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Research on the Practice of Digital Low-carbon Management of Construction Projects from the Perspective of Globalization

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Abstract

Traditional construction projects have high energy consumption and low efficiency of low-carbon management mode. Under the background of global carbon neutrality development trend and digital transformation of construction industry, low-carbon management of construction projects in the whole life cycle has become the trend of industry development. From the whole life cycle of construction project decision-making stage, design stage, construction stage to operation and maintenance demolition stage, this paper explores the application path of BIM, big data, Internet of things, digital twin and other digital technologies in the low-carbon management of the whole life cycle of construction projects, so as to reduce costs and promote sustainable development. By analyzing the practice cases of digital low-carbon management of typical construction projects at home and abroad, this paper compares the differences of construction project management modes in different countries and regions, summarizes the implementation mode, core advantages and existing problems of digital low-carbon management, combs the specific low-carbon management mode from the whole life cycle of the project, and puts forward optimization countermeasures for the existing technology, system and talent challenges of the industry development.

Keywords

globalization perspective, construction engineering, digital management, low carbon management

1. Theoretical Basis of Digital Low-carbon Management of Construction Project

1.1 Concept and Connotation of Low-carbon Management

With the rapid development of digital technology in the field of construction engineering, it has gradually

developed from a single software application to an integrated management system with multi-technology integration, and has become the core support for low-carbon control and fine management of engineering. With informatization and intelligence as the core, it effectively solves the problems of information island and experience-led management and control in traditional engineering management. At present, construction projects are mainly applied in the whole life cycle, including BIM technology, Internet of things, big data analysis, digital twin, cloud collaborative platform and other digital technologies.

1.2 Application and Development of Digital Technology

The digital technology of construction engineering is a technical system that takes information and intelligent technology as the core, breaks the information island of traditional engineering management and the disadvantages of empirical management and control. The core covers BIM technology, Internet of Things, big data analysis, digital twin, cloud collaborative platform and so on. BIM technology can realize three-dimensional visual modeling, energy consumption simulation, collision detection and fine control of materials, and provide data support for low-carbon design and precise construction. The Internet of Things technology can collect data such as energy consumption, dust and equipment conditions in the construction site in real time through intelligent sensors and monitoring equipment to realize dynamic supervision of the construction process. Big data technology can analyze and judge massive engineering data, accurately calculate building carbon emission data, and optimize resource allocation schemes; digital twin technology can build a virtual simulation model of buildings, realize real-time synchronization between physical engineering and digital models, and support intelligent management and control of the whole life cycle. At present, digital technology has developed from the application of a single tool to the integrated management system of multi-technology integration, and has become the core carrier of landing low-carbon management and realizing fine management and control of engineering. With informatization and intelligence as the core, it effectively solves the problems of information island and experience-led management and control in traditional engineering management. At present, construction projects are mainly applied in the whole life cycle, including BIM technology, Internet of things, big data analysis, digital twin, cloud collaborative platform and other digital technologies.

BIM technology can complete three-dimensional visual modeling, energy consumption simulation, collision detection and precise control of materials, and provide data support for low-carbon design and refined construction.

Internet of things, with the help of intelligent sensors and monitoring equipment, real-time collection of construction site energy consumption, dust, equipment operation status and other information, to achieve dynamic supervision of the construction process;

Big data technology can analyze and process massive engineering data, accurately calculate building carbon emissions, and optimize resource allocation schemes;

Digital twin can build a virtual simulation model of buildings, realize the synchronous linkage between physical engineering and digital models, and support intelligent management and control of the whole

life cycle.

2. The Practice of Digital Management of Construction Engineering from the Perspective of Globalization

The digital low-carbon transformation of the construction industry in developed countries started earlier and has formed a relatively mature practice system. Europe and the United States take standard leading and market driving as the core, have a perfect international green building standard system, have a high popularity of digital technology application, and have a strong sense of independent low-carbon transformation of enterprises, focusing on building life cycle carbon emission accounting and long-term low-carbon operation and maintenance management; singapore is characterized by government coordination and global coordination. It builds a unified digital management platform for buildings, realizes the interconnection of low-carbon data for urban construction projects, and implements strict index control for building materials, construction, operation and maintenance.

