

Applications of BIM in Construction Engineering in China: A Review

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Abstract. Based on the CNKI database from 2002-2019, this paper conducts the comprehensive literature survey on the BIM applications in construction engineering. Aiming to pros and cons summarized from the current research examples, the BIM shows great potential and the related study is a rapidly evolving field in construction engineering. In general, the diversity of BIM application studies is involved in construction engineering, such as, design and construction of new building, operation and maintenance of the existing buildings. BIM can be a powerful tool if it was properly taken advantage. However, the BIM application in design is more emphasized than that in the other aspects, which hinders the popularization of its application. Therefore, suggestions for future research are given accordingly: (i) constructing a feasible and flexible system according to the different applications; (ii) expanding the research content based on proposed system; (iii) establishing a method of evaluation of BIM application.

1 Introduction

BIM concepts originated from Dr. Charles Eastman's project [1]. The main promoter was Jerry Laiserin [2]. Its purpose was to provide reliable basis for decision-making in the future [3]. Comparing to the western developed countries such as US and Europe, BIM research started relatively late in China and it was introduced by Otike Company in 2002. Subsequently, many design and construction firms in China began to pay attention to this new area [4]. After about two decades, BIM has become a key project of the national science and technology support plan in the eleventh plan and a key research subject in the twelfth plan. With the continuous promotion of the national level, China's scholars have made great progress in the research of BIM. At the same time, many construction projects have already used BIM technology. The paper summarizes the research examples of BIM in construction engineering from 2002 to 2019, summarizes the research status of BIM in construction engineering application in China, reveals the shortcomings in the research process, and prospects the development trend and direction of BIM technology in construction engineering application.

2 Literature survey on the BIM applications in construction engineering

2.1. Literature statistical reports

Based on CNKI retrieval platform, the periodical literature database in CNKI database of China is selected. Because BIM technology was introduced into China in 2002, the starting time of literature retrieval is January 1st, 2002, and the ending time is September 1st, 2019. With "BIM technology" and "construction engineering application" as the retrieval keywords, literature search is carried out; and 2881 relevant references are acquired. Furthermore, "BIM" and "construction engineering application" are used to narrow down the searching results. Additionally, the papers which are in the database of SCI, EI, core journals, CSSCI and CSCD document are considered as high-quality articles. Therefore, the number of articles is reduced to 112, which is only 3.89% of the total number. It indicates that this BIM in construction engineering is very popular; however, the high-quality results are not reported adequately. Still, many research aspects about this topic shows great potential and can be improved. According to figure 1, the applications of BIM in construction engineering from 2002 to 2019 can be divided into two stages: the first stage (2002-2014): there is no relevant research results and the development is slow from 2002 to 2005, and this indicates that scholars in China start to learn the BIM, and the understanding is still in a preliminary stage; in second stage (2014-2019): the research on BIM in construction is booming, and many

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researches are aware of its importance, which promotes the development of the construction industry.

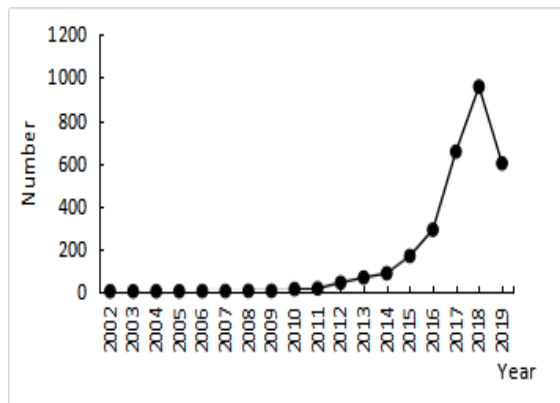


Fig. 1. The trend of publication.

2.2 Research hot pots

To further understand the hot spots of BIM in construction engineering application, the paper uses the original measurement and analysis tool in CNKI library. The threshold of keyword frequency is set as 100, while extracting keywords and ranking them. The paper is based on "BIM" and "construction engineering application", so these two keywords are eliminated and the main keywords are ranked first. Consequently, ten categories are defined: architectural design (351), architectural information model (317), assembly building (296), architectural construction (199), construction industry (179), architectural structure design (164), green building (135), Revit (123), architectural engineering management (122), construction management (113). However, the correlation between each keyword node is weak, which indicates that the research needs to be further explored.

