

# Research on the Application of BIM in the Construction Industry

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## **Abstract**

*BIM is a major innovation in the past ten years, it has had a broad and far-reaching impact in the construction industry. Based on the research and analysis of the application value and application status of BIM, this paper forecasts the application prospect of BIM, and puts forward the application scope and application mode of BIM in the construction industry. In this paper, the author participate in BIM projects, he details BIM's Technology of Application in the green building design and analysis process; he explore the using BIM Technology for green building design and simulation analysis, finally ,he summarizes the technical advantages.*

**Keywords:** *BIM; construction industry; Application Research*

## **1. Introduction of BIM**

BIM is the abbreviation of building information model. It is based on the information of the construction project. It is used of building a 3D model. BIM is not only a common understanding of a class or a class of software. It is not limited to the establishment of building models. BIM is run through in the whole construction project life cycle of information collection, is a different in traditional working mode and collaborative management mode, the traditional extensive mode of the construction industry to a technical revolution in fine, efficient and unified change, this technology revolution is called is the construction industry following the 20th century dump of manual drawing board to the transformation of CAD technology and a major technological change. BIM technology began in the end of the United States in twentieth Century, in recent years, the application of BIM technology in Europe and the United States and Japan and other countries developed rapidly. Statistics show that more than 80% of the 300 companies in the construction of the United States have applied the BIM technology<sup>[1]</sup>. And Europe and the United States have introduced the national BIM technology standards.

Virtual simulation is developed cross subject based on computer graphics, computer simulation technology and human-machine interface technology, multimedia technology and sensor technology. On the technology widely used in military, aerospace, machinery manufacturing and other fields, the research and application in the construction engineering construction has just started, mainly concentrated in 3D BIM Building modeling technique or Information Modeling and 4D technology, BIM technology mainly integrates information related to the construction project itself, which belongs to the static information, mainly for project design and analysis; 4D technology is based on the 3D model, introducing the factor of time, display the visualization of construction schedule, but did not consider the key factors of resources construction. The virtual simulation technology will improve the application of visualization technology in construction projects to a new level.

In recent years, with the continuous development of China's construction of information technology. The technology of building information model as a new generation of computer aided design on the basis of technology and the application in the field of engineering construction in our country is increasingly widely. Introduced BIM

Technology Concept and the domestic and foreign construction industry with the development of times, puts emphasis on the study of construction stage of BIM Technology Application, existing problems and solving ways, for future construction enterprises in the application of BIM Technology in practical engineering, provides certain reference for the test. Construction information in BIM construction project. With the development of social civilization, information technology has brought revolutionary changes to the manufacturing industry, electronic industry and other industries, and the level of information technology in the construction industry has been in a low level. In the context of the pursuit of low energy consumption, low pollution and sustainable development, the construction of information technology has become the inevitable direction of the development of the times. BIM technology<sup>[2]</sup> as a new generation of innovative computer aided design tools and production methods. Become the direct application of the construction of information technology in the construction industry.

At present, the application of BIM technology in our country is still in the initial stage. Application of BIM construction enterprises is less than 10%. But in the "11th Five-Year" National Science and technology support project "modern building design and construction of key technology research", has been clearly put forward to the research of BIM technology. And in accordance with the BIM standard and the construction of our country based on international standards, to focus on the development of BIM included in the "12th Five-Year" during the construction of information technology, the construction of digital city is the overall goal of the development of science and technology building. The development of BIM technology is the inevitable way to achieve this goal. At present, domestic has many successful applications of BIM case, such as Shanghai Center, Olympic venues "Water Cube", the Expo venue, *etc.* large complex construction projects; it has made a good application effect.

Virtual simulation construction mainly contains the following technical content:

(1) Three dimensional modeling technology

The use of full dimensional modeling and building information modeling technology, set up to the construction model of virtual construction and construction process control, cost control. The model to the process parameters and the effect of applying the attribute relation of soil up, the interaction between reaction construction model and the design model, model construction to have reusability, so it is necessary to establish construction product master model description framework, with the advance of product development and construction process, a model describing the increasingly detailed. Through BIM technology, consistency model and information inheritance, realize the preparation stage and each ten thousand effective integrated virtual construction process.

(2) Simulation technology

Computer simulation is the application of computer to the complex system of reality through the abstract and simplified system model, and then on the basis of the analysis of the operation of this model, so as to obtain a series of statistical properties of the system. Simulation of the basic steps: system of collection data to establish the system model - determine the simulation algorithm - the establishment of simulation model, run the simulation model output results, including numerical simulation, visual simulation and virtual reality VR simulation.

