Proceedings of CONF-FMCE 2025 Symposium: AI and Machine Learning Applications in Infrastructure Engineering
DOI: 10.54254/2755-2721/2025.MH25336

Analysing the Application of BIM Technology in the Various Stages of a Construction Project's Life Cycle

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Abstract: At present, the traditional construction industry is gradually exposed to inefficiency, information fragmentation and other problems, making it difficult to meet the needs of sustainable development in today's society. With the continuous progress of science and technology, BIM technology, with its high efficiency, has begun to be gradually applied to the construction industry. This paper firstly describes what Building Information Modeling(BIM)technology is by giving an overview of BIM technology, and then analyses the application of BIM technology combined with Geographic Information System(GIS) in the planning stage of construction, the application of BIM technology in building design and the application of BIM technology in construction, such as virtual construction and so on. Through the analysis, the combination of BIM and GIS can greatly help the planning of buildings in site selection and energy consumption optimisation; the multi-disciplinary collaboration of BIM can greatly improve the efficiency of building design; the intelligent calculation of project quantity and dynamic cost control of BIM and virtual construction can greatly help the construction of buildings. This study aims to summarise the previous findings and promote the application of BIM technology in the future construction industry.

Keywords: BIM, Design, Planning Construction

1. Introduction

In the context of the rapid development of today's construction industry, the dilemma facing the traditional construction industry is becoming more and more significant. There are many problems, such as fragmentation of information between the various professions, waste of resources and so on. Taking the design stage of architectural projects as an example, two-dimensional drawings are difficult to show the complex spatial structure of our architectural projects clearly and concisely, and our architects need to spend a lot of time to integrate these different drawings. This shows that the traditional way of building projects is too inefficient and needs to be changed urgently.

However, along with the development of science and technology, the emerging Building Information Modeling(BIM) technology has gradually begun to be applied, which has brought a lot of convenience to our traditional construction industry. Many researchers have already begun to study the use of BIM technology in the construction field. Zhong Ling discussed the application of BIM in engineering cost control, which let us understand the relevant use of BIM in cost control [1]; Xue Xiaojing analysed the role of BIM in construction progress management, and BIM is effective

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for construction schedule management [2]; Zhao Qiand others analysed the use of BIM technology in the optimization of the design of the assembled building, and solved some problems in the design [3] ; Liu Jiangnan and others studied the BIM technology in the construction field [4]. and Ren Xiaolong focused on the application of BIM in road design, showing the advantages of BIM [5]. These studies have shown that BIM technology can be applied to our traditional construction industry and can effectively solve the pain points of the traditional construction industry.

Based on this, this paper will focus on analysing the use of BIM technology in various life cycles of construction projects. From the planning stage to the design stage and finally to the construction stage, the paper will make a detailed account.

2. Overview of BIM technology

BIM is a digital technology applied to design, construction, and management. It is defined by the International Standards Organisation's Facility Information Committee as a computable, algorithmic representation of the physical and functional characteristics of a facility and full life-cycle information under open industry standards, to maximise the value of a project by providing support for decision-making [6]. Compared with Computer-Aided Design (CAD) technology, BIM has significant features: it is a three-dimensional model database containing information about the whole process of building design, construction and operation, and the information in each stage is interrelated, and any change in the information will trigger synchronous updating of the related information; it also supports collaborative work and is based on the IFC open data standard, which can effectively realise data exchange and whole-process management among various systems in the construction industry. As a new technology in the construction industry after CAD, BIM is promoting the industry to change to an efficient and accurate whole life cycle management mode through the concept of digital integration and collaboration [6].BIM technology is a brand-new technology that is bringing changes to the construction industry.