3 Research progress

BIM technology was introduced into China in 2002, but there was no research on BIM in construction engineering application in 2002-2005. Since 2006, some relevant research results start to be reported with variety of the focus. The paper summarizes the high-quality articles, and finds that the main research contents are mainly in three parts: BIM application in design of new building [5-18], BIM application in construction of new building [19-27], and BIM application in operation and maintenance management of existing building [28-34].

3.1 BIM application in design of new building

BIM database can be used to create three-dimensional model in construction engineering design. At the same time, the natural collision and automatic error correction function of BIM can identify the conflicts between various designs, which makes the construction design scheme clear and convenient; and it also enables relevant professionals to intuitively understand the design

information and reduce unnecessary design changes. Liu Mengwen [5] applied CATIA software to increase the complexity of the design and special-shaped buildings based on BIM theory; and the problems such as the complex structure of steel grid frame, special-shaped modeling of buildings, and low efficiency caused by massive non-standard construction are solved, which provides an option for the application of BIM in complex and special-shaped buildings. Chen Ting [6] discussed the design and application of BIM in the tea house building, analyzed the building site of the tea house and the auxiliary design scheme, and put forward the construction design and promotion of the tea house based on BIM. Zhao Peng [7] based on EPC mode combined with BIM, applied Revit software to explore the key points in BIM forward design, including modular design, masonry typesetting design, brick typesetting deepening design, electromechanical precise positioning, and information integration. He believed that visualization could be realized based on BIM to determine the construction scheme. Li Tian [8] applied BIM to carry out transformation of industrial steel structure design, coordinated the process requirements and structure, and considered that the influence of original structure and the change of related planning and design standards brought difficulties to BIM transformation design.

3.2 BIM application in construction of new building

Combining BIM with VR technology and Arcgis in the construction of construction project can realize visual simulation of construction progress of construction scheme. By comparing and analyzing actual progress with simulation progress, we can control and manage the whole construction process. The possible problems in time can be found to avoid slow down the process caused by the insufficient experience and lacking of skills and coordination among the personnel in the construction field. Zhang Ailin [19] combined BIM with 3D scanning technology to predict the construction deviation of prefabricated steel structure, and believed that the accumulation of deviation caused the staggered joints of color steel plate, leading to stopping work and rectifying. In addition, the author concludes that the main reason for the construction deviation lies in the construction technicians' indifference to the deviation and the imprecision of the acceptance personnel. Tao Xin [20] used BIM to manage the construction process of the library through collision inspection, fine decoration deepening, low visualization, field proofreading, three-dimensional site layout, one-key fine brick arrangement, cost management, etc., providing a reference idea for the application of BIM in building construction. Ding Ying [21] combined BIM with Arcgis visualization software, simulated construction deployment, component splicing, prediction deviation, etc. The purpose of the research is to real-time control the implementation of high-rise buildings, to ensure the construction progress, accuracy and improve the safety of the construction site. And also,

the author believed that the basis of the successful application of BIM lied in the rational planning of the overall implementation. Based on BIM, Zhao Wenkai [22] used 4D method to simulate construction site to provide baseline for future construction plan arrangement. In addition, BIM and VR were combined to simulate and verify the hospital sample room, which can shorten the launch cycle of new products and save costs.

