Research on Optimization Technology and Application of BIM in Building Optimization

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Abstract

Information technology has the most powerful driving force for industrial development and enterprise development. It has been one of the most important technical means. However, in the construction industry, the application of information technology is not yet mature. In addition, the construction industry is becoming increasingly competitive. Therefore the use of information technology to improve competitiveness, promote the modernization of the design industry has become the direction of efforts the construction industry. The BIM technology is a new stage of information construction in China's construction industry. It provides a platform for the project participants to work together to improve production efficiency, and reduce project cost, shorten the project cycle. At the same time BIM provides a new production mode. What's more, it makes sharing functional characteristics of the construction project at different stages of information possible.

Keywords: BIM, Architectural design, Optimization, Construction industry.

1. INTRODUCTION

With the economic globalization, market integration and development, the growing proportion of science and technology in the production is more and more obvious. The study made by United States shows that in the past 40 years technology do more for production efficiency of a substantial increase, but the construction industry of the production efficiency has declined. From the manufacturing industry, the industrial efficiency of the substantial increase in experience can be seen, information technology is to solve the most direct means of low efficiency of the industry. So how to effectively use information technology in the construction industry is the current construction needs to focus on tackling the problem. According to China construction industry (Machairas et al., 2013; Wang et al., 2014) information forum, the international construction industry information rate average of about 0.3%, while China's construction industry information rate of only 0.03%, the gap is up to 10 times. In addition, under the strong pressure of China's infrastructure construction, large and super-large construction projects are emerging, mainly for large public building venues and high-rise, high-rise commercial and residential buildings (Wang et al., 2014; Asl et al., 2015).

These structures have large-scale construction, high investment; deep foundation construction, difficult construction; large or ultra-high structural span, high construction technology content; tight schedule, small work space, high difficulty in construction organization; organization requirements higher characteristics. The construction and management of large-scale construction projects is a complex and systematic project. Therefore, China's construction industry needs to accelerate the application of information technology in the construction field, optimize the allocation of industrial resources rationally, and improve the production efficiency of the construction industry as soon as possible. Industry structure, the antagonism between the participants, the level of poor information management and other reasons, to a certain extent, have caused the construction industry is inefficient. The direct result of the construction project is often the construction of such as unreasonable (Machairas et al., 2013; Costa et al., 2013; Liu et al., 2015) program design rework, construction management inefficient delay construction period, the construction process can’t meet the design requirements and other phenomena, which will not only lead to waste of construction resources, of course and it will also affect the progress of construction control, cost control, quality assessment and even building function.
BIM technology is a new digital technology developed rapidly in the field of architecture in recent years. It is based on the information data of construction project. It builds highly integrated information model of construction project. BIM technology has changed the way of information transmission in the life cycle of the construction project. Participants can improve the project on the unified building information integration platform and get the project in real time. BIM technology can improve the information and integration of the construction project in the whole life cycle of the construction project. Information, so as to effectively improve the design and management of the contact efficiency, all of the building model information can be applied to construction management and post-operation and maintenance to improve the building information data sharing level and information use efficiency. It brings a second transformation to the field of construction engineering, and realizes the transformation from two-dimensional drawing to three-dimensional model, which is especially important for the planning and design and construction management of large and complex construction projects.

2. MATERIALS AND METHODS

2.1 Current research status

With the rapid development of computer information technology, the information technology and project management of construction industry based on the whole life cycle of the construction project has gradually entered the management and application stage of the whole life cycle of the construction project, and BIM technology provides the construction industry implementation information of the foundation. BIM was first in the 1970s by the United States, Dr. Chuck Eastman's "Building Description System" concept model evolved (Attia et al., 2013; Yalcinkaya and Singh, 2015).

BIM is a shared library of building information resources, from the concept of the project to the completion of the mission to complete the mission and the final demolition of the full life span of the construction of the building information resources. All the stakeholders in the project can insert, extract, update and revise the information through the BIM information integration platform to support and reflect their respective responsibilities at different stages of the construction project, and to realize all of the decisions in the cycle. Professional collaborative work." In addition, with BIM technology group of Tsinghua University, BIM technology is the integration of 3D digital information technology platform, the creation of professional construction projects (if the technology is mature and standardized building information can be refined processing) a variety of The information model of engineering information is used to realize the digital representation of the physical and functional characteristics of the construction project.