3. Application of BIM technology in building life cycles

3.1. Application of BIM technology in building planning stage

In the engineering planning stage, the combination of BIM and Geographic Information System technology(GIS) brings multifaceted support to the planning of the building: BIM can establish the 3D information model of the building, integrate the information of the building, and support the design collaboration and the whole life cycle management; GIS is to integrate the information of the building with the external information, and both of them are interoperable through the data standards such as Industry Foundation Classe(IFC) and City Geography Markup Languag(CityGML), to form the fusion of micro and macro information [7]. In planning practice, BIM combined with GIS can efficiently complete the simulation of terrain conditions, using AutoCAD Civil3D to generate 3D terrain data to assist in the adaptive design of the building form; simulate the light environment through software such as Radiance and Ecotect Analysis; and analyse the distribution of the wind field of the site with the help of Computing Fluid Dynamic(CFD) technology, and in addition, based on the CGB architecture, the application can integrate geographic coordinates and building parameters, and visualise the adaptability of the site and the surrounding environment through GoogleEarth [7]. It greatly optimises the efficiency of our architectural planning phase, and at the same time, makes the planning phase visual.

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3.2. Application of BIM technology in design

In the design stage, BIM technology through the construction of three-dimensional digital model, is no longer the traditional relay between the various professions, but multi-professional in order to unify the interaction through the BIM model to achieve real-time data interoperability and dynamic adjustment. Architecture, structure, electromechanical and other professions can work on the same model at the same time, the architectural profession will build the model, and the structural profession will carry out the structural-related calculations and so on [8]. This approach greatly improves the efficiency of design in the construction industry. This 'model is the language of communication' collaborative mode, so that the design decision-making moves from the abstract imagination of two-dimensional drawings to the three-dimensional reality of the accurate deduction. Let the building design become visualised. As shown in Fig. 1, BIM technology enables collaboration between various disciplines, making the design more efficient.

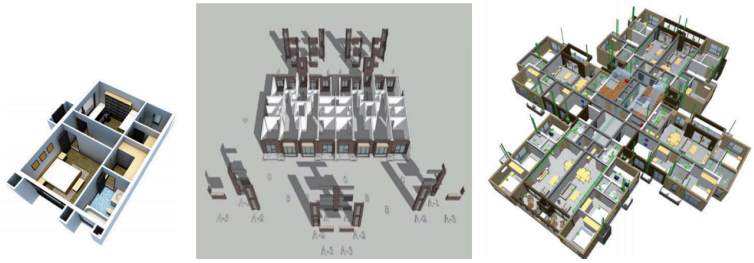

Figure 1. Interprofessional co-design through BIM technology [9]

3.3. Application of BIM technology in the construction stage

One of the key applications of BIM technology in the construction phase is virtual construction. Virtual construction is a three-dimensional dynamic construction management method based on BIM technology combined with virtual reality, computer simulation and other technologies [10]. Through the digital modelling of the whole process of construction visual simulation, continuous optimization of the construction program, to find the most efficient and economical construction program. The technology takes the BIM model as the carrier, integrates the data of the whole life cycle of the building, and uses 4D (3D model + time dimension) simulation technology to analyse the construction progress, process convergence and potential problems, which can effectively discover the design conflicts, optimize the allocation of resources, and reduce the construction risks [8]. Figure 2 shows the virtual construction through BIM technology. Its advantages are reflected in three aspects: first, to enhance the feasibility of the construction programme through visual deduction; second, to achieve multi-professional collaborative management and enhance the scientific nature of decision-making; third, to form a digital construction guidance system, and to promote the transformation of the construction industry to intelligence. With the popularity of BIM technology and the improvement of computational power, it will become the key technical support for improving construction efficiency and realising lean construction in the future. Fig. 2 shows the virtual construction through BIM technology.