3.3 BIM application in operation and maintenance management of existing building

BIM can monitor and prevent the occurrence of disasters in advance during the use of construction projects. Meanwhile, it can localize the damages of buildings so that maintenance personnel can repair it accordingly to avoid further catastrophe; to this end, the service life of buildings can be extended and the cost can also be reduced. In addition, the responsibility can also be clearly defined in the process of using BIM to avoid confusion in investigating the accident. Through data acquisition and data processing of BIM, Yao Xihong [28] found that the difference between three-dimensional laser scanning BIM and total station monitoring data is less than 2 mm, and the resolution is very high, which can prove that the proposed method has enough reliability. Shen Xianming [29] studied the application of BIM in archives, and found that BIM and its system can not only monitor the use of archives and find abnormality in real time, but also manage archives space to provide an optimized plan for archives storage, and carry out disaster warning model. Chen Xinghai [30] combined the Internet of things and BIM to design the management and control platform of urban lifeline operation and maintenance, which can maintain urban security and provide an early warning. It can facilitate the smart city. Hai Tao [31] took photovoltaic building as an example to design a scheme using BIM for BIPV. By comparing and analyzing the simulated data and measured data of photovoltaic roof for 6 months, it is concluded that the error is within 5% when the atmospheric transmission value is 0 or 2.5, which provides theoretical and practical basis for the application of BIM in BIPV.

4 Conclusion and prospect

4.1 Conclusion

In summary, it is found that the application of BIM in construction engineering mainly concentrates on three aspects: design of new building, construction of new building, operation and maintenance of existing building, and the research perspective is not comprehensive enough through summarizing the literature. BIM has been widely studied in construction engineering design, but less in construction and operation and maintenance management. In the research on the application of BIM technology in construction engineering, China's scholars mostly choose cases to study, but lack of comparative research. In addition, there is a lack of research on the

promotion policies and standards of national BIM in construction engineering, and a lack of discussion on how construction enterprises strategically use BIM technology and how colleges and universities should train BIM technical personnel.

4.2 Prospect

(i) Constructing a feasible and flexible system. China's scholars often choose one case to analyze the application of BIM in construction engineering, but there are few unified studies and no completed theoretical system has been formed. In the future, it is necessary to strengthen theoretical research and form a certain theoretical system to provide guidance for practice.

(ii) Expanding the research content of BIM in construction engineering application. From the perspective of the government, the government has been actively promoting the application of BIM in construction engineering. Although relevant standards have been issued, there is a lack of interpretation and policy research in China. At the same time, with the continuous changes of the times, how to follow the pace of the times also needs to be strengthened. From the perspective of enterprises, enterprises are the main users of BIM, but there is a lack of strategic research on how to systematically use BIM in the construction process. From the perspective of colleges and universities, the application research of BIM in construction engineering in China is still in the primary exploration stage, and BIM related talents are needed. How should colleges and universities cultivate BIM technical talents is also a research perspective.

(iii) Establishing a method of evaluation of BIM application. The evaluation research of BIM application ability in construction engineering is related to the promotion of BIM in construction industry, but at present there are few related studies. In the future research, we should strengthen the evaluation of BIM application ability of design and planning institute, construction enterprise and enterprise, so as to timely understand the use of BIM and explore the influencing factors and strategies of BIM promotion.

