Practice on Green Design of Building Energy Efficiency Based on BIM

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Abstract

According to China current situation of building energy efficiency design and from the perspective of building design, this paper conducted digitized expression on the facility entities and functional characteristics of engineering project. It also analyzed and shared the building energy consumption with building energy conservation and environmental protection as research orientation as well as with the technical model of BIM as guidance that is based on three-dimensional digital technology. Therefore, it can provide effective theory, process, method and technological means in building design phase, so as to realize the target of building energy saving.

Keywords: BIM, building energy saving, green design

1 Introduction

With the increasing intensification of energy consumption, energy conservation and environmental protection has become the key of global development strategy. Building energy efficiency has become the key problem of national energy conservation strategy, since building energy consumption is increasingly rising [1]. Traditional 2D building design software refers to that professionals input relevant data into professional software through manual input so as to conduct energy analysis, which is tedious and of large workload. With the development of digitalization, informatization and intelligent technology, 3D software of building centered on BIM is becoming more mature. At the same time, the building energy efficiency design based on BIM may obtain multiple building information of building orientation, building material, function and division through the architects' BIM. Many projects are calculated, analyzed and modified based on it, so as to solve the data conversion problem in process of building design and energy conservation deign and improve work efficiency [2].

Started with many aspects like BIM and its relevant software, building energy conservation design and its application value to building energy conservation design, Zhang Meiliang [1] explored the practicalness of building energy conservation design based on BIM, which embodied its energy-saving effect and provided certain reference for peers. He Guanpei, Luo Zhixing, et al [3,4] started with the sustainable development of building design industry brought by the application of BIM. Result showed that the introduction of the idea and method of BIM in building design and the analysis of model data can provide the basis for the improvement of building design, thus to realize the purpose of achieving sustainable building design with lesser cost. Based on the above mentioned related bases, this paper explored the current practical application of building energy conservation and environmental protection based on BIM.

2 Current Situation of Building Design and Energy Consumption

Oil crisis in the early 1970s has caught people to pay extensive attention to energy. Building energy consumption occupies the most of social consumption, thus the priority among priorities of reducing social consumption is building energy conservation. China now is in the peak of construction. According to the estimate from ministry of construction, it is predicted that the national covered area of high energy consumption will reach to 72 billion square meters in 2020, and the building energy consumption will accounts for 40% of total energy consumption which will directly intensify energy crisis. In China, the total energy consumption in building has far greater than the total architecture energy resource in developed countries.

In China, building energy consumption is increasingly growing, but the promotion of energy conservation and environmental protection is far from the requirements of current social technology and live developmental level. Most of architectural designers are used to apply mechanically the existing or even elder building technology, let alone considering whether the building design effect can save energy, can protect surroundings, can adapt to the specific requirements, etc. For the

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moment, China building designs are more stress on the appearance and function of building, but neglect the energy efficiency design of building, that is to conduct building efficiency design at the beginning of building design through passive design, so as to select the optimal design scheme to meet the criteria of green building [5] (as shown in table 1).

TABLE 1 the green building assessing standard

land saving and environment	building site, land saving, environmental load reduction, afforest, traffic facilities
water saving and water resources utilization	enhance water-use efficiency, rainwater treatment and emission, water saving index
water saving and material utilization	use green building material, building material saving
indoor environmental quality	lighting and vision, thermal comfort, illumination, acoustic environment, indoor air quality, alterability
operations management	intelligent management, estate management, establish ISO140000 environmental management system

The energy analysis of current building industry still is the 2DCAD age occupied and ruled by AutoCAD. Builders need to manually input the related data of building design into various software systems for energy analysis. The operation and application of these software is by no means easy, for which not only need you to have sound storage of the basic knowledge of energy analysis, but also the system itself needs to experience a series of professionalized and strict systematic operation program. The input procedure is extremely complicated, and non-professionals can not conduct operation analysis simulation on the vast professional data if they have not had vocational training. That is why many builders cannot directly conduct building energy analysis on designing scheme in design process. In traditional 2D design mode, energy efficiency calculation is generally arranged at the final phase of design, and serious disjoint phenomenon appears between building design and analysis calculation, which makes it difficult to accomplish for the ecological building design that facing energy conservation.

