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BIM technology and sustainable application development of green building under new evaluation standard

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Abstract. Taking the integration of modern information technology and green building as the research background, we study the current status of BIM technology and green building development and application in the existing green building evaluation standard system, analyze the obstacles existing in the practical application of BIM technology in the whole life cycle of green building under the new global evaluation standard, and point out the direction of further research. The results of the study show that at this stage, BIM technology and green building-related regulations and systems are not yet sound, the evaluation standard system is not yet perfect, and there is a lack of organic synergy between each other,"Siloing" at certain points throughout the life cycle of a building. Green buildings are far away from the development and application of BIM technology and green buildings. The phenomenon of "isolated" in some stages of the whole life cycle of the building, some links appear as an "island" phenomenon, there is still a gap between green building and comprehensive coverage, and the widespread application of BIM technology needs to be promoted. In the future, the application research on sustainable development of green buildings based on BIM should be committed to further improve the relevant regulations, systems, and evaluation standards, create a core database of all relevant information in each stage of the whole life cycle of the building, realize the interactive sharing of information, implement the BIM integrated application mode, give full play to the advantages of the whole life cycle and integrated management of BIM, and integrate BIM technology with green building in a deeper way.

Keywords: Building Information Modelling, Green Building, Sustainable development, applications.

1. Introduction

Globally, 35-40% of energy-related carbon dioxide emissions come from the construction sector, and the construction industry consumes 40% of the world's energy and raw materials, while the efficiency of the construction industry is very low compared with other industries [1,2]. With the increasing global attention to the high consumption of resources and energy, low capacity, and high pollution caused by the construction industry, green building has become the development concept and pursuit of the construction industry in the new era and has become the goal of sustainable development of the construction industry at a higher level. In the 1970s, since the Emergence of the BIM concept, Building Information Modelling (BIM),as a direct expression of digital technology in the construction industry, triggered the construction industries. Since the 1970s, BIM, as a digital technology directly expressed in the construction industry, has triggered an unprecedented and radical change in the construction industry,

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providing a strong and realizable core technology support for the healthy, green, and sustainable development of the construction industry.

2. Current status of domestic and international development and application research

2.1. Development of BIM Technology

Building Information Modeling (BIM), as a brand-new technology and concept, has the characteristics of visualization, coordination, simulation, optimization, controllability, etc., and has the value of being used in the pre-design stage, design stage, construction stage, quality management, cost control, operation, and maintenance, etc., and is used throughout the stages of the whole life cycle of a building, which has been widely recognized by the industry around the world. Widely recognized by the industry. BIM was first introduced by Eastman in the United States[3]. Consequently, Laiserin [4], Guo et al. and McGraw-Hill Construction have defined the concept[5,6]. The definition given by the Facilities Information Council (FIC), an international standards organization, is more accurate: BIM is a computable, algorithmic representation of the physical and functional characteristics of a facility and its associated project lifecycle information in a computable, algorithmic form under open industry standards to support decision-making to better realize the value of a project [7].In recent years, the United States, Germany, Hong Kong, Australia, the United Kingdom, China, South Korea, Singapore, and other countries have introduced strategic planning to promote BIM technology, BIM technology accounted for an increasingly higher market share, according to Research and Market's "Building Information Modelling (BIM) Global Market Trajectory and Analysis" report, the global building information modeling (BIM) market size in 2020 is about $4.8 billion, and is expected to be $13.6 billion in 2027, a compound annual growth rate of 17.1%. The U.S., Canada, China, Japan, and the European Union will further fuel the BIM market. Asia Pacific is expected to reach $1.6 billion by 2027, led by China, Australia, South Korea, and India.