Through the whole life cycle, this virtual building model takes the relevant information data of the construction project as the basis of the model (Wang et al., 2014; Costa et al., 2013; Liu et al., 2015). It can not only be used in building structure design, but also can be used for bidding and tendering management, construction management, cost calculation, equipment management, property management, etc., to realize dynamic sharing and reuse of building information data. In the continuous improvement of the construction of the entire life cycle of information at the same time the construction of the latter part of the management and maintenance.

2.2 Building Information Modeling (BIM) Connotation

2.2.1 Information Integration

BIM technology information integration mainly reflects the design process integration and design information integration. Building information integration of the real carrier, that is, the professional aspects of information are entered in a model which, while the traditional CAD software (Wang et al., 2014; Yang and Liao, 2016; Li et al., 2014) is only a simple representation of building components. Therefore, in the collaborative design, the professional designers can all participate in to achieve the integration of the design process. Building information database based on computer is the core content of BIM technology. BIM technology design process integration and design information integration has been based on data information, abandon the traditional CAD drawing mode, especially in the design has a significant substantive effect.

2.2.2 Model Visualization

In recent years, different architectural forms, complex modeling chic, architectural features are also complex and diverse, the effect of these projects (Attia et al., 2013; Asl et al., 2015) if the two-dimensional plane
drawings alone may show poor results, the project participants are also more difficult to imagine the difficulty. BIM technology visualization is a three-dimensional virtual entity display that can create interaction and feedback among components, and can significantly improve the ability to communicate and communicate with each other in the construction project participants.

2.2.3 Modeling Parameterization

One of the most obvious features of BIM technology is the object-oriented information model, that is, in the process of building the model to determine the geometric parameters and constraints. Such as the creation of the model when the doors and windows with the proposed structure between the relationship and deductions (Yang and Liao, 2016; Liu et al., 2015; Lee et al., 2016), this relationship does not change due to wall movement, which is also to achieve the unity of the professional design of the basis. And in the building information model, the most basic building components that are also digital information, such as doors and windows, roof, curtain wall, etc. fully contains its corresponding physical properties and functional characteristics.

2.2.4 The Application Value of BIM Technology

The application of BIM technology can be continued throughout the life cycle of the project from concept generation to final dismantling, including pre-planning and design, construction and construction, use and transfer after construction, operation and maintenance, and construction service after a certain period of time. BIM technology to support the software provides a powerful data storage and computing analysis capabilities, the most critical is the practical benefits of BIM integration of facilities Engineering Center summarized as follows: (1) the design drawings of high accuracy, low error, Project cost reduced by 3-5%;(2) Eliminate about 30% of resource depletion due to design changes due to design conflicts;(3) The co-design through BIM technology can effectively avoid collision conflict, the contract price of the project reduced by about 10%;(4) reasonable and efficient construction organization to save time, speed up the construction schedule of about 10%.

3. RESULTS AND DISCUSSION

3.1 The Role of Building Information Model (BIM)

In building information transmission, for different types of buildings, the construction process may be completely different. But they will have a common process, this process has six stages, namely the feasibility of the preliminary research project, preliminary design, acceptance of construction results, put into use,
management and maintenance and destruction of six stages (Figure 1). These six phases are the stages that all buildings have to go through. At different stages, the people involved may be different, and the activities involved will be different, but there will be a lot of in-between Contact, it is precisely because of the existence of such a link in order to ensure the smooth implementation of the project (Liu et al., 2015; Lee et al., 2016). Building data information is the core of the entire construction project, can achieve the design goal depends on the whole construction project some details are accurate, is in place, this is an important basis for the audit. Of course, the building information at each stage will vary depending on the stage of the project. The first of the six phases is the feasibility study. Feasibility study stage is the primary stage, are some of the existing facilities and past experience, and on this basis, the analysis of the entire market environment, the status of sales of materials, on-site equipment, personnel entry, and then prepare a feasibility study based on these circumstances, but also to give some economic and technical aspects of the feasibility of the proposal; some of the existing equipment and experience can also give existing building data information do a viable reference. But we are disappointed that very few designers willing to review the use of equipment, nor will it be made into a complete database to record the information in order to timely feedback of the situation.

