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Enlightenment of Intelligent Construction in the Construction of First-Class University Campus

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Abstract: In September 2017, the Ministry of Education, Ministry of Finance, and the National Development and Reform Commission jointly announced the first batch of "double first-class" construction universities, aiming to improve China's education level and strengthen the country's core competitiveness. In addition to first-class teaching and first-class scientific research, first-class universities should also have first-class campuses. The campus of a first-class university should have a complete range of infrastructure, scale, and function to meet the requirements of school-running and scientific research; it should also advocate sustainable development, which includes the concept of energy-saving, smart, and green. The traditional production methods and management models of the construction industry are far from being able to meet the needs of the construction and development of first-class campuses. Digital, intelligent, and informatized construction models are the only way for current campus construction.

Keywords: Intelligent construction; First-class university; Digitalization; Intelligentization

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1. Introduction

The construction of a first-class university focuses on building a first-class faculty, cultivating top-notch innovative talents, improving the level of scientific research, inheriting and innovating excellent culture, as well as striving to promote the transformation of outcomes. In order to achieve this goal, it is inseparable from first-class infrastructure as the guarantee of space resources. In regard to the first-class university construction plan of domestic first-class universities, there has been improvement in all aspects of the campus construction standards compared with the past. For example, Peking University proposed the construction of a "quality campus"; Shanghai Jiaotong University proposed to build an international and smart campus that meets the development needs of world-class universities; Fudan University proposed to build a first-class campus and a first-class university culture to accelerate the construction of a smart campus; Harbin Institute of Technology proposed to create a multi-dimensional and "experience-style" living space in campus that integrates vision, hearing, and touch; Beijing University of Aeronautics and Astronautics proposed to enhance the cultural content and taste of the campus environment.

American quality management expert, Deming, believes that product quality is produced, not tested. This theory has been hailed as truth in the production industry. Similarly, quality campus, smart campus, and cultural campus need to run through the entire process of campus construction, rather than relying on maintenance and reconstruction at the later stages. The traditional project organization model and construction technology can no longer meet the requirements of the current first-class university campus construction. Chinese universities should seize the opportunity to upgrade and transform the construction

industry as well as actively apply BIM, prefabricated building technology, and green building technology in campus infrastructure projects. Building big data and other intelligent construction methods promote the upgrading and transformation of campus infrastructure.

2. Concept of intelligent construction

2.1. National policies to support the development of intelligent construction

During the "Thirteenth Five-Year Plan" period, the role of China's construction industry as a pillar industry has continued to rise. The construction industry in China has reached the world's leading level in terms of scale, but its informatization level and labor efficiency are low, its production method is extensive, its energy resource consumption is large, its capacity for technological innovation is insufficient, and its quality of development needs to be improved. In order to promote the transformation and upgrading of the construction industry as well as promote a high-quality development, thirteen departments including the Ministry of Housing and Urban-Rural Development jointly issued the *Guiding Opinions on Promoting the Coordinated Development of Intelligent Construction and Construction Industrialization* in July 2020. The *Opinions* clearly stated that it is necessary to focus on the overall goal of a high-quality development of the construction industry, vigorously develop intelligent construction, and apply intelligent construction in all aspects of engineering construction to form an intelligent construction industrial system that covers the entire industrial chain of scientific research, design, production, processing, construction, assembly, and operation. The proposition of promoting the coordinated development of intelligent construction and building industrialization comes from seven aspects: accelerating the upgrading of industrialization, strengthening technological innovation, improving the level of informatization, cultivating industrial systems, actively promoting green construction, opening up and expanding application scenarios, and innovating industry supervision and service models. The integration of the construction industry should be further enhanced with advanced manufacturing technology, information technology, and energy-saving technology. Among them, intelligent construction methods such as digital design system, building industrialization, and green construction are regarded as key development tasks.

On July 28, 2021, the General Office of the Ministry of Housing and Urban-Rural Development issued the *List of Reproducible Experiences and Practices for the Coordinated Development of Intelligent Construction and Industrialization of New Types of Buildings (First Batch)* to explore the experience of digital design, intelligent production, and intelligent construction from all parts of the country. There is a total of nineteen measures in six major tasks for promotion. Among them, the development of digital design mainly centers on the in-depth application of building information modeling (BIM); the promotion of intelligent production is mainly based on the standardization of prefabricated buildings, while the promotion of intelligent construction first requires the construction unit to guarantee the construction costs of intelligent sites in accordance with the contract (**Figure 1**).

