Basic model of building information modeling comprehensively applied in building energy consumption and environment

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ABSTRACT: *Chinese construction industry has not gained breakthrough and development in quality recently, and studying and application of building information modeling (BIM) is still in a start-up stage. Based on the basic model of BIM technology comprehensively applied in building energy consumption and environment and starting from building design and planning, this study uses BIM technology to assist design of energy saving and environmental protection of building combining with the relevant theoretical basis of practical application of BIM technology and design of the building itself, in order to present its sustainable effect in building and environment and finally construct green building in a real sense.*

Keywords: Building information modeling (BIM), Building energy consumption, Design of energy saving and environmental protection, Sustainability

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1. Introduction

As Chinese economy is booming and the living level of Chinese people is improving constantly, building energy consumption accounts for a higher and higher proportion in social total energy consumption. Meanwhile the idea of green building is born at the right moment, when energy consumption, heavy weather and environmental pollution sound the alarm over and over. To date, green building is the focus of the whole world, and developing design of energy saving and environmental protection with building information modeling (BIM) has become an important issue for modern architects. Besides Liu Chao (Chao, 2011). who performs building design with BIM technology, many other scholars also have studied the application of BIM technology in multiple views. For instance, Xu Qisheng, Su Zhenmin et al. analyzed the integrated application of key technologies of lean

construction and BIM under integrated product development, in the aspects of concurrent engineering, continuous improvement and value management and also made an analysis on an example (Qisheng *et al.*, 2012; Qisheng *et al*., 2012). In building industry, integration of BIM and other technologies can achieve unexpected effect and fully perform strong functions of BIM software platform. Zhang Jianping et al. proposed technical framework, system flow and solutions for BIM applied in engineering construction by combining BIM with 4D (Yong *et al*., 2013; Jianping *et al*., 2012). Faced with these new situations, some previous means and technologies become out of date, but BIM technology which integrates a great deal of building information provides a opportunity for solving difficulties.

As a new aided design tool, BIM first establishes simple building information model which is used for architect to make analysis of energy consumption and environment on schemes and then they improve scheme accordingly, to achieve a better effect of energy saving and environment protection. Also, BIM technology has defects cannot be ignored. Many experts have studied defects of BIM technology in practical application by making summary from different aspects. Based on achievements of living examples, He Qinghua et al. discussed the status of BIM in China and abroad and made a summary. They proposed defects of software and blank in law and contract management would affect the implementation of BIM (Qinghua *et al*., 2012; Qinghua *et al*., 2012). To find out the basis of improving building design and environmental protection and realize sustainable development of construction technology, this study introduces ideas and methods of BIM technology into construction energy consumption and environment field, which greatly improves precision and reliability of design schemes and provides a technical basis for construction engineering of energy saving and environmental protection type.

2. Research background

2.1 Situation of Construction Energy ConsUmption and Environment

It is known to all that, energy, the focus worldwide, is faced by both developing countries and developed countries. However, considering the relationship between construction energy consumption and environment, developed countries effectively relieve adverse effects brought to sustainable development by energy shortage with building energy efficiency design containing high technology combined with modern ideas. To date, China has high construction energy consumption and severe environmental pollution. According to the statistics, about half of raw materials taken from nature world are used for constructing buildings or accessory equipment. We live in dirty air and environment due to the huge consumption of natural resources, shortage of fresh water resource and natural raw materials and emission of carbon dioxide, automobile exhaust gas and industrial sewage. That threatens physical health of us and even our descendants.

2.2 Status of Construction Energy Conservation Design

Due to the limitation of modern design technology level and ideas and the relatively low professional quality of national people, construction energy conservation in China develops slowly. But in foreign countries, many experts have made researches on this aspect. For instance, Kevin Tantisevi et al. studied overall heat-transfer calculation of building maintenance structure based on BIM technology (Tantisevi *et al*., 2010); Eng. Parisa Esmaeili Moakher made a research on the application of BIM technology in energy consumption analysis (July-Aug 2012); Paola Sanguinetti et al. discussed over interoperability of BIM and simulation analysis model (Sanguinetti *et al*., 2009). Overall, Chinese has started to introduce ideas of construction energy conservation design consciously, but they mostly present schemes on the paper rather than connect with building design in reality. Moreover, architects engaging in this aspect are not such professional. These points all block the solution of construction energy consumption and environment problems. To work out these problems and improve construction energy conservation design, it is urgent to adopt new technology. Only by inputting sustainable design ideas and relative technology into all stages of building design can change the status of high construction energy consumption and poor environment in China.

