Building Model and Information Technology

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Abstract. Building Information Modeling is to build the building model based on the relevant information data of the construction project and to simulate the real information of the building by the digital information. It is characterized by visualization, coordination, simulation, optimization and drawing.

Building Information Modeling covers geometry, spatial relations, geographic information system, the nature and quantity of various building components, such as supplier's detailed information, which can be used to show the whole construction life cycle, including the construction process and operation process. It is very convenient to extract the information of the materials in the building. All parts and systems in the building can be presented.

Building Information Modeling represents the components for construction in the real world with digitalized building components. It is a basic change for the traditional method of computer-aided design that uses vector graphics to represent the object, because it can be combined with many diagrams to display the object.

The requirements for accurate information from the construction documents are from various aspects, including drawings, procurement details, environmental conditions, file submissions and other documents related to the quality and specifications of the building. People who support Building Information Modeling expect this technology to create a communication bridge for designers, contractors, building owners/operators, and to provide real-time information needed to deal with special project cases. And the method of providing accurate information is to add and refer to the building information model by the various participants of the project during the period of their responsibilities in respective operations based on the information they own. For example, when a mansion administrator finds out some leakage events, it may not be the first to explore the whole building, but to find a valve located in the suspected location in the building information model. Moreover, he should be able to obtain the specifications, the manufacturer, the part number and other information of the valve that has been studied in the past according to the appropriate computer computing power to maintain it for the possible reasons.

American Institute of Architects further defines the Building Information Modeling as a “modeling technique combined with the information data base with the special project cases”, which reflects that the technique is based on database technology. In the future, structured documents, such as specifications, can be easily searched and conform to regional, national and international standards.

It includes four characteristics, namely, visualization, coordination, simulation and optimization.

Visualization

Visualization is the form that “what you see is what you get”. For the construction industry, visualization really plays a great role, such as the often obtained construction drawings, while the information of each component is expressed by lines on the drawings, but the real structural form of requires the participants in construction industry to imagine themselves, which is not impossible on something simple. But now the architectural forms are different and the complex models are constantly being introduced, so such imagination by human brain is rather unrealistic. Therefore, BIM provides a visualized idea for people to turn the previous linear components into a 3D physical figure in front of people. Now the construction industry also has the design effect diagram, which is subcontracted to the professional effect diagram producer to read and design it based on the line information produced, while it is not automatically generated through the information of the
component, so it lacks interaction and feedback between the components. However, the visualization mentioned in BIM is the visibility that can form interaction and feedback with the component, and in the BIM building information model, the whole process is visualized. Therefore, the visualization results can be used not only for the display of the effect diagram, but also for the generation of reports. More importantly, communication, discussion and decision making in the process of project design, construction and operation are visualized.

**Coordination**

This aspect is the key content in the construction industry, because whether it is a construction unit or a proprietor and a design unit, all of them are coordinating. Once there are problems in the implementation of the project, it is necessary to organize the relevant people to hold the coordination meeting, find the causes of the construction problems and solutions, and then make changes, and do corresponding remedial measures to solve the problem. Can such coordination really happen only after problems arise? In design, here is often a collision between various professions due to the lack of communication among professional designers. For example, when the pipes in the HVAC and other specialties are arranged, the construction drawings are made by the designers respectively, but in the actual construction process, the beams and other components with structural design may be in the place where the pipeline is arranged, which hinders the layout of the pipeline. This is the common collision problem in the construction. Can a coordinated solution to such a collision problem be solved only after the problem arises? The BIM coordination service can help deal with such problem, that is, the BIM building information model can coordinate the collision problems in different specialties at the early stage of the construction, generate and provide coordinated data. Of course, the coordination role of BIM is not only a solution to the collision problem between the various specialties. It can also solve the coordination between the elevator hoistway layout and other design layout and clearance requirements, the coordination of the fire protection zoning and other design layout, the coordination of the underground drainage layout and other design layout.

**Simulation**

Simulation is not only a simulation of the building models designed, but also a simulation of things that cannot be operated in the real world. At the stage of simulative design, BIM can simulate something that needs to be simulated in the design, such as energy saving simulation, emergency evacuation simulation, sunshine simulation, and heat conduction simulation. In the stage of bidding and construction, 4D simulation can be carried out (the 3D model plus the project development time), which is to simulate the actual construction according to the organization design of the construction, so as to determine the reasonable construction plan for guidance. Furthermore, it can also carry out 5D simulation (cost control based on 3D model), so as to achieve cost control. In the later stage of operation, it can simulate the handling methods for daily emergency, such as the personnel escape simulation at an earthquake and evacuation simulation for fire fighters.