The architectural design phase is a critical stage in which the entire building implementation plan can be determined and the construction of the entire building project information can be determined. The design phase is based on the first stage of feasibility, and it is with the first phase of the information collection that the results of the second phase are available (Attia et al., 2013; Costa et al., 2013; Lee et al., 2016). Architectural design phase of the results include design drawings and instructions, the list of materials required, the contract documents and other materials, detailed information. Only these related materials and design drawings complete, in order to ensure the smooth start of the entire project. At this stage, the work involved in the team more, because they are concerned about the point of view is different, so there will be some differences in some views, the communication reflects the importance of communication. Because this stage can be considered a construction phase of the new construction, so the need for more documents and materials, the resulting information is more complex and complex, this time on the need to have someone to take care of, convey the correct information. Because the entire architectural design project is a need to constantly improve, and constantly improve the project, many places need to change at any time. Therefore, we need to design the members of the team to conduct frequent exchanges. At the same time designers and materials suppliers of communication is also very necessary, through their timely communication and coordination, can reduce part of the unnecessary expenses. Similarly, contact and communication with the open business is essential. But so far, in the design drawings and the establishment of the file in the process or there will be some contradictions to be resolved.
Building information model BIM plays an important role in the process of building information transmission, and the application of building information model covers the whole process of building life cycle. The Building Information Model (Yalcinkaya et al., 2015; Costa et al., 2013; Ding et al., 2014) (BIM) is built, delivered and applied throughout the life cycle of a building. The information contained in the model is consistent at each stage. The information obtained from different sources is unique and should not contain redundant information, and the information is also extensible. It can be used in the whole building life cycle Management within the free increase in the type and quantity of information.

Through the combination of BIM technology and BIM model in the standard construction, all stages of the project information into the BIM model under the premise of the model can effectively use the data to achieve the project life cycle design and management to improve the overall project design, construction and operation of the quality and efficiency of the practical process. (Figure 2)

3.2 Feasibility Study Phase

For construction projects undergoing a feasibility study phase, BIM can assist both the technical (Attia et al., 2013; Liu et al., 2015; Azhar et al., 2015) and economic aspects of the argument, making the results more credible. In the feasibility study stage, the construction project program to meet the quality and function as the prerequisite, under this condition to discuss economy and technology is feasible. But in order to make the results more accurate, you need to consume a lot of time, money and energy. The summary model developed using BIM technology solves the consumption problem for investors. It can clearly analyze and simulate the project plan, make full use of the visualization, simulation and analysis methods to make the managers make the best decision in advance so that the cost of project construction is significant. Reduce, shorten the time limit (Asl et al., 2015; Li et al., 2014), quality significantly improved.

In the early stage of the project, BIM is used to optimize the project, and the traditional decision-making time is advanced to the most cost-effective pre-design stage, which effectively avoids the cost increase caused by the decision-making change in the project implementation process. It not only greatly improves the decision quality, operations management and sustainable cost savings. At the same time, through the BIM information in each stage of the effective transfer, early decision-making can be effectively implemented throughout the building life cycle. (Figure 3)

![Figure 3. The change brought by BIM](image)

3.3 The Phase of Design Work

BIM in the design phase of the application is currently the most extensive, but also a key stage of technology applications. Traditional two-dimensional design technology provides a kind of drawing-based information expression, which uses the scattered drawings to express the design information, the lack of necessary and effective automatic correlation between the design information, the professional, the design phase of the information is isolated, difficult to share. This results in the designer can not timely reference to others in the middle of the design results, which usually use time-sharing (Liu et al., 2015; Li et al., 2014), orderly serial work mode, through regular, node-way information to each other in order to achieve information exchange. BIM can be avoided by showing the significant value of the advantages of the traditional 2D design technology in the
design stage, such as many drawings, frequent errors, complex changes and communication difficulties. BIM can be very good to avoid, reflecting its significant value advantage.

BIM technology provides a unified expression of digital model, in the design process, through the standard construction BIM model standards, in order to make full use of information contained in the BIM model to work together to achieve the professional, the design stage of the effective transmission of information. BIM technology can truly support multi-professional team work together to share information on the parallel mode of operation (Figure 4).

The BIM model created at this stage should take full account of the application of BIM model in all stages of the project life cycle. We should consider the information needs of virtual construction, functional simulation, performance analysis, technical economic calculation and so on, so as to realize the full utilization of BIM model and information in the follow-up.