(3) Optimization technology

It is to optimize the reality of the physical model through the simulation process transformation mathematical model for the future. By setting the goal of optimization and calculation methods, in the formulation of the constraint conditions, the objective function to achieve the optimal, so as to provide the scientific decision-making and quantitative basis. It uses the method includes: linear programming, nonlinear programming, dynamic programming, operations research, decision theory and game theory and so on.

(4) Virtual reality technology

Operator immerse and interaction, through a variety of media to sensory stimuli, needed to resolve the question of virtual construction is implemented in the virtual environment, virtual reality technology is the core technology of virtual construction system. Virtual reality technology is a fusion of artificial intelligence, computer graphics, human-computer interface technology, multimedia industry building technology, network technology, electronic technology, mechanical technology and other high technology integrated information technology. The goal is to use computer hardware, software, and a variety of sensors to create a fusion of vision, hearing, touch and even smell, immersive virtual environment. The operator is immersed in and interacts with them, through a variety of media on the sensory stimulation, to obtain a clear and intuitive understanding of the problem that is solved.

## 2. The Application Valuing of BIM

BIM technology is a technical model that runs through the whole process of building life. Construction stage of the project which is the key link of the construction project planning and design into reality, the construction enterprise established to BIM application as the carrier of project management information system to improve the construction level, to ensure the quality of construction, get more economic benefits. The application value of BIM technology<sup>[3]</sup> which is in the construction stage that is reflected in the following aspects:

1) It is three dimensional rendering, publicity and display, that is to give people a sense of reality and direct visual impact. According to the construction plan, the image to display the layout of the site and the large equipment, the construction scheme of complex nodes, the choice of the construction sequence, 4D simulation, the different construction scheme for comparison and selection, *etc.*. Built BIM model can be used as the model base for the development of the two rendering. Greatly improve the accuracy and efficiency of the three-dimensional rendering effect, to the owners of a more intuitive propaganda, enhance the chance of winning the bid. Such as Zhejiang industry and trade group Zhejiang Bank headquarters building, Zhejiang newspaper building, MTR superstructure dig inverse construction has played a very good effect.

2) It can fast calculation, greatly enhance the accuracy. To create BIM database which can through the establishment of 6D relational database. It can accurately and quickly calculate the engineering quantity, and improve the accuracy and efficiency of the construction budget. Because the data granularity of the BIM database can reach the component level, it can provide the data information needed to support the project management, and effectively improve the efficiency of construction management. To extract the material and equipment that is through the BIM model. The statistical control cost, cost prediction, cost control so as to provide reasonable basis for the construction unit project bidding and construction process.

3) The precise plan, reduce waste. The fundamental reason is very difficult to achieve fine management of construction enterprises in the engineering data which can not be fast and accurate access to support resource planning, resulting in the prevalence of empiricism. The BIM can quickly and accurately obtain the basic engineering data for the relevant management personnel, for the construction enterprises to develop accurate talent plan to provide effective support and, greatly reducing the waste of resources, logistics and warehousing sectors, in order to realize the limits of picking, cost control to provide technical support.

4) Virtual construction, effective collaboration, three-dimensional visualization function plus time dimension. Virtual construction can be performed. Anywhere quickly and intuitively the construction plans and the actual progress were compared, and the effective cooperation of. Construction side, supervision, even