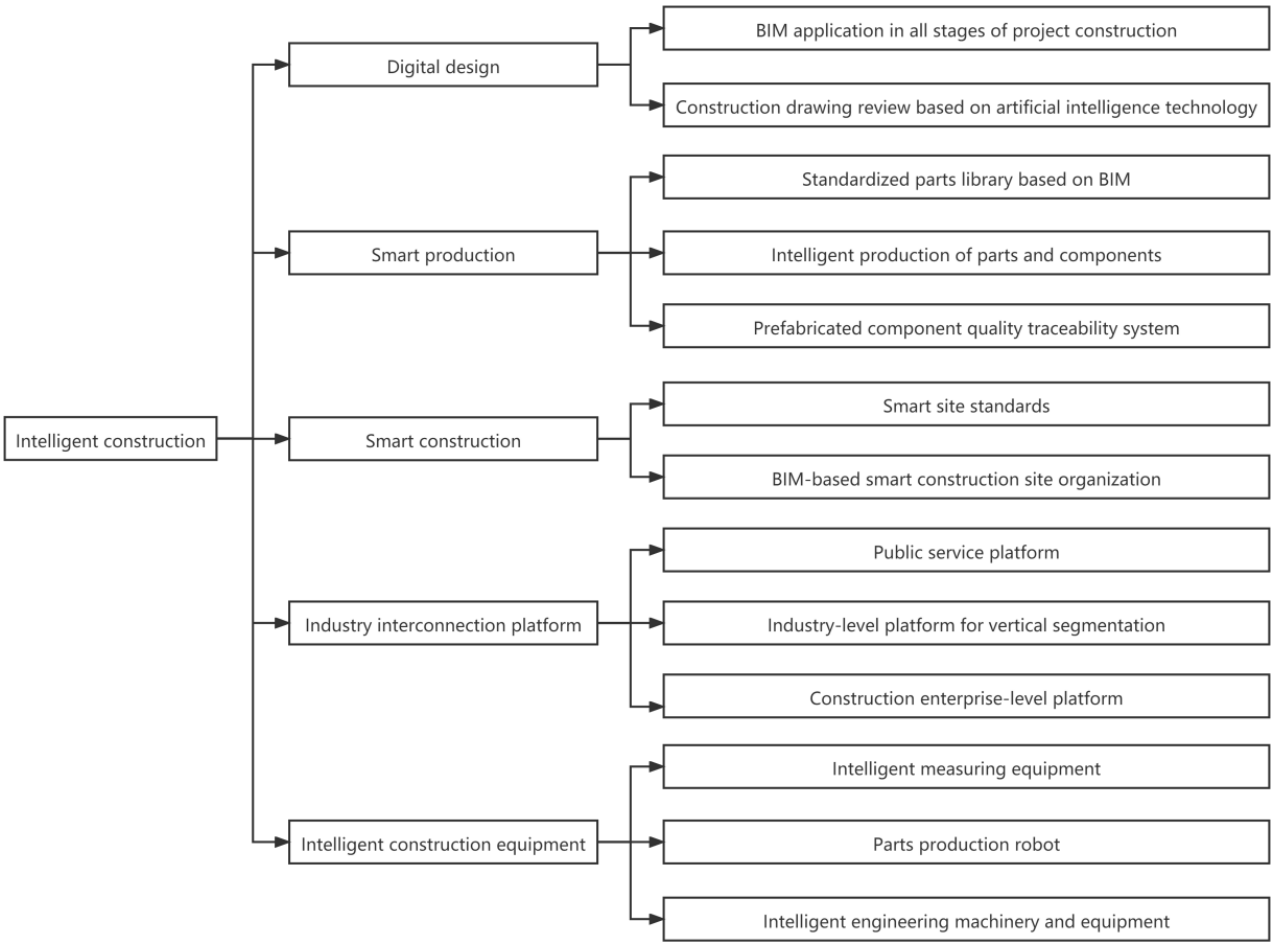

Figure 1. Main content of intelligent construction

2.2. The intelligent construction model of construction project based on life cycle

The core of the intelligent construction management model based on life cycle is the intelligent construction management platform, comprising of the engineering project information collection system, the supply chain information collection system, and the engineering project function management information collection system. It aims to establish an integrated management of engineering projects based on intelligent construction platform.