3. Theory of BIM technology and application concept of BIM technology

BIM is the abbreviation for building information modeling. It includes all aggregation model information, functional requirements and member performance (Xiaokang, 2015) BIM covers a large amount of 3D geometry information as well as other useful information such as characteristics, outlook, functions, materials, price and project progress. Architects can confirm and modify schemes of architecture design based on data of established virtual building models. With the help of digital technology, BIM establishes a virtual building information model which can support integrated design and management of construction engineering, improve building efficiency and avoid some unnecessary risks. Wei Xiaofei held that, BIM technology was the important support of smart cities and integration of BIM and Geographic Information System (GIS) had a significant application in smart

(Xiaofei, 2013). Compared to traditional building design methods, BIM technology has disadvantages cannot be ignored. It possesses 3D intuitive visualization, timely and effective feedback and comprehensive coordination and information output diversification. It gains a great position in building industry because of these features.

3.1 Analysis of application of BIM technology

Currently, there are 350 kinds of performance analysis and simulation software in the whole society. However, these software require much time and effort as modeling needs to be performed once again due to different ports of software and moreover, a great deal of professional data needs to be input. In building design, virtual building model established by BIM technology can clearly present a large amount of building information such as raw materials, 3D space effect, outlook and functions of building to architects. As a result, architects can simplify analytical procedures, clarify every step and improve efficiency and accuracy of construction works.

3.2 Basic model of BIM technology applied in built environment

Basic model

"BIM technology software platform – data format – other relevant professional analysis software" is the basic model for BIM technology applied in building energy consumption and environment field. It can be taken as the basis of every stage, which can optimize building design. Under the premise of meeting use functions, how to make people feel comfort and healthy is the main content of researches on built environment. More importantly, it is urgent to find out the equilibrium point of contradiction between indoor comfort, building energy consumption and environmental protection (Yueyun *et al*., 2011). BIM software platform constructs profound BIM model and output different data format. We can select suitable data format according to different cases and then input them in professional analysis software to solve the problem of data consistency and improve working efficiency (Figure 1). When analysis of every single item is completed, we can repeatedly modify models based on the results to find out the equilibrium point of comprehensive performance of building, thus greatly improve the performance of whole building. Content of every stage of BIM is shown in Table 2.

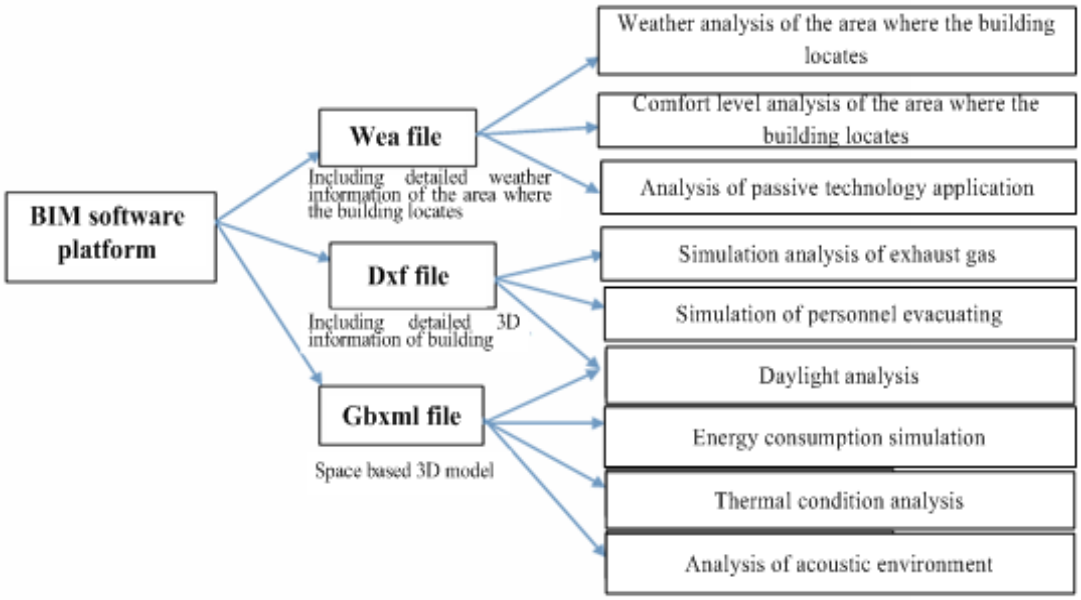

Figure 1. Basic model of BIM technology applied in building environment

3.3 Transformation between basic model

The maximum function of building is to make people live comfortable. Then it is a big issue that how to figure out the maximum comfort level brought by building and environment. First, it is important to find a balance point of low construction energy consumption, strong environmental protection strength and high comfort level. Building information model is the numericalexpression of physical and functional structure of construction projects. During the whole construction process,