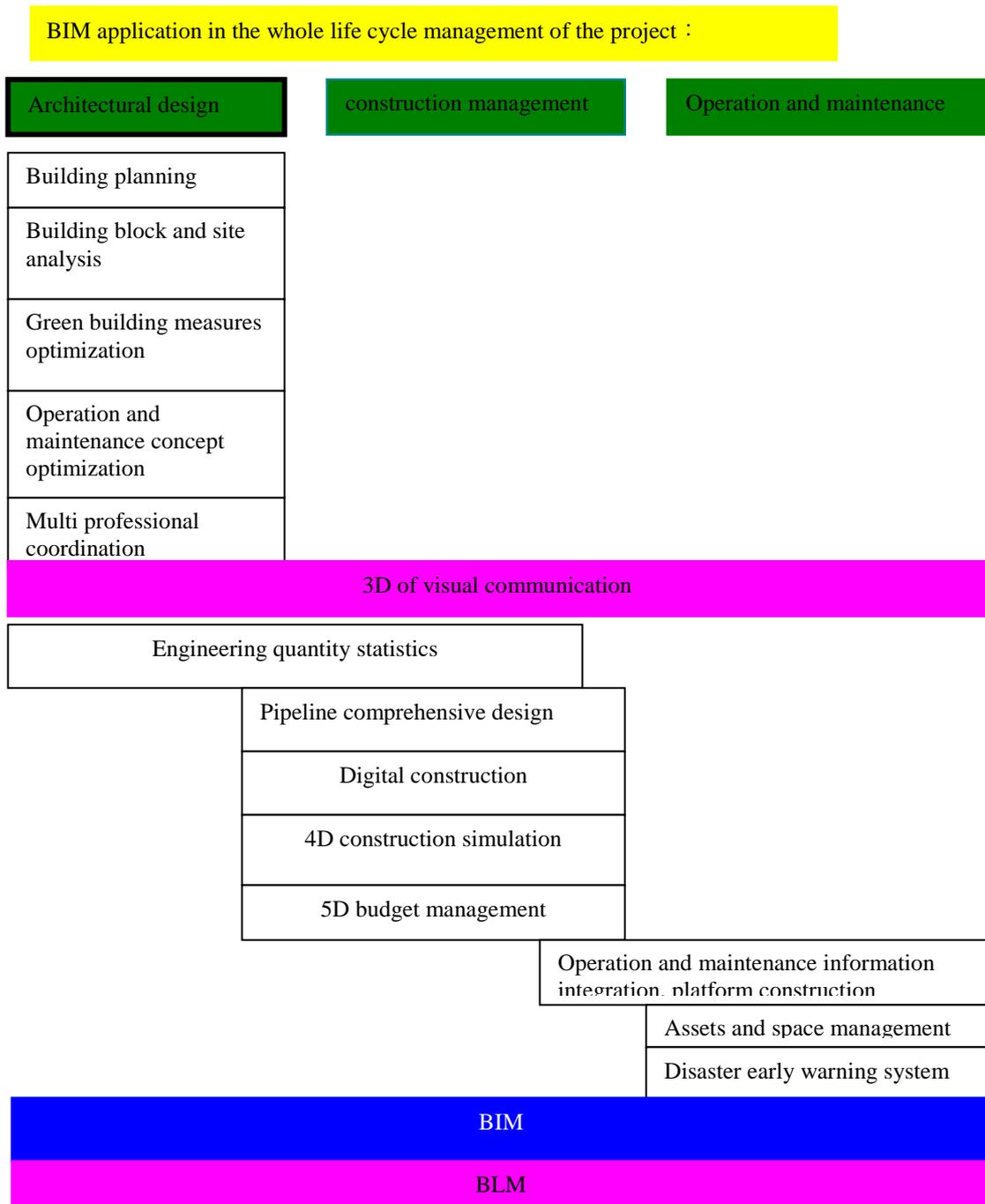
non engineering industry background owners leadership are the project various problems and well aware of the situation. In this way, through the BIM technology combined with the construction scheme, construction simulation and field video monitoring, that can greatly reduce the construction quality problems, safety problems, reduce rework and rectification.

5) Collision check, reduce rework. The most intuitive feature of BIM is three-dimensional visualization, the use of three-dimensional BIM technology in the early collision check can be. Optimize the engineering design, reduce the possibility of errors and rework in the construction phase and it can optimizing clearance. Pipeline arrangement optimization. Construction personnel can use collision after optimization of 3D pipeline scheme. Construction simulations, it is not only improving the quality of construction, but also improving the ability to communicate with the owners.

### **3. The Applications and Procedures of BIM**

BIM has played an important role in the process of building information transfer, and the application of building information model covers the whole process of the whole life cycle of the building. BIM is to create, transfer and application in each stage of the whole life cycle that is of the building. Expressed by the information contained in the model at each stage is consistent with the information, information obtained from different sources has uniqueness and it should not contain redundant information. At the same time, it also has the scalability, in the construction of the entire life cycle management free to increase the type and quantity of information<sup>[4]</sup>.

Through a combination of BIM Technology and it is in the standard construction of BIM model, the various stages of the project information aggregated to the BIM model under the premise, it can effective use of data model, realize the design and management of the project life cycle, improve the project overall design, construction and operation of the quality and efficiency of the process of practice. (As shown in Figure 1)



**Figure 1. BIM Application of which is in the Whole Life Cycle of Building**

#### **4. The Present Situation of BIM and Application Prospect of BIM**

At present, our country achieved good results in the field of BIM technology research, Such as Jianping Zhang who is study in Tsinghua University that completed on "research based on IFC construction 4D construction management system", and in the National Stadium, multiple large complex engineering obtained successful application<sup>[51]</sup>; Tsinghua University and China Academy of building research completed the establishment of IFC BIM framework based on; some colleges and universities gradually carry out the relevant academic research, nearly 10 universities in Harbin Industrial University, Tsinghua