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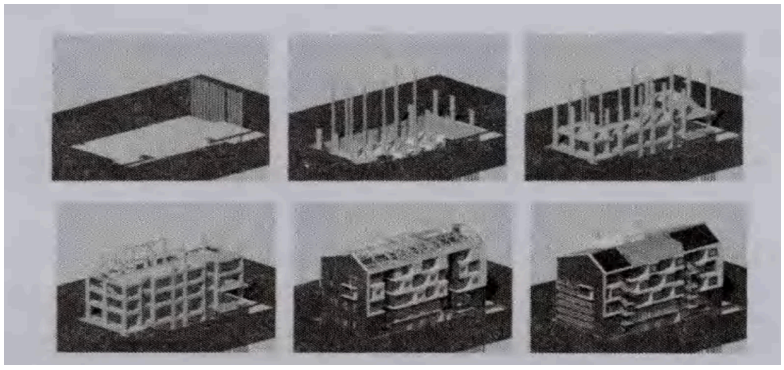

Figure 2. 4D construction simulation of a building [8]

4. Challenges and prospects

Although BIM technology has been used in the life cycle of construction projects, it still faces many challenges. For example, there is a lack of domestic software, there is still a gap between domestic BIM software and foreign software, and some of them are even still blank; the stages need to be re-modelled, the use of BIM technology requires the establishment of the model, but the establishment of the model in each stage often needs to be repeated, which largely reduces the efficiency of the construction of building projects; the lack of standards for BIM, different units have different application and understanding of BIM and there is no exact standard for BIM in China, which leads to the lack of standards for BIM in the application of BIM. The lack of BIM standards, now different units for the use and understanding of BIM is different and BIM in the country there is no exact standard, which will lead to the use of BIM in the face of difficulties; BIM on the hardware requirements are also very high, the use of BIM technology on the use of computers and other equipment requirements are relatively high, resulting in cost exacerbation [11].

Looking to the future, BIM technology will be. With the continuous development of artificial intelligence, Internet of Things, big data, and other emerging technologies, BIM technology is expected to be deeply integrated with it to achieve intelligent upgrading. For example, with the help of artificial intelligence algorithms, BIM models are intelligently analysed to automatically identify design defects and construction risks; real-time data interaction between building facilities and BIM models is achieved through IoT technology, which improves the refinement level of building operation and maintenance. At the same time, as the industry attaches increasing importance to BIM technology, relevant standards and specifications will be gradually improved to promote data interoperability between software and standardisation of project management processes, and to reduce application costs and technical thresholds. In addition, colleges and vocational education institutions will increase the training of BIM professionals, and enterprises will also strengthen internal training, forming a multi-level, multi-channel talent training system to provide solid talent support for the wide application of BIM technology. In the future, BIM technology will certainly promote the construction industry to a more efficient, intelligent and green direction, helping to achieve sustainable development of the construction industry.

5. Conclusion

The core value of BIM is to build a digital twin covering the whole life cycle of a building, and to achieve non-destructive data transfer and process management from planning, design and construction.

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In the planning stage, BIM technology can be combined with GIS technology to break the barrier between micro building information and macro geographic environment data. It also integrates 3D terrain, light simulation (e.g. Radiance), wind analysis (CFD technology) and other data through IFC and CityGML standards, optimising site selection, energy consumption assessment and sustainable design, and significantly improving the scientific and visualisation level of planning.

In the design stage, BIM has changed the traditional 'relay' design mode and constructed a multi-disciplinary collaboration platform with a 3D model as the core. Architecture, structure, electromechanical and other professions promote the real-time linkage through parametric models to achieve the goal of 'one-time design'.

In the construction stage, virtual construction is carried out through BIM technology to simulate the whole process of construction, and the construction process is constantly polished before the actual construction, so as to strive for the most efficient way of construction.

In conclusion, BIM technology has reconstructed the collaboration ecology and value chain of the construction industry through multi-dimensional data fusion, parametric drive and full-cycle information inheritance. Its application not only improves the technical efficiency and management accuracy at all stages, but also promotes the transformation of the construction industry in the direction of intelligence and integration. With the improvement of technical standards and arithmetic power, BIM will further expand the application scenarios and become the key technical support for the high-quality development of the construction industry.

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