate training and education to construction professionals to effectively implement intelligent construction techniques. Projects that invested in training programs for their staff on how to use new technologies and tools experienced fewer implementation challenges and better adoption rates. This underscores the need for ongoing education and skills development to keep up with the rapidly evolving landscape of intelligent construction.

4.4. Collaboration and Communication

Effective collaboration and communication among all project stakeholders were identified as critical factors for the successful implementation of intelligent construction techniques. The case studies showed that projects that fostered a culture of collaboration and open communication among team members were able to overcome challenges more effectively and achieve better results. This emphasizes the need for clear communication channels, regular meetings, and shared project goals to ensure that all parties are aligned and working towards a common objective.

4.5. Continuous Improvement

Finally, the case studies demonstrated the importance of continuous improvement in the application of intelligent construction techniques. Projects that embraced a culture of innovation and were open to feedback and lessons learned from previous experiences were able to adapt quickly to changing circumstances and drive continuous improvement in their construction processes. This highlights the need for a mindset of continuous learning and adaptation to stay ahead in the rapidly advancing field of intelligent construction.

Overall, the lessons learned from the case studies emphasize the need for meticulous planning, integration of technologies, training and education, collaboration and communication, and a commitment to continuous improvement in the application of intelligent construction techniques in China. By adopting these best practices, construction professionals can navigate the challenges and opportunities presented by intelligent technologies and drive positive outcomes in their projects.

5. Future Trends and Recommendations

5.1. Future Trends

Intelligent construction techniques have been rapidly developing in China in recent years, and the future of this industry holds immense potential for further growth and innovation. In this section explores the future trends and potential developments in intelligent construction techniques in China.

5.1.1. Integration of AI and Big Data

One of the key future trends in intelligent construction techniques in China is the integration of AI and big data. AI technologies, such as machine learning and deep learning, are increasingly being used in construction projects to improve efficiency, accuracy, and safety. By analyzing large amounts of data collected from sensors, drones, and other sources, AI can help construction companies make better decisions and optimize their operations. In the future, it can be expected to see even greater

integration of AI and big data in intelligent construction techniques, leading to more advanced and automated construction processes.

5.1.2. Adoption of BIM

Another important future trend in intelligent construction techniques in China is the widespread adoption of BIM. BIM is a digital representation of the physical and functional characteristics of a building, which can be used to simulate and visualize construction projects before they are built. By using BIM, construction companies can improve collaboration, coordination, and communication among project stakeholders, resulting in better outcomes and reduced costs. In the future, it can be expected to see BIM becoming a standard practice in the construction industry in China, driving greater efficiency and productivity.

5.1.3. Development of Smart Construction Materials and Technologies

As the demand for sustainable and environmentally-friendly construction practices grows, there is a growing focus on the development of smart construction materials and technologies in China. These materials and technologies are designed to improve the performance, durability, and sustainability of buildings, while also reducing energy consumption and carbon emissions. Examples of smart construction materials and technologies include self-healing concrete, energy-efficient windows, and solar panels integrated into building facades. In the future, the continuous innovation of smart building materials and technologies will bring more sustainable and resilient buildings to China.

5.1.4. Expansion of Robotics and Automation

Robotics and automation are also expected to play a significant role in the future of intelligent construction techniques in China. Robots can be used for a wide range of tasks in construction projects, such as bricklaying, painting, and demolition, which can help improve productivity, safety, and quality. In addition, automation technologies, such as drones and 3D printers, are becoming increasingly common in construction projects, allowing for faster and more accurate construction processes. In the future, robots and automation are widely adopted in China's construction industry, thereby improving efficiency and saving costs.

