

# The Analysis of Influence of BIM Technology on the Performance of China Construction Production Operation and Maintenance System from the Perspective of System Theory and Information Theory

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**Abstract**—In China, the construction industry is divided into the secondary industry, with the division of "construction industry", and the definition of "architecture". However, for construction production, operation and maintenance, we generally use stages to carry out restricted. After analyzing the concepts of industry, field, and construction, the author regards construction production operation and maintenance as a system, and analyzes project establishment, design, construction, and operation and maintenance as the four elements of the system. Analyze the impact of BIM technology on the performance of the system from the perspective of system theory and information theory, and demonstrate that the application of BIM technology will bring about the optimization of the performance of the building production operation and maintenance system, which is the best way for the construction industry to achieve industrial upgrading. The focus of the development of BIM technology application should be on the reconstruction of the system structure and the cooperation mode of all parties, that is, the production relationship. In the end, the author looks forward to the future development of BIM technology.

**Index Terms**—System theory, information theory, BIM, building production operation and maintenance system.

## I. CONSTRUCTION PRODUCTION OPERATION AND MAINTENANCE SYSTEM

### A. Determination of System Elements

System elements refer to the basic units or elements that make up the system.

According to the different stages of the current building production, operation and maintenance process, it is divided into four elements: "project", "design", "construction" and "operation and maintenance". These four elements are also the most popular concept of "building life cycle". Each of the four stages corresponds to construction-related industry enterprises. What we are proposing here is the construction production operation and maintenance system, including the entire process of building project approval, design, construction, operation, and use and maintenance, involving the time dimension of the full life cycle of the building, and not just the process from construction to completion.

### B. System Structure Combing

System structure refers to the internal way of the

proportions of the various elements that make up the system and their interconnection and mutual influence.

At present, the relationship between these four system elements is linear in the current construction production, operation and maintenance system, that is, work is divided, connected to each other, and passed one by one. Once there is a "three-sided" project, design, approval, and construction are performed. Or affected by the inherent habits of the domestic construction market, bidding at low prices or even at a loss, and then gaining profit through design changes [1]. In this system, the final goal of the building will be difficult to control the final results and the time and money spent on the operation of the system.

## C. The External Environmental Conditions of the System

### 1) Related policies and systems

(1) On July 25, 2014, the Ministry of Housing and Urban-Rural Development issued the "National Construction Market Supervision and Credit Information System Basic Database Data Standards (Trial)" and "National Construction Market Supervision and Credit Information System Basic Database Management Measures (Trial)" "The issuance of the notice (Jianshi [2014] No. 108) officially launched the construction of the "Four Databases and One Platform".

(2) The report of the 18th National Congress of the Communist Party of China stated: "Persist in taking the path of new industrialization, informatization, urbanization, and agricultural modernization with Chinese characteristics, and promote the deep integration of informatization and industrialization, the benign interaction between industrialization and urbanization, and the coordination of urbanization and agricultural modernization. Promote the simultaneous development of industrialization, informatization, urbanization, and agricultural modernization". Informatization as a national strategy.

(3) On July 11, 2017, the Ministry of Finance and the State Administration of Taxation jointly issued the "Notice on the Pilot Policy of the VAT Reform for Construction Services, etc." (Caishui [2017] No. 58). It puts forward higher and stricter requirements on the procurement methods, accounting and reporting, invoice management, cash flow management, and business strategies of construction companies. Although the current policy can force the optimization and adjustment of the construction industry structure, whether Research on the promotion of the development of the construction industry is still insufficient, but the "VAT reform" will help extend the industrial chain of construction enterprises, optimize the structure of the

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construction industry, and help deepen the management of construction enterprises. This is not only a challenge but also an opportunity for construction companies, construction companies should actively respond to and promote their own transformation and development [2].

(4) In August 2016, the Ministry of Housing and Urban-Rural Development issued the "Notice on Online Application and Approval of the Qualifications of Construction Enterprises and Engineering Bidding Agencies" Jianbanshi [2016] No. 41.

(5) On September 12, 2018, the Ministry of Housing and Urban-Rural Development issued the "Notice on the Unified Implementation of Electronic Application and Approval of the Qualifications of Construction Engineering Enterprises", which will be implemented on January 1, 2019.

From the successive notice standards and policies, we can see that the national level provides policy support for the development of BIM technology.