The engineering project information collection system includes planning, design, procurement, implementation, operation and maintenance, as well as dismantling, covering the entire life cycle of the construction project; the supply chain information collection system includes universities, design units, supervision units, construction units, subcontractors, and supply units, covering all parties and links in the entire industrial chain; the engineering intelligent management information collection system includes safety management, quality control, schedule control, investment control, contract management, information management, as well as organization and coordination of engineering projects, including various tasks and responsibilities of engineering project organizations. The above contents constitute the intelligent construction management model, which puts forward specific requirements from the entire management process of the project construction, the management of the main construction parties, and the functional management structure. It also provides a basis for the application of the intelligent construction model (**Figure 2**).

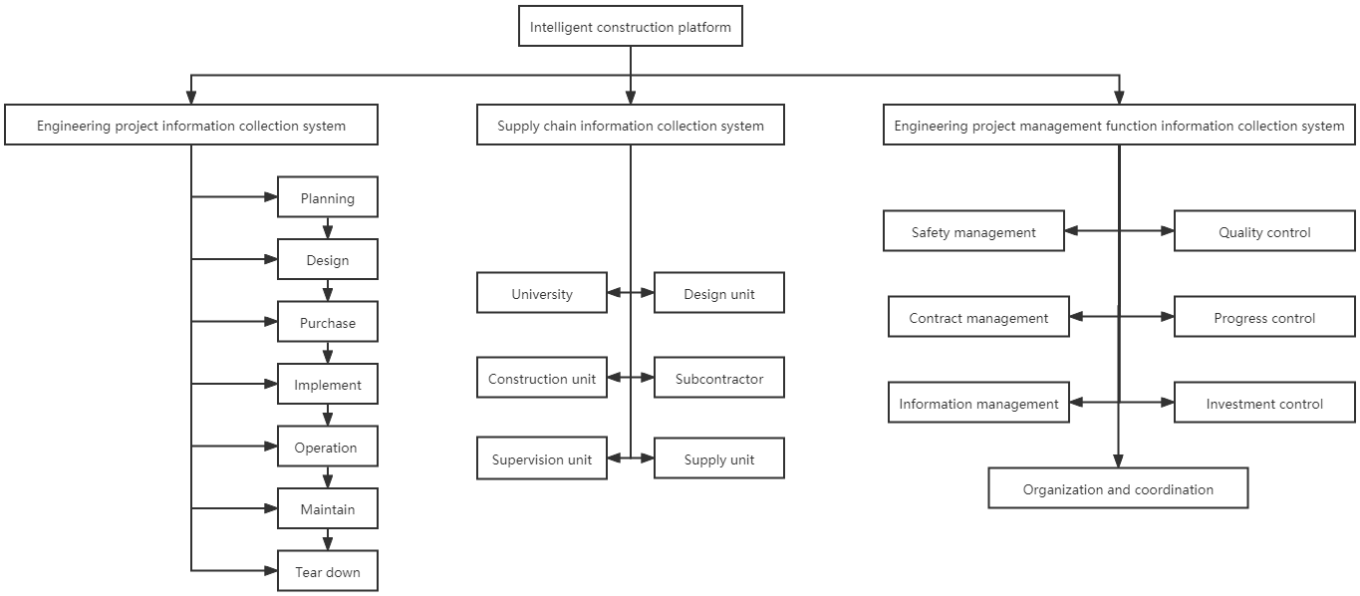

Figure 2. Intelligent construction management model framework

In addition, the operation of the intelligent construction management model cannot be separated from the overall coordination and support of the government. First of all, the government construction administrative department should take the lead in establishing a coordination and promotion mechanism as well as coordinate all relevant government departments to jointly promote the application and development of an intelligent construction management model. Secondly, preferential policies are given to relevant units of intelligent construction applications in terms of finance, taxation, etc.; the policies are used to drive the landing and implementation of intelligent construction models.