University, Tongji University, Huazhong University of science and technology<sup>[6]</sup>, South China University of technology, has set up a BIM research group. The BIM market research, 2009, organized by Autodesk company compiled "BIM (building information modeling in China Market Research Report", clarifies the BIM at present in China's development present situation, China Real Estate Association of commercial real estate projects organizing committee compiled "China commercial real estate BIM Application Research Report 2010", to commercial real estate perspective that BIM is in China's development prospects, and plans to from 2010 start year research and released a research report, for guidance and tracking of BIM application and development in the field of commercial real estate. BIM application in the project implementation process mainly in the following aspects of the main performance in the following aspects<sup>[7]</sup>:

(1) More and more experienced owners require BIM applications

The BIM has the visual effect, so the owners can real-time inspection of project design, it is better and faster that meeting the requirements of owners and BIM Technology can be produced, such as shortening the time limit for a project, accurate pre sentenced to budget, optimization of project results, simplify the equipment maintenance and management of huge value advantage.

(2) 4D tools of BIM technology is to become the mainstream of construction management technology

With the development of BIM, 4D function was almost all BIM software R & D personnel that BIM software in the future an important part, some of the smaller size of the more software development company will develop 4D software tools as an important project for their survival. Compared to the traditional construction management mode in plane drawings based on BIM, the 4D function has obvious advantages: 1) to optimize the project schedule, compared with the traditional bar chart, the BIM 4D function can clearly simulate the whole construction process, which is more effective to adjust the construction schedule it is more reasonable and efficient; 2) on the construction site can be simulated, and the reasonable arrangement of material, effective choice material transport path and accurately determine the location of large machinery; at the same time can also project process for real-time tracking, quickly and accurately judge the actual progress of the fast and slow; 3) each participants and stakeholders have better communication and contact through the function of BIM.

(3) The organization structure and working mode of the project personnel change.

Because BIM is very smart, so for the project personnel in the organization, the selection of mode and content of the work will have a radical change, these changes are mainly manifested in 3 aspects: 1) IPD model, which is a collaborative work of the organization, to each party is no longer the opposite relationship; 2) because of improved work efficiency, so to reduce the number of engineers, but to increase the number of BIM professionals, but also to increase the intensity of training BIM personnel; 3) the United States National Academy of Building Research (National Institute of Building Sciences, NIBS BIM (National) on the national standard BIM Standards) are defined, the main purpose is to unify the format of the data in the project implementation process, reduce unnecessary workload, with the development of BIM, I China is also to develop appropriate standards.

(4) The advantages of the integrated cooperation model that is recognized

Many leading enterprises in the construction industry began to slowly realize that the integration of the project team will be the main force in the implementation process of the project in the future, and the application of BIM technology will bring significant benefits. For large construction units, the future of the establishment of their own design team that is a thing which must to do; it will be applied to the DB model or IPD model to carry out the project management.

(5) Enterprise resource planning has been widely used in the world

ERP is abbreviation of Enterprise resource planning, ERP is a modern enterprise management mode in the world is the leading, enterprise is the main object, intended to relatively reasonable configuration of all aspects of the enterprise, financial, material, production, supply, marketing and other resources, in order to enable departments to better play its role, in the fierce market competition so that enterprises invincible, the maximum achieved economic benefits. Nearly 80% of the world which is top 500 enterprises in the application of ERP software to manage the daily work and investment decisions, the people as the acme of perfection. Now, the work areas of building contractors began to apply EPR software to manage the enterprise construction project, such as purchasing, bill and project plan *etc.*. With the establishment of enterprise background management system (system Back-office), and with the CAD, 3D, BIM and other systems to apply, so that the management level of enterprises has been significantly improved, which led to the promotion of economic effects.

(6) More services in green building

It is in order to adapt to climate change, it is to meet the sustainable development of the society, construction projects to improve the comfort, and building toward the ecological environmental protection is an inevitable direction of development. The application of BIM technology can in the aspect of energy saving analysis and material selection of design personnel to give technical support.

## 5. Case Analysis

### 5.1 Case Project Overview

The Case is the LDK Avenue Sports Center project in Xinyu of Jiangxi Province, it located along the Yangtze River Road area, LDK Avenue in the north, with a total area of 17 square kilometers, with a total construction area of 1166m<sup>2</sup>, the construction area of 1070 m<sup>2</sup>, underground construction area of 960 square meters, divided for the construction in three phases. According to the planning of the 45 Xinyu municipal governments, will Xinyu City along the Yangtze River Road area construction become livable community, becoming the first center city population concentration areas of green ecological residential. The Planning must keep clearing requirements, all new construction within the region to meet the national green building standards.