3.4 Construction and Implementation Phase

In the construction phase of the project, the traditional CAD model drawing 2D drawings have many shortcomings, such as: low construction, construction quality is unstable, difficult to guarantee the duration, the efficiency is not high and so on are common problems, and BIM technology can avoid these problems, which also reflects the obvious value of BIM advantage. In the traditional CAD era, it is difficult to check and correct some design errors and loopholes before construction, because it is difficult to show the contradiction between the professional in the 2D drawings, until the construction was carried out half of the time was found, of the case can only rework. The BIM technology is the professional design model in real time associated with a central document (Costa et al., 2013; Ahmad et al., 2016), in this case, the conflict between the various professional leap into the overall model, which can be resolved before the construction of contradictions, not only shorten the duration, But also reduce the waste of human resources, more importantly, eliminating the discord between the professional situation.

At the same time, through the construction information model during construction can also be details of the construction program in advance to consider the use of BIM parameter model can simulate the construction, and to optimize the construction program, not only to improve construction efficiency, but also reduce the change brought about by funds loss, which is the "4D" reflects the value. And BIM model has a good interoperability relationship between the 4D software to be the project construction schedule and with the BIM model tripartite link through the dynamic three-dimensional model to show the entire construction process and the construction site, so that we can find some Problems usually difficult to find and optimize the construction program (Yang and Liao, 2016; Ding et al., 2014; Li et al., 2014) (including space and space between the conflict, the safety of personnel and equipment, etc.). (Figure 3-4) Moreover, 4D simulation of the construction process also includes access to construction equipment, such as time, such as cranes, scaffolding, a good cost savings, arrangements for the overall construction schedule.
3.5 Application of BIM in Green Building Design Optimization

The dynamic information model based on BIM has good uniformity, completeness and relevance. At the same time, it implements the model classification according to the different requirements of BIM model in different stages of architecture design. (Figure 6) and BIM model as a carrier, in the energy simulation, the professional collision detection, cycle verification and other sustainable design attempts, has accumulated a large number of mainstream tools for BIM and analysis software application experience for the application of BIM in green building design.

4. CONCLUSION

Nowadays, information technology has become one of the most powerful driving forces. And it is the most important technical means of industrial progress and enterprise development. We can see the tremendous effect of information technology in industrial upgrading and rapid development in every field. However, the application of information technology in the construction industry is not yet mature, coupled with the increasingly fierce competition in foreign construction industry. Information technology to improve the competitiveness of China’s construction industry should be the goal in this industry. With the development of the construction industry and the increasing complexity of the construction project, BIM technology has become the...
basic research of the whole life-cycle integrated management of the construction project. The BIM technology
has been applied in the construction stage of the construction project and the construction stage tool. In this
paper, we introduce some applications of BIM in real buildings. The optimization of building project using BIM
is discussed. Through our exploration, BIM on the construction project optimization is of great help, is the
development and application prospects.

REFERENCES

Ahmad T., Thaheem M.J., Anwary A. (2016). Developing a green-building design approach by selective use
of systems and techniques, Architectural Engineering and Design Management, 12(1), 29-50.


performance optimization tools in net zero energy buildings design, Energy and Buildings, 60(4),
110-124.

Azhar S., Khalfan M., Maqsood T. (2015). Building information modelling (BIM): now and beyond,


process of expanding from 3D to computable dD, Automation in Construction, 46, 82-93.

Lee X.S., Yan C.P., See Z.S. (2016). Irregular shaped building design optimization with building information
modelling. MATEC Web of Conferences, 2016, 66.


algorithm to support building fire emergency response operations, Automation in Construction, 42(2),
78-89.

under resource constraints, Automation in Construction,53, 29-43.

Liu S., Meng X., Tam C. (2015). BIM-based information modeling based building design optimization for
sustainability, Energy and Buildings, 105, 139-153.

Renewable and Sustainable Energy Reviews, 31(2), 101-112.

technology, American Society of Civil Engineers, 59(1), 22-23.

5(1), 1-7.

Yalcinkaya M., Singh V. (2015). Patterns and trends in building information modeling (BIM) research: A
latent semantic analysis, Automation in Construction, 59(11), 68-80.