**Optimization**

In fact, the whole process of design, construction and operation is a process of continuous optimization. Of course, there is no substantial connection between optimization and BIM, but on the basis of BIM, the optimization can be better conducted. Optimization is restricted by three aspects, information, complexity and time. Without accurate information, a reasonable optimization result cannot be done, and the BIM model provides the actual information of the building, including geometric information, physical information and rule information, and the actual existence after the building changes. At a certain high complexity, the participants are unable to master all the information by their own ability, so they must have the aid of some science and technology and equipment. Most of the complexity of modern buildings is beyond the ability limit of the
participants themselves. BIM and its various optimization tools provide the possibility of optimizing the complex project. At present, BIM-based optimization can carry out the following work:

**Optimization of Project Plan**

Combining the project design with the investment return analysis, the impact of the design change on the return on investment can be calculated in real time, so that the owner's choice of the design scheme will not mainly rest on the evaluation of the shape, but more can allow the owner to know which project design is more conducive to his own needs.

**Design Optimization of Special Projects**

For example, special-shaped designs can be seen everywhere in the podium, curtain walls, roofs and large spaces, which seem to be small in proportion to the whole building, but account for a much larger proportion in investment and workload than the former, and it is often where it is relatively more difficult in construction and more problems. Optimizing the design and construction plan of these contents can bring prominent improvement in construction period and cost.

**Drawing**

BIM is not to get the common architectural design drawings and the drawings of component processing produced by architectural design institutes. Instead, it can help the owners to produce the following drawings after visualized display, coordination, simulation and optimization of buildings:

- **Comprehensive Pipeline Drawing** (after collision check and design modification, the corresponding error is eliminated);
- **Combined Builder’s Work Drawings** (Embedded sleeve drawing);
- **Collision Check and Debugging Report and Proposal for Improvement**.

From these contents, we can understand the contents of BIM in general. At present, there are already more mature BIM standards or systems in many foreign countries. Can BIM develop as smoothly as some other countries in China's construction market? It is necessary to see how BIM combines with the features of the domestic architectural market. When it is able to meet the special needs of the domestic construction market, BIM will bring about a great reform to the domestic construction industry.

Query building model information can provide all kinds of practical information and help decision-makers to make accurate judgments. Moreover, compared with traditional drawing, it can reduce the errors produced by the members of the design team at the early stage of the design, so that the subsequent manufacturers can make fewer mistakes. The computer system can use the function of collision detection to notify the query personnel of the detailed information about the collision or interference of each kind of component in space in a graphic manner. As computers and software have more powerful building information processing capabilities, compared with the current process of design and construction, this method has brought positive impact and help to engineering projects in some known applications.

For every participant in the project, reducing errors has a very important impact on reducing costs. Therefore, reducing the time needed for construction is also helpful for reducing the cost of the project. The world-famous successful cases of the application of Autodesk Building Information Model include BMW Welt, Mercedes-Benz Museum and the Porsche Museum in Stuttgart, which all adopt this technique to complete the whole design.

The storage of building information data in BIM is mainly based on all kinds of digital techniques, thus taking this digital information model as the basis of various architectural projects to carry out various related work.

In the whole life cycle of the construction engineering, the building information model can realize integrated management, so this model not only includes the information model of the building, but also includes the model of the management behavior of the building engineering. The information model of building is perfectly combined with the management behavior model of
building engineering. Therefore, in a certain range, the building information model can simulate the actual construction behavior of the building, such as the sunlight of the building, and the heat transfer state of the external enclosure structure.

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At present, the construction industry has entered the introduction and popularization of computer-aided technology. For example, the introduction of CAD has solved the problem of computer-aided drawing, which has been greatly welcomed by the people in the construction industry. Since it has well adapted to the demand of the construction market and the designers no longer draw by hand, and it also solves the malpractice of manual drawing and modification. In “drawing check”, we will not use backward professional drawings of sulfuric acid for overlapping check. These CAD drawings can be used in different specialties, bringing people a convenient way of work and reducing labor intensity, so computer-aided drawing has been warmly welcomed.

The application of digital technology in architectural design is mainly embodied in three aspects, namely, computer-aided drawing, computer-aided design and computer-aided presentation.

The common method of drawing two-dimensional graphics aided by computer is to directly use the functions provided by the GSS (Graphic Support Software) and to work out the graphics in the way of human-computer interaction. Later, with the development of technology, many parametric drawing is integrated, which improves the efficiency of drawing. From the actual application of most architectural design units in China, the computer-aided architectural drawing involves a wide range of application, including the plan and construction drawings of the architectural design.

Architectural design is a high combination of rational thinking and perceptual thinking. Especially in the initial conceptual stage of the designer, it is more fuzzy judgment and jumping thinking, and because of such particularity, it is impossible to replace human in architectural design with a set of intelligent technology and equipment. But the computer provides the processing capability that the previous design medium does not have, especially the digital architecture model which combines 3D technology, network technology and multimedia technology. It contains all data about architecture and environment, as a centralized digital model. “More comprehensive understanding of the design process, the induction of solutions to problems by architects and planners, with the assistance of technical means, especially the large number of applications of computers, enable architects and planners to quickly accumulate and analyze more information in order to more accurately understand and respond to the needs of the society. It is impossible to achieve such a scale and speed of data analysis without a computer.” At present, the application of digital technology in the auxiliary architectural design is mainly reflected in the visual digital model and the accurate data analysis.