Sports Center project is the region's first non operating property of public buildings and its range of services including all the starting area and some nearby built-up area, it is to provide the function of fitness, leisure, culture and entertainment service places for the surrounding residents and make residential areas supporting more perfect function, and reduce the actual operating costs, for the society to show green building concept to. The design objectives are: low carbon and zero energy consumption, the national green building evaluation of Samsung, the United States LEED platinum certification.

After the completion of this project will become the central region of Jiangxi, the first zero energy building, to achieve this goal, it is saving measures to seek the best program in the design of a comprehensive energy. First according to the climatic conditions of Xinyu is located in the cold area to select suitable passive energy saving measures, at the same time, the research combined with the architectural style and; followed by passive energy-saving measures and other conditions to the active measures of energy saving are optimized. This design to integration of many of the simulated data, and a comprehensive analysis and to analyze the results as a basis for design, so data analysis methods based on BIM Technology are fully applied to the architectural design of the project.

## 5.2 Working Mode of BIM Application in Green Building Design

BIM technology in the design process of green building plays in many aspects of the role, for different design order segment, analyze and integrate the corresponding data model, each stage is carried out to extract data, interactive analysis, loop test the process of forming a closed application mode for the green building design to provide a strong number of quantitative. According to support, strengthen the design of persuasion. Below by the project practice, combined with the different stages of architectural design, detailed introduction of BIM Technology Used in green building design, pay attention to BIM Technology in green building project pre planning, scheme selection and design optimization of the process in its character, while combing according to different needs in different stages of the BIM model and the corresponding model classification method.

(1) Conceptual design -- preliminary site planning -- site model, volume model

In the early stage of concept, architects can use BIM technology to analyze the situation of the building gradually, according to the analysis of the results of the building design.

1) the interpretation of the basic topographic data, the site model using BIM Technology to build up, so that construction of use to the surrounding urban environment for fast and easy understanding, using the visual function of the BIM, also enables the designer more intuitive understanding of the site environment and the planning intention, and the use of site model is built to analyze the site environment, this is as shown in Figure 2. There are two ways to extract terrain data in this process: a. Mapping of topographic maps, we can use AutoCAD civil 3D software and Google map contains the terrain data and simple analysis; b. In the Party of the first part provides a mapping of topographic maps, we can use the layer concept, from the topographic map read to the corresponding information.

2) Through the transfer of local environmental data, using Ecotect software for simulation analysis, to site environment sunshine, wind environment, and concluded that, for guiding the creation of architecture form, as is shown in Figure 3.

3) Based architect people can be free to design a variety of architectural form and adapt site environmental requirements and planning conditions and natural generated, is to carry out the next step of architectural design based, for these buildings form a BIM model called "volume model.

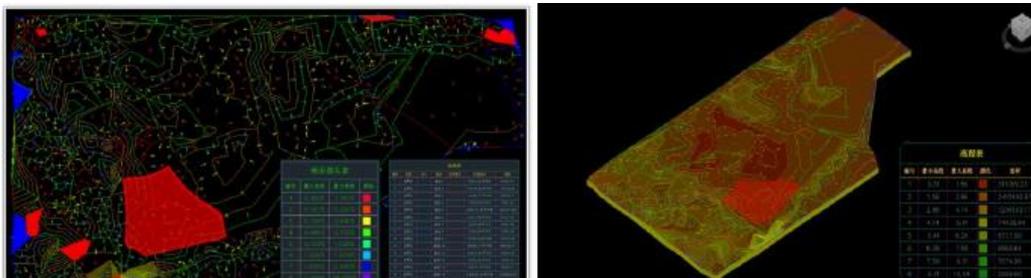
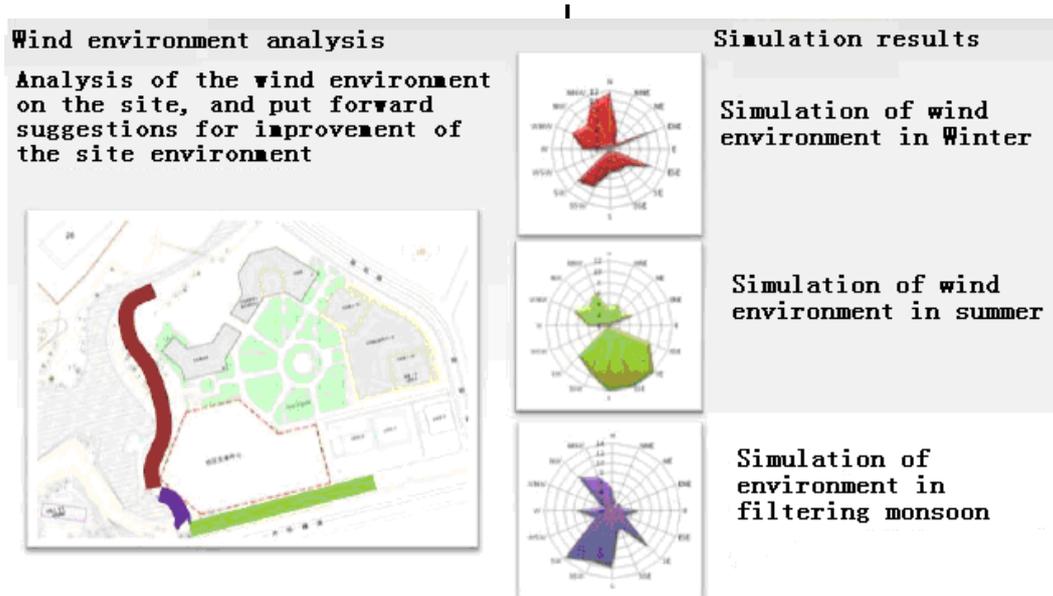