#### 2) Administrative approval process

All procedures for construction projects from project establishment to completion include project approval, planning and design, construction project submission, and construction project completion acceptance:

- (1) Project approval
- (2) Planning and design
- (3) Construction project application
- (4) Construction project completion acceptance
- (5) Review of completion settlement of construction projects.

At present, most of the application of BIM technology is concentrated in the reversal stage after the design is completed, and it has not exerted greater value in the investment decision-making, construction management and operation and maintenance stages.

There are a lot of approval procedures and materials to be prepared for the construction production operation and maintenance system. On January 1, 2017, the administrative license approval system of Shaanxi Provincial Department of housing and urban rural development was revamped and put online, which started paperless administrative approval of housing and construction industry [3]. Other provinces and cities are also in the process of gradually landing.

#### 3) Analysis of the current construction market

The overall performance of the construction industry is: low efficiency, poor returns, heavy burdens, and fierce competition.

(1) Industry development relies too much on external input.

(2) A typical labor-intensive industry with a low proportion of technical personnel, low average technology content, low capital dependence, low income, high burden, and fierce competition [4].

#### 4) Current status of construction talent training

Only 20% of the formal workers in the construction industry in my country are technical personnel, which is a quarter of the number one education industry. Due to the particularity of the industry, a large number of migrant workers are engaged in production labor in the construction industry, so the number of employees is far more than that of formal employees. Currently, the number of employed persons in the construction industry is about five times the

number of employees. Based on the actual total number of employees, the ratio of technical personnel in the construction industry is 4.6%, which is only higher than the three industries of agriculture, forestry, animal husbandry and fishery, residential services, and wholesale, retail and catering, ranking fourth from the bottom [5].

At present, there are polarized differences in the source of architecture education in higher education institutions. The scores of college entrance examinations for students studying architecture in undergraduate colleges are ranked first in the professional admission scores of colleges and universities. The professional admission scores of construction engineering technology or engineering cost in higher vocational colleges are 180 about. At the same time, many colleges and universities architecture majors and construction engineering majors even in two different secondary faculties, the establishment of professional post-based architectural education talent training program also greatly limits students' ability to construction production operations. Not all colleges and universities that offer architecture have the ability to provide students with the overall view and the concept of the whole life cycle of the building. Therefore, many architectural design students have no or very shallow understanding of construction. I don't understand the impact of design on construction.

#### D. Basic Type of System

According to the different fields in which each specific system belongs, it belongs to a social system; according to the different ways and degrees of mutual connection and interaction between each specific system and its external environment, it belongs to an open system; according to people's understanding of the composition, state, process and the author believes that the difference in the degree of understanding of the law should belong to the gray system.

Based on China's classification of the construction production process through various aspects such as occupational certification, industry division, and administrative approval processes, there are few professionals who can fully grasp the four elements of the construction production operation and maintenance system, and most of these talents live in the design and At the management level, it is impossible to truly participate in the construction, production, operation and maintenance system of our country. The current higher education and talent training in the construction industry are also divided by industry and occupational assessments. Therefore, people engaged in the construction industry are directly involved in the construction, production, operation and maintenance system. The knowledge of one or two of the elements is more in-depth, and the knowledge of other elements may be very shallow.

#### E. System Performance

The performance of the system includes the characteristics and functions of the system as a whole.

##### 1) The characteristics of the construction production and operation and maintenance system include

###### (1) Sequence between elements

Due to the productivity, production relations and general laws of the current construction industry in my country, the

current construction production and operation and maintenance system must achieve the system goals, and the sequence between the elements must exist.

(2) Irreversibility between elements

Due to the constraints of the external environment of the system-the administrative approval process of construction projects, for example, the building facade renderings submitted for approval to the planning department cannot be changed during the construction drawing design stage and after completion after approval by the planning department. , It needs to be approved by the planning department again. Once the building has passed the completion acceptance, it will not be demolished and rebuilt, and will immediately enter the operation and use stage.

(3) Diversity and complexity of system objectives

Due to the functional and artistic requirements of the building production and operation and maintenance system goal "building", each goal will not be the same, and each goal is an independent and complex system, but the diversity of system goals does not affect the system The decisive factor of performance

2) System functions

The function of the system reflects the degree of interaction between the system and the external environment, or the ability of the system to obtain input and transform it to produce output.