3 BIM and the Sustainable Cycle of Building

BIM is a kind of digitalized tool which applies to the building and management of engineering design. An American national BIM standard defines BIM as a digital expression of facility physics and functional performance. The sharing of information relevant to this facility has provided reliable the basis process for all the decisions in full life circle of the facility from concept and demolition. In different stages of this project, different interested parties support and reflect their own functional cooperative work through inserting, extracting, updating and modifying information in BIM. Mr Dana K. Smith of American buildingSMART union president put forward a common explanation of BIM in his BIM monograph, and he put "data-information-knowledge-wisdom" in one chain, and believed that BIM s essentially such kind of mechanism: transform data into information so as to obtain more knowledge, and then we act with wisdom [6]. Designers can build the "visualized" data building model through BIM, which provide the cooperation platform of virtual model and analysis for builder, equipment engineering, developer and even end-user, so as to realize the project design and building and operations management. BIM can provide the project design conditions and design information at any time for each professional designer, provide project account valuation for developers, provide visual constructing technology for builders, and also provide visualized property management for tenement. Therefore, it has perfected the communication of each segment in construction from design and build to operation maintenance, thus to enhance efficiency and save cost and realize building lifecycle management [3].

4 Energy Conservation and Environmental Protection Based on BIM

A. ENERGY CONSERVATION AND ENVIRONMENTAL PROTECTION THOUGHT OF BUILDING

The so called building energy conservation and building environmental protection is the generic terms of social activities in building field between energy conservation and environmental protection idea and technology. Building energy conservation and environmental protection reflects in every aspect of whole construction activities, and it also needs the coordination with various specialized knowledge, such as the construction relevant engineering science, sociology, culturology, economics, etc.

The energy conservation and environmental protection design of building mainly start from the overall social and natural environment that building in and the building itself. In the planning of overall environment, builders must take the relationship between building itself and the surroundings into consideration. However, its relation with surroundings also can be divided into its relation with geomorphic features and the natural environment of vegetation and wind direction. Builders need to draw up the strategy of building energy conservation design according to the specificity of building energy consumption with different characteristics.

B. THE KEY MATTER AND TARGET OF BUILDING ENERGY CONSERVATION DESIGN

The architectural mould, direction and external envelop structure in building energy consumption accounts for 70% of total energy consumption. Therefore, they are the key factors in determining building energy performance and directly affect the thermal exchange between building and external environment as well as level of natural ventilation and lighting. Different architectural moulds produce enormous differences to architectural energy consumption, and it also play a decisive role in architectural energy properties. Through numerical calculation and approaches of image display, we can quantitatively and qualitatively describe building performance from the perspective of time and space using BIM. Then we can visually express the building and its relevant energy properties, sun moving trajectory chart, interior and outdoor ventilation and lighting, thermal comfort degree, etc. We utilize and transform climate through the planning and design of architectural composition, thus to form favorable work and living environment and mould the microclimate to the benefit of realizing building energy conservation.

By means of using BIM and the relevant building energy simulation software, centered on the "passive" energy conservation design of low-technology and accompanied with "active" energy conservation, this paper aimed to discuss the energy consumed by keeping indoor necessary thermal comfortable environment during the process of reducing the utilization of building in the monomer building design through reasonable design strategy. Design aims to:

(1) During the process of building design, according to the regional climate features of construction base, abide by the basic principle of building environmental control technology, and synthesize building functional requirements and form design requirements, various architectural elements are reasonably organized and processes. It makes building to depend on temperature-controlled equipment as less as possible to save energy, and creates the favorable building internal and external environment which meets users' physiological and psychological requirements as well as energy conservation requirements;

(2) Realize the utilization of building to natural lighting and natural ventilation. Reduce its dependency on artificial lighting and mechanical ventilation. At the same time, discuss the combination of natural lighting and ventilation strategy with the building itself, thus to create a favorable strategy that both can meet the requirement of green energy saving and can combine with building form [7];

(3) Utilize BIM of ArchiCAD, and comprehensively use the relatively mature energy conservation design technique that has been practically tested. Start from the gain and loss of heat of architectural natural ventilation, natural lighting and architectural interface, through appropriate building energy conservation design strategy to effectively reduce the energy consumption during the operation of future building [8].