Figure 2. Using BIM Technology to Establish the Site Mode



**Figure 3. Using BIM Technology for Analyzing the Site Environment**

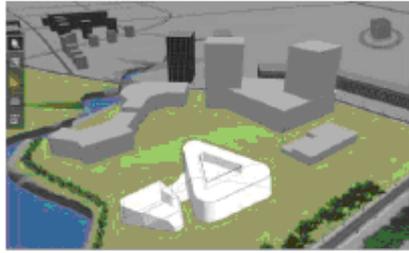
(2) The design of the scheme -- the multi program comparison and selection -- -- analysis model

According to the conceptual design stage of the architectural form, the final selection of four architectural forms to deepen the program, that is such as Figure 4. At this stage, will be able to use BIM software quickly established four schemes of BIM model to analyze the, using BIM software and other professional analysis software of data exchange function, of different schemes for simulation analysis, finally come to the best solutions to meet the design of the requirements.

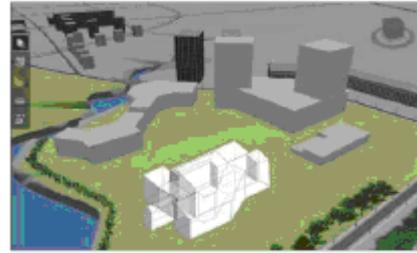
1) People are using simulation CFD software (Autodesk company produced fluid dynamics analysis software), of different schemes of the facade wind pressure difference were calculated, and according to the analysis to the effect of natural ventilation for each scheme is evaluated. (As is shown in Figure 5)

2) People are using Ecotect analysis software for carrying on the thermal analysis of building envelope, to evaluate the energy consumption of each plan. (As is shown in Figure 6)

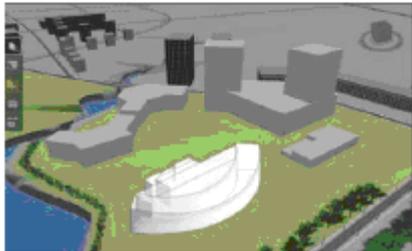
3) People are using the fluid dynamics analysis software CCM+ Star, the outdoor wind environment analysis, and evaluation of the outdoor wind speed to meet the green standard requirements. (As is shown in Figure 7)