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References

1. Y. Qinlin. Application research of BIM visualization collaborative design. D. SJU, (2016)

2. J. Laiserin. Comparing Pomes and Narajas. *J. TLTM*, **16**(2002)
3. S. Mingqin. Research on Parametric Modeling and Secondary Development Application of Bridge Engineering Based on BIM technology. *D. ECJU*, (2019)
4. Z. Jiajia. Research on The Application Status of BIM Technology in China. *J. ET*, **17**(2013)
5. L. Mengwen, W. Zhengqing, L. Shuishou. Application of Complex and Irregular Building Design Based on BIM. *J. CE*, **40**(2019)
6. C. Ting. Research on The Application of BIM Technology in The Construction Design of Double-storey Tea House. *J. TF*, **39**(2017)
7. Z. Peng, C. Hao, Z. Mingyou. Design Application and Practice of BIM Technology in Assembly Building under EPC Mode. *J. BS*, **49**(2019)
8. L. Tian. Ding Qingrui and Fan Jia. Application of BIM technology in Industrial Steel Structure Reconstruction Design. *J. CE*, **33**(2017)
9. R. Jiao, T. Li, X. Shaohua. Application of Building Information Modeling Technology in An Underground Garage. *J. IC*, **08**(2019)
10. S. Xiaoxiang, L. Jiazhang, Y. Zixin. Application of IPD and BIM Technology in Prefabricated Buildings. *J. BS*, **49**(2019)
11. J. Han, Z. Xuefei, Z. Bingtuo. Integrated in Design and Construction of A Prefabricated Building. *J. ERER*, **41**(2019)
12. P. Minghua, Z. Shoufeng, W. Xusong. Application of BIM Technology in The design of Prefabricated Buildings. *J. BS*, **48**(2018)
13. S. Shilong, W. Zhen. Application of BIM Technology in Drawing Design of Building Water Supply and Drainage. *J. AT*, **48**(2017)
14. S. Zhaojie, G. Yan, H. Wenshuai. Application of Building Information Modeling Technology in Logistics Warehouse Design. *J. IC*, **47**(2017)
15. W.Cheng, W. Wenyue. Research and Application of BIM Technology in Architectural Engineering Design. *J. CT*, **45**(2016)
16. L. Zhicheng, W. Feilong, J. Jiumao. Application of BIM Technology in Architectural Engineering Design. *J. JRSE*, **13**(2016)
17. Z. Guohua. Key Technology and Application of BIM Based Architectural Engineering Design Optimization. *J. MET*, **41**(2018)
18. J. Ming, F. Changjian, L. Chundie. Application Research of BIM Technology in The Deepening Design of Prefabricated Building. *J. CT*, **46**(2017)
19. Z. Ailin, L. Shuang. Application of Deviation Prediction Based on Assembly Building Construction. *J. JCEM*, **36**(2019)
20. T. Xin, P. Hongtao, H. Feng, Z. Xianyi. Application of BIM Technology in Library Construction. *J. CT*, **46**(2017)
21. D. Ying. Application of Building Life-Cycle BIM Technology in Shanghai International Financial Center Project. *J. CE*, **39**(2018)
22. Z. Wenkai. Application of BIM in Construction and Operation Management of Medical Buildings. *J. CE*, **39**(2008)
23. F. Xiaoke. Application Research of BIM Technology in Construction Management of Prefabricated Buildings. *J. BA*, **48**(2018)
24. Z. Ailin, Z. Xiuying, L. Lu. Application Research of BIM Based Information Integration Dynamic Management System in The Construction Stage of Assembly Building. *J. MA*, **39**(2017)
25. T. Junfeng, W. Junjie. Application of BIM Technology in The Construction of Super High-rise Buildings in Chengdu International Trade Plaza. *J. CT*, **46**(2017)
26. L. Zhansheng, T. Hongling. Application of Building Information Modeling Technology in Construction of Changsha International Exhibition Center. *J. IC*, **46**(2016)
27. G.Cheng, Z. Xuexin, G. Shixiang. Application Research of BIM Technology in Construction of Zun Building Project in China. *J. SC*, **31**(2016)
28. Y.Xihong, C. Hao, J. Song. Application of Three-dimensional Laser Scanning Building Information Modeling Technology in Deformation Monitoring of Super High-rise Steel Structures. *J. IC*, **49**(2019)
29. S. Xianming. The Application of BIM Technology in Archives Construction and Operation. *J. CA*, **3**(2018)
30. C. Xinghai, Ding Lieyun. Application Research of Building Safety Operation and Maintenance Management Based on Internet of Things and BIM - -- Taking Urban Lifeline Project as an Example. *J. CE*, **35**(2014)
31. H. Tao, Z. Nanhao, Z.Mingyu, C. Xian. Research and Application of Building Information Model Technology in Photovoltaic Building Integration. *J. JGUNSE*, **43**(2018)
32. L. Lu. Application of BIM in University Building Operation and Maintenance. *J. CE*, **39**(2018)
33. Y. Wenting, L. Xisheng. Information Extraction and Application of Building Facilities Management Based on BIM Technology. *J. JCEM*, **33**(2016)
34. W.Zaijunh. Application of BIM Technology in Construction Operation and Maintenance. *J. CE*, **09**(2013)