3. Necessity of applying intelligent construction in the construction of first-class university campus

When it comes to building a first-class university, it often refers to capacity building in terms of scientific research level, faculty, talent training, cultural heritage, and achievement transformation. The campus of a first-class university should be a modern and smart campus with energy-saving and green features. In the construction plan, formulated by various universities, specific goals are put forward for campus construction. The use of the model for university construction projects is a strong guarantee for achieving the goal of building a first-class university campus as well as a strong support for the construction of historical and cultural material carriers in campus.

3.1. Conducive to adapting to new government services and supervision models

Intelligent construction supports the government's gradual development of multi-departmental joint audits. The opinions from various departments can then be shared with other departments, avoiding independent governance and breaking the information island [1]. In the government's administrative evaluation and approval, most campus construction projects are recognized as government investment projects, and the requirements are often higher than social capital investment projects. For example, it is necessary to achieve the two-star mark for the pre-evaluation of green buildings, and the assembly rate should not be less than 30%. The *Green Campus Evaluation Standards (GB/T51356-2019)*, implemented in 2019, provides detailed evaluations on the construction and evaluation of green campuses in terms of planning, ecology, energy, resources, environment, health, operation, management, education, and promotion. The specific requirements include the application of BIM and campus assembly rate. In addition, the government has

introduced a reward and compensation mechanism for BIM demonstration projects and prefabricated teacher training projects.

3.2. Conducive to the development of collaborative design

The BIM-based digital design in intelligent construction creates the basic conditions for the collaborative design of engineering projects, while the supply chain information collection system provides external conditions for the collaborative design of engineering projects. First of all, the integrated platform formed by BIM-based digital design technology can closely link various disciplines in architectural design, form effective interactions, and avoid design information islands. At the same time, designs can be carried out at different stages with the help of 3D modeling. It is also possible to conduct intersection inspection and detect collision problems between pipelines and structures due to mistakes at an early stage. Secondly, the supply chain information collection system can closely link the design, construction, supervision, supply, and other major participants in the construction, forming a timely and effective exchange of information during the implementation process as well as promptly resolving design changes that may occur during construction.

3.3. Conducive to the organization of efficient construction and reduce the impact on campus environment

The BIM-based smart site planning system automatically collects project-related data and information as well as combines project construction environment, node duration, construction organization, construction technology, and other factors, so as to arrange the project construction site, construction machinery selection, construction plan, and resource plan. It makes intelligent decisions and provides data to assist decision-making, thus avoiding unreasonable construction procedures, equipment conflicts, unreasonable use of resources, hidden safety hazards, and the lack of workspace.

The intelligent construction model has been established to promote energy-saving and green concepts in the entire management of construction projects, reduce air, noise, lighting, and other pollution, realize efficient construction and green construction, as well as avoid affecting the normal operation of university teaching, scientific research, etc. It is in line with the current requirements of the state for the evaluation of green campus operation. At the same time, it is also a rare practical case to promote the green concept in campus.

3.4. Conducive to the rapid and efficient realization of the goal of building a first-class university campus

Based on the goals in constructing a first-class university campus set by the aforementioned universities, the main focus is on campus planning, functional layout, smart campus, ecological environment, and campus culture. Traditional civil engineering construction technology has been unable to meet the requirements; hence, it is necessary to adopt advanced construction methods. In the implementation of projects, in addition to the five parties responsible for construction, survey, design, operation, and supervision, there is also a construction unit. This construction unit bears the primary responsibility, plays an organizational and coordinated role, as well as determines the implementation level and effect of the project. In the life cycle of construction projects, the application depth and extent of the intelligent construction model depends on the construction unit. With the development of industrialization and informatization, the leading intelligent construction industry has a relatively solid foundation for development and plays a leading role in the practice of transformation and upgrading. As construction units, universities have the responsibility and obligation to promote the application of intelligent construction in

construction projects [2].