Taking the intelligent green building project in Berlin, Germany as an example, the project park was formerly a gas station abandoned for many years, and was later transformed into a high-tech demonstration park for Germany 's energy transformation strategy. The project adopts the integrated management and control mode of digital twin + BIM throughout the whole process to build a digital management platform for the whole life cycle. In the design stage, the building lighting and ventilation structure is optimized through energy consumption simulation to reduce the energy consumption of later operation and maintenance. In the construction stage, the mechanical energy consumption, hydropower consumption and construction waste generation are monitored in real time based on the Internet of Things equipment, and the construction carbon emission is accurately controlled. The final project carbon emission is 32 % lower than that of the traditional project, and successfully passes the LEED platinum level certification.

However, the digital low-carbon management of buildings in China started relatively late, showing the characteristics of policy-led and rapid implementation. In recent years, mainly relying on the construction of smart construction sites and the support of " double carbon " policies, the digital low-carbon management and control in the construction stage has developed rapidly, but there are still problems such as insufficient digital integration in the design and operation and maintenance stages, weak adaptability of international standards, and imperfect data systems. The industry as a whole is still in the deepening stage of digital low-carbon transformation.

With the continuous advancement of economic globalization and the ' Belt and Road ' infrastructure development strategy, the domestic construction industry is deeply integrated into the international market, and the traditional construction project management model has been completely changed. The international construction market generally implements green building evaluation standards such as LEED and BREEAM, and puts forward clear quantitative requirements for engineering carbon emissions, resource utilization, and green construction processes, and promotes the domestic engineering

management system to move closer to international standards.

3. The Specific Implementation Strategy of Digital Low-carbon Management in the Life Cycle of Construction Projects

3.1 Low-carbon Integrated Management in Decision-making Stage

The decision-making stage is the starting point of the construction project declaration cycle, which has the greatest impact on the project decision-making. It is also the starting point and general outline of the project 's low-carbon management, which directly determines the project 's full-cycle low-carbon goal and implementation direction. In the process of project establishment, feasibility study and scheme comparison, low carbon index should be taken as the core index for the success of project establishment. Using big data and digital decision-making platform, the project address and location selection, functional positioning, construction scale design, structural system rationalization and so on are compared and selected. The scheme with lower carbon emission, less resource consumption and stronger adaptability is preferentially selected, and the life cycle carbon emission reduction target and control path of top-level design are defined to ensure that the project is low-carbon and feasible from the source, which lays a solid foundation for the digital low-carbon management of the whole life cycle.

3.2 Low-carbon Optimization in Design Stage

The design stage is the key link in the application of digital technology. This stage mainly relies on BIM technology to establish a three-dimensional model of the building, combined with international LEED, BREEAM standards and domestic green building specifications, to carry out digital analysis and design of building energy consumption simulation, lighting and ventilation simulation, structural collision detection, etc. Optimize the building layout, envelope structure, doors and windows materials, give priority to the use of low-carbon environmental protection, sustainable use of green building materials, reduce the building life cycle energy consumption. At the same time, the digital platform is used to integrate the needs of design, construction, operation and maintenance, so as to avoid the problems of late rework and waste of resources caused by unreasonable design. The digital low-carbon design ledger is established to realize the quantitative evaluation and dynamic adjustment of the design scheme, so as to ensure that the design scheme meets the domestic norms and international low-carbon standards at the same time.

3.3 Fine Management of Construction Process

Building carbon emissions are concentrated in the construction stage. At this stage, digital technology is needed to achieve refined low-carbon control. On the one hand, a digital management system for smart construction sites is built, and data such as hydropower consumption, energy consumption of mechanical equipment, dust noise, and construction waste production at the construction site are monitored in real time through intelligent sensors of the Internet of Things.Real-time accounting of carbon emissions is completed based on big data technology, early warning and rectification of high energy consumption and high pollution construction links are carried out, construction procedures and equipment scheduling are

optimized, and energy waste is reduced. On the other hand, BIM technology is used to optimize the construction schedule, material procurement and stacking plan, accurately calculate the amount of building materials, and reduce material loss. Promote digital low-carbon construction ledger, standardize green construction process, strictly control extensive construction behavior, and ensure the realization of low-carbon, efficient and controllable construction process.

3.4 Intelligent Management in Operation and Maintenance Phase

The carbon emission in the operation and maintenance stage accounts for the largest proportion of the whole life cycle of the building, which is the core link of long-term low-carbon control. This stage is mainly based on digital twin technology to build a digital simulation platform for building operation and maintenance, so as to realize real-time monitoring and dynamic regulation of building equipment and energy consumption system. It can automatically count the operation energy consumption of hydropower, HVAC, elevator and other equipment, and optimize the operation mode of equipment through big data analysis to reduce invalid energy consumption.