Design stage	Model establishment	(1) Establish professional information models; (2) Visualized analysis and communication of different types of works in each step; (3) Generate 2D plane graph, space graph and profile graph for design coordination; (4) Output of graphs of different specification: statistic and dynamic.
	Design optimization	(1) Examine drawing in every stage and control the quality; (2) Provide aided services such as spatial orientation, surface sectioning and geometry optimization for complex building shape, to improve design precision.
	Pipeline layout	(1) Examine crash; (2) Generate crash report; (3) optimize adjustment suggestions.
	Cost accounting	(1)Generate various detailed statements and material statistics; (2) general estimation of budget and construction cost; (3) Investment optimization proposals: influence of design change on investment return
	Performance analysis	(1) Sunlight analysis, daylight simulation and optimization suggestions; (2) thermal condition analysis, construction energy consumption simulation and optimization suggestions; (3) sun-shading design; (4) wind environment simulation and design optimization; (5) acoustic environment simulation and optimization and sound field design optimization
	Data integration	(1) Integrate project deliverables; (2) Set up informatization model platform
Construction stage	Model establishment	Information model establishment during construction stage
	4D construction simulation	(1) Confirm procedures of 4D simulation; (2) Perform 4D simulation on important construction cycle such as typical floor and office building
	Dynamic crash examination	(1) Dynamic crash of layout of construction work; (2) Generate crash report
	Construction scheme optimization	Contact with construction party in advance and optimize construction scheme based on 4D simulation
	Design coordination	(1) Integration and coordination of 3D data document of all participants; (2) Provide design aided services such as space location and curtain wall division for complex building shape
Operation stage	Model establishment	Establishment of detailed information about equipments including suppliers, specification and contact person
	Dynamic crash examination	(1) Dynamic crash examination of real estate operation schemes; (2) Generate crash report
	Operation scheme optimization	Optimization of operation scheme
	Customized service	Develop application systems used for operation management based on platform data as required
	Optimization plan of emergency plan	(1) People escape simulation for earthquake; (2) Evacuation simulation of firefighter
	Document output	Aided manufacturing of various documents (statistic and dynamic)

Table 1. Main working content in every stage during implementation of building products