2.2. Global Green Building Practices

As a representative of green and sustainable building products, green building is an international scientific development model that promotes the sustainable development of the construction industry [8].Green building refers to a high-quality building that saves resources (energy, land, water, and materials), protects the environment, reduces pollution, provides people with healthy, suitable, and efficient use of space, and maximizes the harmonious coexistence of human beings and nature during the whole life cycle of the building. The whole life cycle of a building includes the whole process of site selection and planning, architectural design, engineering construction, operation and maintenance, and renovation until demolition. Italian-American architect Paolo Soleri first proposed a new concept of ecological architecture in the 1960s. American architect Ian McHarg wrote the book "Designing with Nature" in 1969, marking the official birth of ecological architecture. In 1975, Robert Vale and Professor Brenda Vale of the University of Cambridge published the book "The Autonomous House", which is regarded as the founding work of green building. The World Conservation Organisation (WCO) first put forward the slogan of "sustainable development" in 1980, and the energy-saving building system was gradually improved at the same time, and widely applied in developed countries such as Britain, Germany, France, and Canada. The United Nations Environment Programme (UNEP) published the report "Our Common Future" in 1987, which established the idea of sustainable development.

2.3. BIM-Based Green Building Evaluation Systems

The world's first green building assessment method (Building Research Establishment Environmental Assessment Method, BREEAM) was released in 1990 in the United Kingdom, marking the green building into a comprehensive development stage. Since then, countries have successively established green building evaluation systems, representative of the United States, such as the "Leadership in Energy & Environmental Design Building Rating LEED" in the United States, "Green Building Tool,

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GB Tool" in Canada, "Comprehensive Assessment System of Building Environmental Efficiency" in Japan, and "German system of Sustainable Building Certificate, DGNB" in Germany. The German system of Sustainable Building Certificate, DGNB" China's "Green Construction Evaluation Standard for Building Engineering", "Green Building Evaluation Standard" (GB/T 50378-2019), and so on. However, most of these evaluation systems belong to the industry organization norms and are not mandatory certifications, and the effect of their implementation is very much related to the development of relevant national rule of law regulations, policy incentives, publicity, and popularity.

3. Research methodology

We searched all the published literature with "BIM" and "green building" in the title through China Knowledge Network (CNN), and analyzed the main themes and contents of the retrieved literature to study the current situation and practical barriers in the application of BIM technology and sustainable development of green building under the new global evaluation standards, and pointed out the directions for further research. The main themes and contents of the retrieved literature are analyzed to study the current status and practical barriers to the sustainable development of BIM technology and green buildings under the new global evaluation standards and to point out the direction of further research. Although this statistic cannot fully represent the research, it can reflect the research trend of the application of BIM technology and green building in global sustainable development to some extent. The total number of eligible literatures is 667, of which 338 are basic theoretical research or exploratory research, and 329 are practical and applied literature in all stages of the whole life cycle, as shown in Fig. 1. Although affected by the global COVID-19 pandemic and the continuous decline of economic development, in general, the research and application of BIM technology and green building research has shown a growing trend in all stages of the whole life cycle of the building.

	The whole life cycle of a building	Green building design	Application and research of green building evaluation	Green building energy saving	Building materials management applications	Green construction and management	Maintenance	Engineering cost
Total articles	34	179	21	37	24	32	1	1
2011-2015	3	13	4	1	2	0	0	0
2016-2019	20	110	4	16	12	11	0	1
2020-2023	11	56	13	20	10	21	1	0

Figure 1. Number of documents for each stage of the building life cycle, 2011-2023

As can be seen from Figure 2, the application of BIM technology in the whole life cycle of green buildings is still dominated by green building design, followed by green building energy efficiency (mainly design application) and green construction and management (mainly management application), and then in order of building material management application, green building evaluation application and research, building energy consumption, project cost, maintenance, and very little application in operation and maintenance.