For architectural design, it is very difficult to make multiple 3D physical models in a short time according to the change of design conception, which cannot meet the needs of architectural design. With the development of the computer, the digital 3D modeling has become a good auxiliary design method, which can produce many 3D models quickly, provide visual representation for the abstract design conception, and provide the optimal scheme for the architect's further design. What’s more, it enables architects to view models from different angles, give designers the overall form of space, and meet the needs of real-time view in design. Using the computer to establish the architectural design model, with the actual material and light effect, allows the designer to observe the appearance, the interior space, and the detail design of the building from the inside to the outside, from the air to the ground, that is, from any angle needed, so as to better polish the design from the whole to the detail, and also to bring the architect a more realistic and vivid image of the architecture. Compared with traditional models, computer models have more advantages.
First, it can choose perspective angle arbitrarily. It can not only grasp the overall relationship through overlooking the whole model, but also observe it at a normal point of sight to fully understand the proportion of the building and scaling relations.

Second, the digital model is much more efficient than the traditional model, and it can make multiple models reflecting the design conception in a short time for further design and optimization.

Third, computer models are more authentic, including material, color and spatial relations, while traditional models are more restricted by material and proportion.

Fourth, computer data can be modified, duplicated and saved, providing basic information for future design, while traditional models need to restart.

The most important feature of computers is data analysis and computation. For architectural design, we need not only perceptual thinking, but also rational thinking, so that we can give full play to the advantages of computers with this regard. Especially for physical environment elements, computers can be used for more accurate and scientific analysis and calculation, so as to optimize and compare the schemes. For example, on the analysis of spatial light environment, the Lightscape software is able to conduct good auxiliary design and analysis, and it can simulate the design effect according to the real lighting arrangement. Moreover, the effect through calculation can be used to guide the design, because it uses Advanced Lighting Visualization, which provides true and honest visualization for design, making it correct in feeling, mathematics and logic. Lightscape's light energy transfer rendering can generate an accurate simulation of diffuse light in the scene, allowing objects to reflect light on the surrounding environment and other objects, thus creating subtle and soft light and shadow. It not only achieves reality from vision, but also extracts light data from every point in space, which provides basis for design. The basic design method is to select several different design schemes, using Lightscape software for simulation, and to determine the best one through analysis and comparison. It can be measured from its artistic effects and spatial illumination requirements, avoiding the regret that the implementation cannot fully meet the requirements of the design. And it is also able to save manpower, material and financial resources, and improve the efficiency of creation. Of course, for other physical environment elements, similar auxiliary designs can be carried out, such as wind environment analysis and energy consumption analysis. The auxiliary design by the powerful analysis and calculation function of the computer can not only obtain the real effect diagram, but also can use the data provided to guide the design. In this way, it has both visual effect and more rational data as the support, and the architectural design can better make the results of the design consistent with the actual construction effect, thereby truly achieving the function of the auxiliary design.

The diversified forms of computer-aided architectural presentation make it easier for decision-makers and people to understand the architecture in all aspects (including image and non-image) to make better judgments, while making urban and rural construction and human surroundings better. The forms of computer-aided architectural presentation include: architectural presentation, digital architecture animation, virtual reality and interactive multimedia.

Computer architecture presentation is based on the digital model, with material and lighting effect, so that architects can express the design works more realistically. Since the advent of 3DS software in the late 1980s, computer architecture presentation has gradually replaced traditional drawing methods. So far, the computer presentation drawing is highly popularized, and it can be said that 99% of the presentation is completed by computer. Of course, it cannot be the only way, but must be combined with the following ways to present an architectural design.

At present, digital 3D animation is widely used, including film and television, games, military, education and so on, and recently it has just begun to show its unique charm in architecture. It shows better architectural design than the static effect map, because the computer can simulate the walking route of people in the virtual building, and display the future use of the building in advance in a way of personal experience. Furthermore, it’s more real than the model. Because of the small scale of the model, it is impossible for a person to feel with normal vision, and it is difficult to have a true and correct understanding of the building. However, the animation completely simulates human behavior, just as camera shooting after the building is built, and it’s closer to the
conventional thinking and visual perception of the people. For example, the advertising video of
Beijing Olympic Center to bid for the Olympic Games is a virtual architectural animation made by
3DS MAX.

Virtual reality is a technique that human can interact with computer’s extremely complex data
visually. In the early 1990s, virtual reality technology was gradually concerned by all walks of life.
And the feature of the technique is that the computer produces an artificially virtual environment,
and the user sees the colored scene of the subject, hears the sound in the virtual environment and
feels the force of the virtual environment by hand or other parts of the body, which allows the user
to feel personally on the scene, that is, the immersion of virtual reality technology. Another
characteristic of VR is strong interaction. It’s an open and interactive environment. Virtual reality
environment can affect users or be affected by users by controlling and monitoring devices. The
above characteristics of virtual reality technology greatly improve the quality of project planning
and design, reduce the cost and risk, accelerate the progress of the project, and strengthen the
cognition, understanding and management of the relevant departments for the project, thus bringing
huge economic benefits to the users.

References