C. DESIGN OF SCHEME BASED ON BIM

(1) Use BIM to analyze the Building Geographical and Structural Distribution that Suit for Illumination

As vessel of human activity, the principal element to meet the use of architecture is illumination, thus the primary factor of building design is to fight for sufficient illumination. Different building structures are mapped out using BIM according to different regional features so as to meet the sunlight demand under different seasonal environments. In building planning, certain distance must be kept out between architecture and buildings, so as to guarantee that the architectural rooms can receive the sunlight. Generally, we determine the distance between buildings according to sunlight building or building interval. Measure the building interval by only regulating the distance between buildings is hard to avoid roughness and curtness, since the sunshine duration obtained in different architectural orientations is related to season. Sunshine spacing not only relates to the architectural height and the distance between buildings, but also closely relates to the building located orientations. Therefore, when we face the complicated constraint of practical building design, we can simply define that building interval lacks of the operability and scientificity of design through the architectural sunshine duration. According to the motion law of sun, and accompanied by advantages like the recognition of BIM to sunshine duration, geographic information and building information, we conducted the analog computation of conceptual level on design, and studied the sunshine situation of different architectural composition. In addition, this paper also visually conveyed the abstract design, which made the existing problems in design more apparent and the obtained result of design strategy more simple and clear.

(2) Use BIM to analyze the building composition suitable for ventilation

With the advantage of guarantying building ventilation without external power, natural ventilation will be of great benefits to building and its user, of which the specific effects are divided into the following several aspects: the first one is health and ventilation. Update the air polluted by incarnate metabolism using the outdoor clean air, so as to guarantee that the indoor air meet the requirement of cleanliness; the second one is thermal comfort ventilation. Increase body heat dissipation and prevent the discomfort caused by the indoor air moist so as to improve the indoor thermal comfort degree; the third one is hypothermy and ventilation. When the indoor temperature is higher than the outdoor temperature, then the building envelope temperature will drop. Natural ventilation plays very important role in improving the building climatic environment. The main purpose of architectural composition guiding natural ventilation is hat dissipation and exhaust of moisture. Building

orientation must take the relation between building windward and area leading wind into consideration.

Compared with sunshine, temperature and rainfall, wind environment is more complicated and its change frequency is faster, thus it is difficult to grasp its rule. In architectural composition, the surrounding buildings and vegetation will radically affect the wind speed and wind direction, thus we should avoid falling into doctrine in the building ventilation design and the relevant issues. Concrete analysis to concrete problem and whether conditions, we should turn to more scientific analysis means, such as the simulation analysis of computer. The environmental wind concerned by architect is visually evaluated through computer analog technology, such as range of wind shadow and size of wind speed, then we can find out the place where problems appear and the direction of modification thus to help architect to better complete building planning.

According to the following formula: $\frac{Fo}{V}=\frac{HX+S}{HS}=\frac{X}{S}+\frac{1}{H}$.

$\frac{Fo}{V}$

In formula, stands for building shape coefficient (measured without steel); H stands for building height (m); S stands for building ground floor area (m); X stands for building ground perimeter (m^2).

We calculated that the building shape coefficient $\frac{Fo}{V}=0.24$, which meet the requirement of building to coefficient based on energy-saving target. Centered on the green design strategy of "passive" low technology, this paper aimed to reduce the energy consumed in maintaining the indoor necessary thermal comfort environment during the utilization of building in architecture noumenon, through reasonable design strategy and using BIM and the relevant building energy simulation software.

Approaches of energy conservation rest on:

1 Enhance the utilization of building to natural lighting and natural ventilation, reduce the dependence on artificial lighting and mechanical ventilation. At the same time, discuss the combination of natural lighting and ventilation strategy and the building itself, thus to create the better design strategy that both can meet the green energy conservation requirement and can combine with building form [9];

2 Comprehensively use the relatively mature energy conservation design technology that has been practiced and inspected, primarily center on effectively reducing energy consumption during the operation of building itself.

5 Conclusion

The utilization of BIM can establish the virtual building model which contains all building information in design process, and it also can optimize the building performance. Under construction, BIM can be used to design reasonable construction line and simulate the possible emergency situation in construction, thus we can make corresponding preparation in advance. In aspect of green energy saving, we can make full use of CAD and BIM to guarantee the scientificity and reasonability of green building design. Import BIM directly into relevant energy consumption analysis at any design stage, we can handily get the analysis result so as to timely adjust the designing scheme. With the continuous development and perfection of BIM, its function in building industry becomes larger. Therefore, BIM will play enormous role in building industry, thus to promote building industry to have fundamental reform.

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