5.1.5. Emphasis on Sustainability and Green Building

Finally, the future of intelligent construction techniques in China will also be characterized by a strong emphasis on sustainability and green building practices. With concerns about climate change and environmental degradation on the rise, there is a growing demand for buildings that are energy-efficient, environmentally-friendly, and healthy for occupants. Intelligent construction techniques, such as passive design strategies, green roofs, and rainwater harvesting systems, can help reduce the environmental impact of buildings and improve their overall performance. China's construction industry is paying more attention to sustainable development and green building practices, promoting innovation and positive change.

In conclusion, the future of intelligent construction techniques in China holds great promise for further growth and innovation. By integrating AI and big data, adopting BIM, developing smart construction materials and technologies, expanding robotics and automation, and emphasizing sustainability and green building practices, the construction industry in China can achieve greater efficiency, productivity, and sustainability.

5.2. Recommendations

Recommendations for promoting the widespread adoption of intelligent construction techniques in China

5.2.1. Enhance education and training programs

It is essential to enhance education and training programs for construction professionals to promote the widespread adoption of intelligent construction techniques in China. It can include incorporating courses on intelligent construction techniques in construction-related degrees, providing training

workshops for industry professionals, and promoting certifications in intelligent construction technologies. By increasing the knowledge and skills of construction professionals in this area, the adoption of intelligent construction techniques can be accelerated.

5.2.2. Establish industry standards and regulations

In order to ensure the quality and safety of projects utilizing intelligent construction techniques, it is important to establish industry standards and regulations. This can help to create a level playing field for all stakeholders and provide clear guidelines for the implementation of intelligent construction technologies. By developing and enforcing these standards and regulations, the adoption of intelligent construction techniques can be streamlined and promoted throughout the industry.

5.2.3. Encourage collaboration and knowledge sharing

Collaboration among different stakeholders, including government agencies, industry associations, research institutions, and construction companies, is essential for the successful adoption of intelligent construction techniques in China. By encouraging collaboration and knowledge sharing, best practices and lessons learned can be shared among stakeholders, leading to more effective implementation of intelligent construction technologies. This can also help to overcome barriers to adoption and promote innovation in the industry.

5.2.4. Provide incentives and support

In order to incentivize the adoption of intelligent construction techniques, it is important to provide financial incentives and support to construction companies. This can include tax incentives for companies investing in intelligent construction technologies, subsidies for training programs, and funding for research and development in this area. By providing these incentives and support, the cost barrier to adopting intelligent construction techniques can be reduced, leading to increased adoption rates in the industry.

5.2.5. Foster a culture of innovation

In order to promote the widespread adoption of intelligent construction techniques in China, it is important to foster a culture of innovation within the construction industry. This can involve promoting research and development in intelligent construction technologies, encouraging the use of new technologies and materials, and supporting pilot projects to test innovative solutions. By fostering a culture of innovation, the construction industry in China can stay ahead of the curve and lead the way in adopting intelligent construction techniques.

In conclusion, promoting the widespread adoption of intelligent construction techniques in China requires a multi-faceted approach that involves enhancing education and training programs, establishing industry standards and regulations, encouraging collaboration and knowledge sharing, providing incentives and support, and fostering a culture of innovation.

6. Conclusion

This paper firstly introduced some representative intelligent construction techniques, and then reviewed the different development stages in the history of intelligent construction technology application in China. With the effort by the Chinese government, a range of policies, regulations, and incentives were introduced to improve the regulatory environment regarding the application and promotion of intelligent construction in China, and many construction companies had already enhanced their competitiveness and drive innovation in the industry. Followed by in-depth case studies, the article then pointed out the benefits using intelligent construction techniques, with the application of smart site management system and BIM techniques as examples. Then the key points of how to correctly apply those techniques are summarized. Finally, the paper raised helpful recommendations with prediction for future trends to provide a feasible guide on the possible development path in the future.

In conclusion, as technology continues to advance and new challenges emerge, it is essential for construction companies in China to stay ahead of the curve and embrace the latest trends and developments in intelligent construction techniques. By doing so, the construction industry in China can embrace the opportunities offered by intelligent construction technologies and drive growth and sustainability in the sector.

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