**Plan 1: Triangle column**



**Plan 3: Type Z**

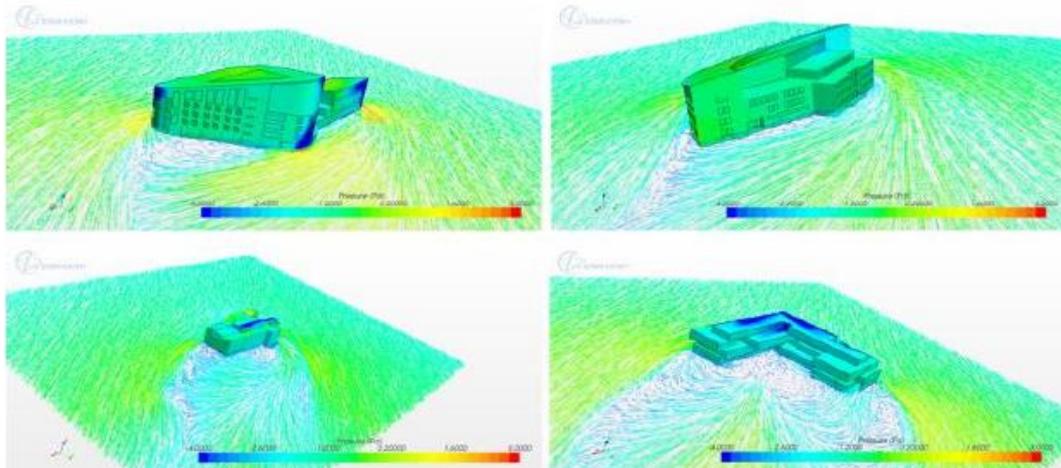


**Plan 2: half cylinder type**



**Plan 4 :Type L**

**Figure 4. People through the Analysis of Data to Weigh the Architectural Form**



**Figure 5. Analysis of the Utilization Rate of Indoor Natural Ventilation**

4) Through the analysis of a series of simulation, the analysis conclusion of the four schemes, weighing the final optimum form, it is the most consistent with low carbon and energy saving requirements of the form, for the next step of zero energy building design lay the foundation for the birth. By the use of the function of the architect, the best form of the comparison of the selection of further optimization, and ultimately determine the project construction program. (As is shown in Figure 8)