4. Suggestions for the application of intelligent construction in the construction of first-class university campus

4.1. Continue to promote the in-depth application of BIM

At present, the breadth and depth of the application of BIM in campus construction projects are insufficient. First-class university infrastructure managers must emancipate their minds, bravely innovate, and promote the establishment of a BIM application mechanism for the project management of the construction unit. In the project approval stage, through the establishment of a BIM model to achieve visual and human-oriented program display, it is convenient for decision-making institutions to make decisions; in the design stage, a digital design system based on BIM can be applied to coordinate the building structure, mechanical and electrical equipment, parts, components, assembly construction, and decorations as well as implement the integrated design; in the procurement stage, the BIM model can be used to compile the bill of quantities to avoid the risks of the content and quantity description at the source [3]. At present, the digitization of BIM-based project approval, design, and procurement stages is an urgent task to improve the management of campus construction projects. Universities should gradually promote the application of BIM in the construction as well as in the operation and maintenance according to specific situations.

4.2. Gradually promote the application of prefabricated buildings

Among university buildings, the most common ones are student dormitories, laboratories, and classrooms. According to the 2018 edition of *General University Building Area Indicators*, the scale of these three types of buildings accounted for nearly 70%. In terms of the layout and structural characteristics of dormitories, laboratories, and classrooms, prefabricated buildings are suitable.

A prefabricated building is a combination of the construction industry and standards, which transforms the traditional method of on-site tying of steel bars and concrete pouring into standardized production in factories, in which the components are then transported to the site for installation. The advantage of this is that the production of building components, such as beams, columns, slabs, partition walls, etc., are all carried out in factories; thus, the production of these components is not affected by external factors, such as weather, temperature, traffic, etc. In that way, continuous production can be realized. On-site assembly greatly reduces dust and noise. The impact on the surrounding environment is one of the important components of green construction. This kind of on-site assembly often uses mechanical connection, which is convenient for disassembly and adjustment, thus meeting the needs of universities for more flexible use.

Intelligent production of building components based on BIM and intelligent construction equipment based on artificial intelligence are the core aspects of intelligent construction. Prefabricated buildings are the industrialization and standardized production of building components. Standardized on-site installation is the basis for intelligent construction. Therefore, in order to promote intelligent construction in the construction of first-class university campus, it is necessary to adopt the approach of prefabricated buildings.

4.3. Select a suitable project contracting mode

At present, the construction projects of universities basically adopt the general contracting mode. As construction units, universities need to coordinate survey units, design units, supervision units, construction units, and many subcontractors. The workload in organization and coordination is extremely heavy. The university's personnel system faces difficulty in allowing its infrastructure management department to establish a professional management team that covers the construction industry. It has largely become an information transmission agency for other participating units and has not formed a management mechanism

with decision-making capabilities. According to empirical value, the equipment-type building adopts the general contracting method to better utilize the advantages of the prefabricated building and reduce the cost of about 3% to 5% of the total project [4]. With the in-depth application of advanced construction technologies, such as BIM, city information modelling (CIM), geographic information system (GIS), and prefabricated buildings, universities should improve their project management and control capabilities by changing the project contracting mode.

Universities should select suitable project contracting modes according to their own characteristics and construction project management experiences. The general contracting mode led by the design unit can provide universities with integrated design, procurement, and overall construction project plan, transform the previous one-to-many management model into one-to-one, as well as emancipate universities from solving complicated coordination problems. In this way, more energy and resources can be used to improve the level of project management. In addition, the entire process of contracting also provides professional consulting services to universities and technical support in the whole process of project establishment, design, procurement, construction, operation, and maintenance. The management of construction projects in universities can then be transformed into goal setting, performance appraisal, and achievement of results.

5. Conclusion

The campuses of first-class universities should live up to their reputations, and the construction methods for first-class campuses should reflect quality, fully embodying economy, sustainability, and wisdom [5]. In the critical period of the optimization and transformation of China's construction industry, intelligent construction provides effective methodological support for achieving the goal of constructing first-class campuses. The digital design mode and intelligent construction system based on BIM would continue to promote the effective implementation of infrastructure projects in universities. Universities should constantly adapt to the overall environment of the reform and development of the construction industry, actively participate in its reform and development, as well as make full use of the opportunities of the reform and development to improve the governance capacity in the implementation of infrastructure projects.

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Disclosure statement

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