The function of the construction production and operation and maintenance system is to realize the process of "building" from nothing to nothing through the cooperation of enterprises and professionals in various construction industries.

F. Summary

After the above analysis, we can conclude that the building production operation and maintenance process can be regarded as a system, which is connected by the four basic elements of "project", "design", "construction" and "operation and maintenance" in a linear development manner. It is an organic whole with definite characteristics and functions, and this whole is a component of the larger whole (my country's architectural system) to which it belongs.

We analyze the building production operation and maintenance system, and its purpose is to adjust and control it. To achieve this purpose, the system must be controlled through the flow and transformation of information.

## II. DOES THE DEVELOPMENT OF BIM TECHNOLOGY BRING ABOUT CHANGES AND IMPROVEMENTS IN THE PERFORMANCE OF CONSTRUCTION PRODUCTION AND OPERATION AND MAINTENANCE SYSTEMS?

Our understanding of BIM technology ranges from the establishment of three-dimensional building models with component data information through software to the establishment of BIM5D concepts including time dimension and cost; from BIM technology, which is the integration of many software on a certain platform, to BIM The application of technology is the collaborative work between various professions in the construction industry; from understanding the characteristics of visualization and simulation of BIM to understanding the application of BIM technology in all stages

of the building's life cycle; from being blindly optimistic about BIM technology to understanding the current situation The limitations of technology, the periodicity of talent training, and the impact of the current external environment on the application of BIM technology, we tend to be calm.

Where is the development of BIM technology going, how can BIM technology produce benefits, and how small and medium-sized enterprises should choose between high-cost hardware configuration and manpower training are the confusions that many construction practitioners face when faced with BIM technology. Sort out the problem.

The performance of the system is determined by both the elements and the structure. To change and improve the performance of the system, the performance of the various elements that make up the system should be changed and improved, the structure of the system should be optimized, the synergy between the elements within the system, and the coordination between the system and its external The relationship of the environment improves the system's adaptability to the environment.

From the perspective of the basic trend of system evolution, information is a measure of the degree of order and organization of the system. As the amount of information increases, entropy decreases, and the system tends to increase order [6]. From this perspective, the application of BIM technology will definitely bring about changes in the performance of the building production operation and maintenance system, but whether it will bring about the improvement of system performance and how to bring about the improvement of system performance, we will analyze from the following aspects.

### A. The Impact of BIM Technology Application on Various Elements of Building Production, Operation and Maintenance System

#### 1) Elements of "project establishment"

The application of BIM technology such as project site selection analysis and visual display only makes the element more concrete, and the effectiveness is not obvious;

#### 2) "Design" elements

Through terrain mapping, terrain mapping visual simulation, geological parameterized analysis, scheme design, construction drawing design, multi-disciplinary design collaboration, parameterized design, sunlight energy consumption analysis, pipeline optimization, structural analysis, wind direction analysis, environmental analysis, collision analysis, etc. In the application of BIM technology, some design units put forward the concept of "BIM forward design", which has indeed made a good performance in optimizing design results and reducing design errors. However, many BIM technologies have been applied to this point. In addition to increasing the cost of the designer, it has not brought actual economic benefits. Therefore, many local design institutes have established at most one BIM center or BIM team, and BIM technology is not used in actual work. Design and produce.

#### 3) "Construction" elements

Through the application of BIM technology such as cost analysis, green energy saving, plan display, roaming simulation, construction simulation, plan optimization,

construction safety, progress control, real-time feedback, site layout planning, construction waste treatment, etc., the construction process has become "higher". But the construction technicians are tired of learning the technology of turning molds. They are unable to solve the design errors and collisions of various professions after turning molds. Sometimes they are modeling for modeling. BIM technology is a formality, and BIM models cannot be practical. In engineering applications, most software companies have the same and expensive software for the construction phase. Even if construction companies intend to upgrade and optimize the industry, BIM technology seems to be unable to create more value for construction companies besides bidding bonus points;

#### 4) Elements of "operation and maintenance"

Project operation stage: intelligent building facilities, big data analysis, logistics management, smart city, cloud platform storage, etc.;

Project maintenance stage: 3D point cloud, maintenance and inspection, cleaning and repairing, fire escape, etc.;

Project update stage: plan optimization, structural analysis, finished product display, etc.;

Demolition stage of the project: blasting simulation, waste treatment, environmental greening, waste transportation treatment, etc. [7].