At the same time, a digital operation and maintenance ledger is established to fully record the data of building energy consumption, equipment maintenance and carbon emissions, so as to realize the accurate positioning and rapid processing of operation and maintenance problems. For international projects, the operation and maintenance data can be connected with the international low-carbon accounting system, and long-term low-carbon control can be carried out in accordance with international standards to improve the green operation level and international recognition of the project.

4. Challenges and Countermeasures

4.1 Technical Problems and Solutions

At present, the digital low-carbon management of construction projects still faces many technical problems: First, the integration of various digital technologies is insufficient. BIM, Internet of Things, and big data systems are independent of each other, and data fragmentation is serious. It is difficult to achieve full-process linkage control; secondly, the carbon emission accounting system at home and abroad is not uniform, and there are differences between domestic accounting standards and international standards, which is not conducive to the development of overseas business of enterprises. Third, the application cost of cutting-edge technologies such as digital twin and intelligent energy consumption simulation is high, and it is difficult to promote them in small and medium-sized construction enterprises.

In view of the above problems, the industry should speed up the construction of integrated digital low-carbon management platform, break the data barriers of various systems, and realize data sharing and business linkage. Unify the digital accounting caliber of building carbon emissions, and optimize the local accounting system with reference to international standards; with the help of policy support and reduce the cost of digital transformation of small and medium-sized enterprises, promote lightweight, low-cost digital low-carbon control programs.

4.2 Personnel Training and Team Building

The lack of relevant professionals is the core bottleneck restricting the international development of digital low-carbon management of buildings. At present, most of the existing management personnel in the industry are good at traditional engineering construction and cost control, but lack digital technology operation ability, carbon emission accounting professional knowledge and international engineering management vision, and there is a big gap in compound talents.

In order to solve this problem, firstly, colleges and universities should optimize the curriculum system of engineering management specialty, and set up or increase digital technology, international green building standards and low-carbon management in related courses such as engineering project management. Secondly,Enterprises establish a normalized training mechanism for on-the-job personnel, and carry out special training such as BIM operation, carbon emission accounting, and international project management; at the same time, we will deepen school-enterprise cooperation, cultivate compound engineering management talents with digital ability, low-carbon literacy and international vision, and improve the construction of industry talent echelon.

5. Conclusion

Under the dual background of global carbon neutrality and digital transformation of the construction industry, digital low-carbon management has become an inevitable trend of high-quality and international development of the construction engineering industry. By combing the theoretical basis of digital low-carbon management of construction projects, this paper clarifies the core connotation and internal relationship of low-carbon management, digital technology and global engineering management. Combined with typical practical cases at home and abroad, the important value of digital technology in low-carbon management and control of building life cycle is confirmed. At the same time, from the four core stages of decision-making, design, construction and operation and maintenance, the implementation path of the whole process of digital low-carbon construction engineering is constructed, and targeted optimization countermeasures are proposed for the two core challenges of existing technology and talents in the industry, which has important practical significance for the transformation and upgrading of the domestic construction industry and the international development of construction enterprises.

In the future, we can further deepen the research on the digital low-carbon collaborative management of cross-border projects, the deep integration of Chinese and foreign standards, and the application of intelligent low-carbon algorithms, and continuously improve the digital low-carbon management system of construction projects from the perspective of globalization, so as to help China 's construction industry fully integrate with the international green development wave and achieve high-quality sustainable development.

References

Chen Yu. (2023). Application of digital technology in low-carbon construction of smart site. *Construction technology*, *52*(11), 89-93.

Li Jing. (2023). Research on low-carbon management of building life cycle under the background of carbon neutrality. *Journal of Engineering Management*, *37*(02), 45-50.

Ministry of Housing and Urban-Rural Development. (2019). *Green Building Evaluation Standard* (GB / T 50378-2019). Beijing: China Construction Industry Publishing House.

Wang Yaowu. (2022). *Digital management and intelligent construction of construction engineering*. Beijing: China Construction Industry Press.

Zhang Ming. (2022). Comparative study on the suitability of international green building standards and domestic standards. *Building economy*, *43*(08), 78-83.