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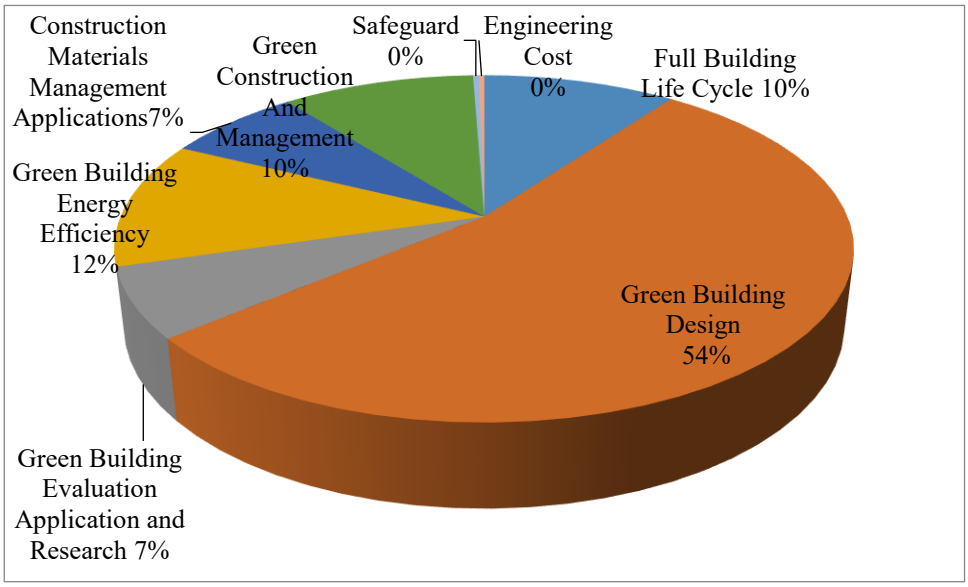

Figure 2. Percentage of research on the application of BIM technology in each stage of the whole life cycle of green buildings

4. Results

4.1. High Adaptability of BIM Technology to Green Buildings

(1)The time dimension is consistent. Theoretically, BIM technology runs through all stages of the whole life cycle of a building from planning and design toconstruction, and operation, and enables building information integration and scientific and reasonable intensive management throughout the entire process of the project. Green building refers to a high-quality building that saves resources, protects the environment, reduces pollution, provides people with healthy, suitable, and efficient use of space, and maximizes the harmonious coexistence of man and nature during the whole life cycle of the building. Both run through the whole life cycle of the building, and the time dimension plays an extremely important role in this process, providing a possibility for the effective integration of the two.

(2)The concept is the same. Green building is the macro development concept and the ultimate goal of the construction industry, BIM is a scientific technology concept, that adheres to the concept of sustainable development, green building focuses on the performance of different stages of the whole life cycle of the building, while the BIM technology for the judgment of the performance of these scientific information data support, the two from the concept of coincide.

(3)Complementary core functions. Achieving the sustainable development goal of green building requires professionals in various fields to use different methods and technologies to divide and collaborate throughout the construction period of the project to achieve the purpose of saving resources, saving money, and reducing pollution. The support of BIM technology provides an overall solution to achieve the sustainable development goals of green buildings [9].BIM technology can efficiently provide green buildings with the required data and related information by integrating and applying informatization and digital modeling throughout the whole life cycle of the building.BIM modeling is convenient for the relevant personnel, and it can be used to control the design and construction process of the green building at different stages, to achieve the goal of achieving the sustainable development goals of the green building. BIM modeling is very convenient for those who can control the design and construction process of green buildings at different stages, to achieve the goal [10].

(4)Open application platform. Green building in the site planning, drawing inspection, site configuration, quantity monitoring, energy consumption, lighting and ventilation, and other aspects of the analysis is indispensable, need to operate with the help of professional software, and at the same time to the relevant application platform to open, to the BIM technology in the green building industry

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provides an immensely broad platform for the development of the development of unlimited development potential. BIM platform not only has the openness of the characteristics of the green building construction process but can serve as a communication platform for different professional synergies and coordinated development. BIM platform has open characteristics and can be used as a communication platform for different professional cooperation and coordinated development in the green building construction process[11].Based on this platform, the design team and other stakeholders, such as the construction unit, the operation department, and the owner, can optimize collaboration to effectively improve work efficiency, environmental protection, and energy saving, reduce costs, and shorten the construction period to achieve sustainable development. At the same time, a series of visualization operations such as collision detection, energy analysis, virtual construction, and green assessment of buildings can also be carried out in conjunction with information technology. Therefore, the openness of the BIM platform is very suitable for the application of the building system,making the green building more scientific and efficient.