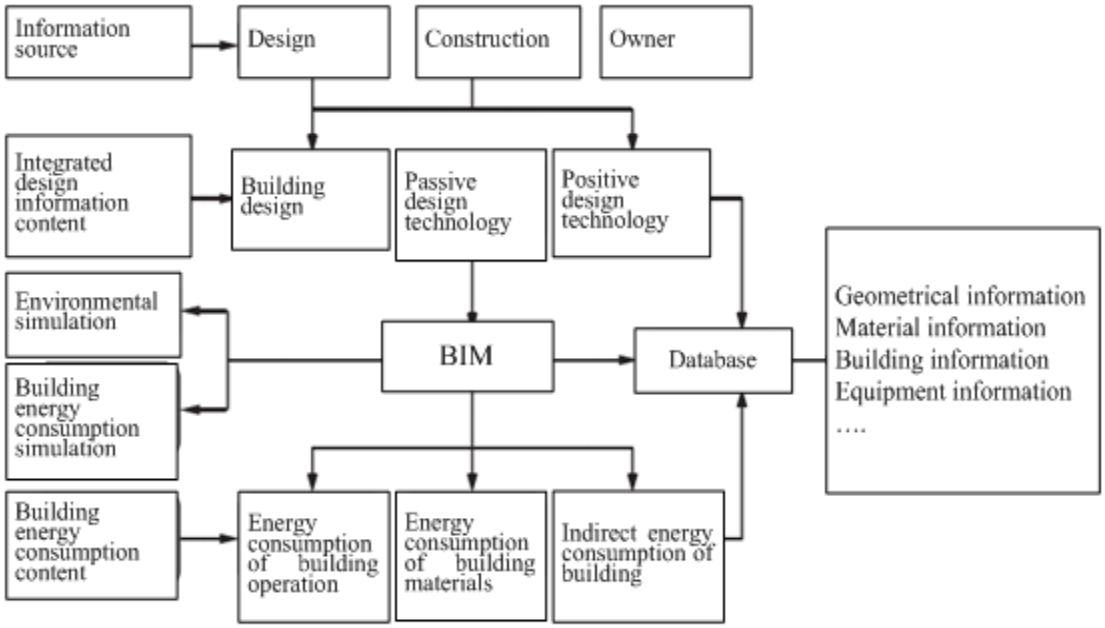

Figure 2. Data management of energy conservation design based on BIM

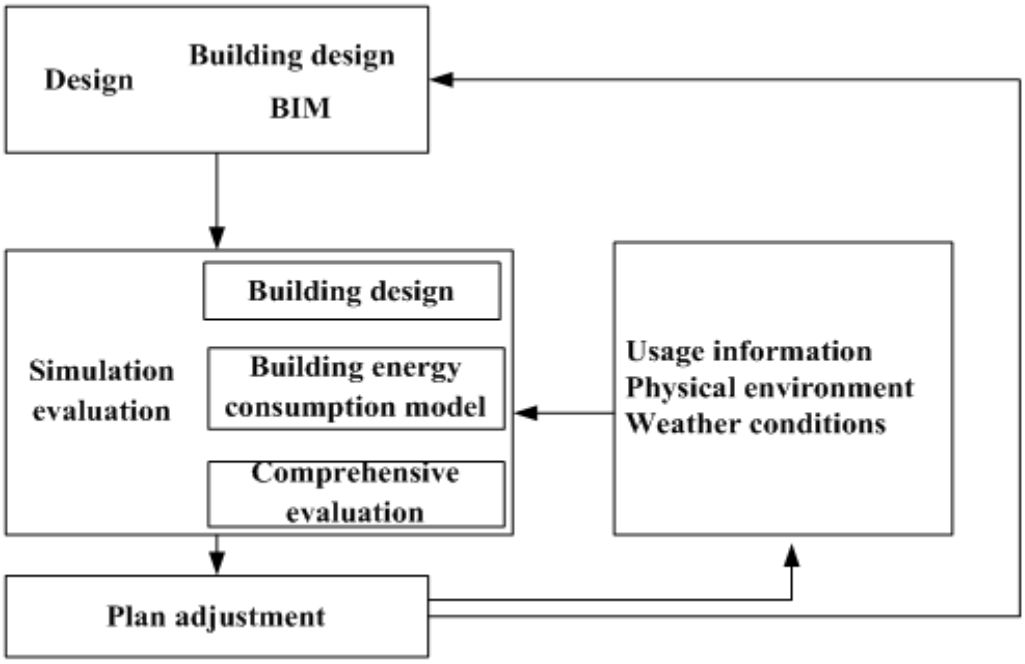

Figure 3. Procedures of building environment analysis

software can simulate building model by inputting data and calculate and update relevant data for guiding practice (Weiqing, 2015). We should extract valuable information based on the requirements of customers, clear up and simplify them, convert them into different document format for designing and finally input them into relevant software for professional analysis. BIM can accurately measure information and performance of ecology and construction land. Architects can integrate many ecological

factors such as greening and water body into the form and function of a building, as a result, the recovered ecological system can provide previous environmental service once again (Zhixing et al., 2010). Now we randomly select a project model for information extraction and model transformation. Details are as follows.

First is to make analysis on object and content of a building. This project includes analysis of weather data of the area where the building locates, comfort level, application of passive technology, daylight, energy consumption, sound environment, thermal environment, exhaust gas and personnel evacuating simulation.

Second is to split and delete detailed information. We can make different models with the help of objects and performance-based requirements.

Third is output documents that have been cleared up into different format through relevant software. Figure 2 is data management of energy conservation design of building which is frequently used.

Finally, different data format are input and modified accordingly. Incomplete and lost information are perfected. Figure 3 is procedures for building environment analysis.

4. Conclusion

This study first introduces the functions of BIM in construction industry, then discusses the status situation of building energy consumption and environment in China, and also summarized the meaning and application of BIM technology and researches on its basic model. BIM software platform, data format and other relevant applications are the important components of the basic model of BIM. The application of BIM greatly benefit integration ability of field data of architects, as a result, model design process becomes clearer. However, many software platforms such as BIM are not perfect enough and ports of different software are also not mature. Thus more professional groups are required to take efforts and bring forth new ideas, thereby contributing their power to construction industry and environmental protection cause.

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