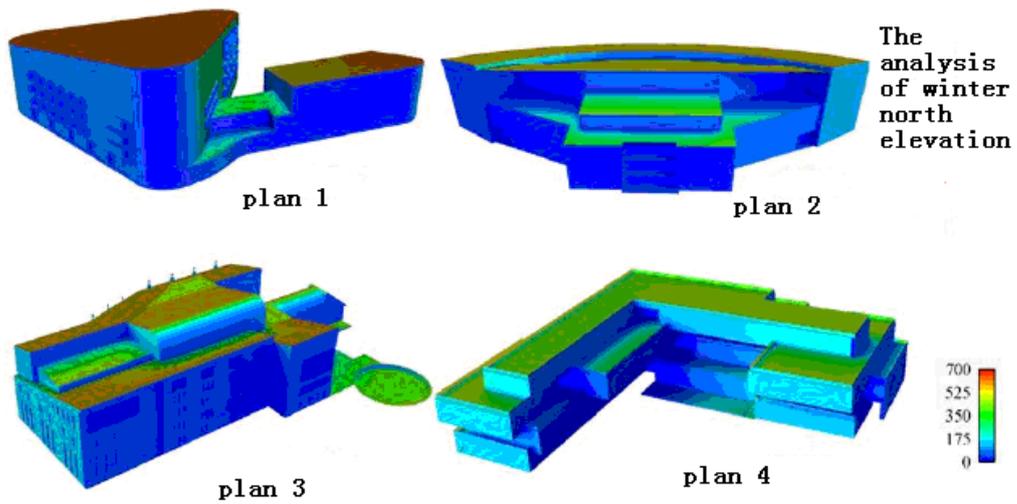


Figure 6. The Analysis of Heat Rate of Enclosure Structure

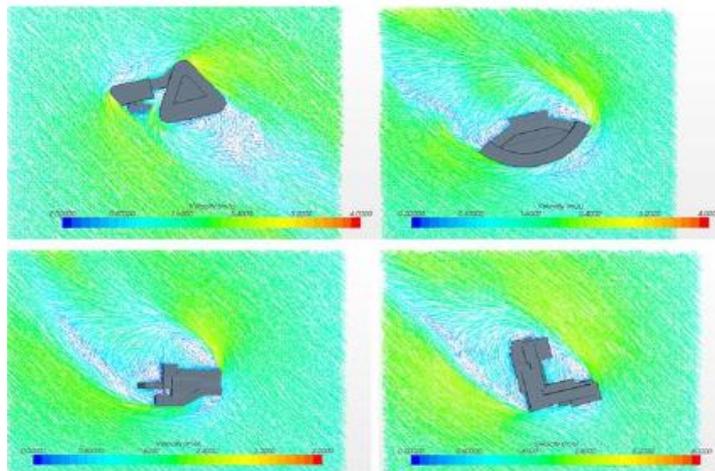


Figure 7. Analysis of Heat Rate of Enclosure Structure

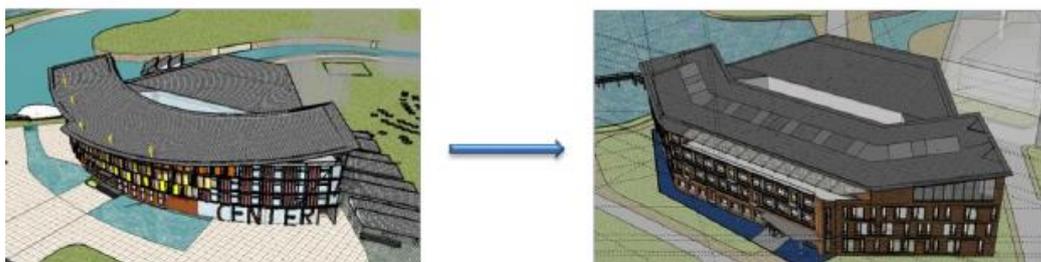


Figure 8. The Best Form for Adjusting the Final Solution

(3) Preliminary design - optimization scheme - detailed model

One of the values of the application of BIM technology in green building design is the choice and optimization of energy saving measures, which is also an important condition to achieve the goal of low carbon and zero energy consumption. Use of these energy-

saving Ecotect, STARCCM+ and IES analysis software, for different professional designers choose appropriate energy-saving measures bring great help, each measure were by the data model and loaded into a BIM model one by one simulation to verify the energy saving and comfort of the final result. Analysis results can be used as natural lighting, shading, natural ventilation, enclosure structure design of passive energy saving measures of judgment basis, also on air conditioning HVAC equipment, lighting equipment and other active energy-saving measures to be integrated and further optimization. At the same time, the conclusion of in renewable energy use to provide quantitative data analysis. In the process of optimizing the program, we constantly improve the information of the BIM model, and finally get a detailed model of the information of all measures.

1) People is using IES analysis software to calculate the HVAC energy consumption and lighting energy consumption, by changing the window to see the change of the ratio of the final energy consumption curve after the minimum interval, to determine the reasonable range of window wall ratio.

2) People is using the IES analysis software through the energy consumption simulation optimization of building envelope K value, weigh, combined with the reality of material and cost requirements, ultimately determine the external wall thermal insulation material and heat transfer coefficient and window material and heat transfer coefficient, to get a reasonable balance of architectural energy consumption and cost.

3) Tunnel ventilation system is as a supplement of air conditioning system, it make full use of natural outdoor wind environment of building wind environment for optimization and to achieve the purpose of energy saving. Using star CCM analysis software. Through the analysis of the simulation, guide the interior atrium design and indoor natural ventilation shaft guide settings; effectively improve the indoor air environment.

4) It will Revit model into IES analysis software, and set the basic climate data, to the whole building lighting analysis, combined with the floor of the room function simulation, according to the data of the room lighting, room window location optimization, adding a skylight atrium meet building room lighting requirements. According to the analysis results of Ecotect, need to add light intensity and guidance range of electrical design, in order to meet the indoor illumination conditions.

5) By using the Ecotect software, the setting sun visor for building simulation analysis, comparison of various shading quality, and ultimately determine the most suitable shading scheme of buildings.

6) For different angle of slope roof building with BIM analysis model, using recovery simulation software PVsyst, import the local climate conditions calculated PV module initial power generation and related loss reduction compared to the full year end generating capacity. And through modular modeling of the unit of photovoltaic panels, the arrangement of the guide the BIM model of solar photovoltaic panels that is to form the final arrangement.

## 6. Conclusion

In this paper, through the analysis, it draws the following 4 conclusions:

1. BIM has many advantages, visualization, easy to coordinate, easy simulation, optimization and is convenient for drawing is an important advantage, its coordination ability can be in a variety of software, project participation between fully reflected. The production efficiency can be improved, the project participants to communicate more convenient, you can control the project quality better.

2. BIM of the vitality of the construction project is to refer to the complete life cycle. Including the study of the feasibility of the stage, the preliminary design stage, the specific stage of construction and operation and maintenance phase, such a division can bring huge benefits for the project.

3. Facing that increasingly complex of green building design, BIM requires support for energy consumption analysis and design means throughout the implementation of the whole construction process, comprehensive utilization of BIM Technology and building energy consumption analysis of sustainable design, through the reasonable scheme optimization, and realize the design concept of green building. At the same time, in the process of BIM application simulation software tools needed for the establishment of data interaction, it is also for the green building energy consumption analysis, sustainable research provides a boost.

4. If you want to make BIM technology in the architectural design to be widely used, it is still faced with many difficulties and challenges. The main of BIM users are able to smooth collaboration, the parties clearly the responsibility and authority, BIM software development and popularity, as well as BIM can bring the expected benefits and so on. In the future, in construction projects in the rapid development of BIM is the trend of the times, for example, many developers' requirements are that f constructing projects need use BIM Technology, BIM 4D tools is construction management play a huge role, in the construction of green buildings, BIM also began to flourish.

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