4.2. Barriers to the practical application of BIM technology

(1)Inadequate laws, regulations, and management systems related to all stages of the green building life cycle, imperfect evaluation standard system, lack of organic synergy among them, insufficient incentive policies for green building development, insufficient professional institutions and talents for green building planning, consulting, designing, evaluating, constructing, assessing, etc., and slow development of green building materials and low integration of the construction industry. Many experts at home and abroad believe that the differences in the existing institutions, standards, and norms in the field of construction are the obstacles that need to be broken through to promote the application of BIM technology [12,13].

(2)The application of BIM technology in the whole life cycle of green buildings, in addition to theoretical research, is still mainly focused on the building design stage, and in recent years, although it has been extended to the stages of building energy efficiency, green construction, application of building materials management, and green building evaluation, the application of it in the cost of the project and the later stage of operation and maintenance is still not much.

(3)The BIM-based data exchange standard IFC does not cover all fields of construction engineering, focusing on the engineering design field, lacking entity and relationship types in the field of engineering management, and not expanding to fields other than construction engineering, and lacking data descriptions suitable for a certain country or region in some fields. Many BIM technology applications are concentrated in the AEC stage, not extended to the FM stage, and the application mode is a designer-driven mode rather than an owner-driven mode, which does not give full play to the important role of BIM in the whole life cycle of green buildings [7].

(4)Existing BIM software is too complex, poor compatibility between software, lack of interoperability, lack of rich model information, and lack of "integrated", "all-in-one", and "one-stop" software, which leads to The lack of "integrated", "integrated" and "one-stop" software has hindered the transfer of sustainable building models in all phases. He et al. analyzed 32 BIM software with international and industry influence and found that the operation phase is in an "isolated" state in the construction life cycle[14], and the three links of "green design", "specification inspection" and "cost management" have the phenomenon of "island"; the interaction analysis of Revit and Archibus software found that there is some interaction between the two software. Green design", "specification inspection", and "cost management" three links appear "island" phenomenon; Revit, Archibus two software interactivity analysis found that there is a certain degree of interactivity between the two software, but in the actual use of communication does not occur. BIM application encounters the "synergy" dilemma and lacks effective integrated management in the whole life cycle of the building.

5. Discussion

BIM technology as a new technology in the field of construction is widely used, more and more by global industry experts and scholars as well as government attention. Green building is the development

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concept and ultimate goal pursued by the modern construction industry, and the introduction and support of BIM technology provide feasible and powerful technical support for green building and lay the foundation for the ultimate realization of the goal of healthy and sustainable development of green building. Green building and BIM technology both serve the whole life cycle of the building, and both have high adaptability, their combination is an inevitable trend, and the depth of integration of BIM technology and green building, to enhance the sustainability of the building is of great significance, but how to better seamless docking of the two, how to optimize the whole life cycle of the green building of the BIM technology, how to achieve the goal of green building to better provide core technical support, has become the core of the green building development concept and the ultimate goal of green building. However, how the two can be seamlessly integrated, how BIM technology can optimize all aspects of the green building life cycle, and how it can better provide core technology support to achieve the goal of green building have become urgent issues for the construction industry.

6. Conclusions

Countries and regions around the world should continue to raise green awareness, improve relevant laws and regulations and management systems, improve the evaluation standard system and incentive mechanism, promote the research of green building and BIM technology in the whole life cycle of the building from the basic theory research to the practical application research, extend from the design stage to the later stages of construction and operation and maintenance, and promote the organic synergy between the various phases, and promote the application mode from the Designer-driven mode to owner-driven mode [7]. Accelerate the training of professional institutions and talents, promote the development of green building materials, and improve the integration with the construction industry. Future BIM technology application research should be committed to creating a core database of all relevant information in all phases of the building life cycle, in order to promote the integrated exchange of global information, achieve interactive information sharing, eliminate all kinds of "island" phenomenon in the whole life cycle of the building, "isolation" state, the implementation of the BIM integrated application model, giving full play to the full life cycle of BIM and the integrated application of the model. BIM's full life cycle and integrated management advantages, the deep integration of BIM technology and green building, to better achieve green, healthy, and sustainable development in the field of construction.

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