In terms of operation and maintenance elements, the application of BIM technology is in the ideal stage of theoretical research. The first batch of companies that started BIM consulting have successfully transformed into technology companies to build and sell BIM platforms. All BIM operation and maintenance are It needs to be operated on a certain platform of a certain company. Of course, due to the uniqueness of the building, the building of the platform is bound to be customized and cannot be mass-produced. Therefore, in the face of high hardware and platform construction costs, it seems to be the original the operation and maintenance method is more intimate, and where it is broken, repair it and dismantle it directly. The product quality problem is simpler. The development company pushes it to the construction company, the construction company pushes it to the property company, and the property company pushes it to the development company. Finally, the user is responsible for all subsequent issues.

We gradually discovered that BIM technology is not a panacea. Many construction practitioners who have spent a lot of money, time and energy have even begun to reject and resist BIM technology. This is what they think is a flashy "gimmick".

The author believes that at the element level, BIM technology is not even an improvement in production methods. The application of single element BIM technology will instead consume a lot of production resources and reduce productivity. The impact of the application and development of BIM technology on the construction production operation and maintenance system is not only on the surface or what some BIM advocates promote is the improvement of the effectiveness of the various elements of the construction production operation and maintenance system, the most important It is the relationship between the elements, that is,

the optimization a.

#### B. BIM Technology Optimizes the Structure of Building Production Operation and Maintenance System

A report issued by the National Institute of Standards and Technology (NIST) in 2004 proposed that the annual cost of the construction industry due to lack of communication and effective data management is about 15.8 billion US dollars, accounting for about 3-4% of the entire industry cost. The emergence of BIM technology really needs to change the way of collaboration between all parties involved in the project, that is, the relationship between the various elements of the building production and operation and maintenance system, so that everyone can improve production efficiency and gain benefits. By promoting knowledge sharing at all stages of the project cycle, Develop closer cooperation and integrate construction, construction and operation expertise into the overall design [8].

The MacLeamy Curve proposed by the American HOK Architects Firm MacLeamy said that the plan changes in the early stages of the project have the greatest impact on the cost and function of the project, and the cost of optimizing the design is also relatively low; Optimizing the plan in the later stage of the project will gradually weaken the impact on costs and functions, and the corresponding expenses and costs will rise. The future trend of BIM technology application is IPD (Integrated Project Delivery), which is able to take advantage of BIM, that is, "integrated integrated delivery model" [1].

The delivery of the BIM model should not be passed from one link to another, from one unit to another, but before the specific construction, the staff of all parties including pre-consultation, design, construction, material supply, and supervision should Form a team and build a BIM model. All parties involved in the project will participate in the preliminary project and design links to ensure the feasibility of the design results. Then, in an environment of information transparency and openness, all parties complete their work according to this model. At present, the BIM technology application designer finishes a model, but does not pass it to the construction party. The construction party will re-mould the model according to the CAD drawings dumped by the designer. This situation will be completely changed. BIM technology can also exert its real advantages and functions.

#### C. External Environmental Impact

##### 1. Policy guidance and promotion

According to the theory of dissipative structure, in the evolution and development process of the system, a new stable and orderly dissipative structure is formed from the original chaotic and disordered state. It should meet the requirements of 1. The system is an open system (after the previous analysis, the construction production operation The dimension system is an open dynamic system.) Second, the system is far from equilibrium. The author's understanding is that the release of my country's construction policy and the informatization upgrade of government functional departments and related industries are to change the balance of the construction production operation and maintenance system, thereby making the system transition from a chaotic and disorderly initial state to a new kind of stability Orderly

state.

2. The approval process of governments at all levels and localities will gradually realize informatization.

3. A number of BIM technology applications have emerged in the current construction market, and associations have been organized to promote the application of BIM technology through training, lectures, research, and competitions. Although the quality of the personnel in this team is uneven, it has played a certain role in the advancement of BIM technology.

4. In terms of talent training, colleges and universities have successively established BIM colleges, BIM majors, and BIM-related courses to cultivate high-level talents who can master and use BIM technology.

#### D. Summary

Based on the above analysis, we can see that the development of BIM technology has indeed brought about changes in the performance of the construction production operation and maintenance system, but at the same time there have been many problems and many contradictions, based on the current status of the construction industry in my country and BIM technology. As the bottleneck of development, we should change our blind attention to improving the effectiveness of BIM technology in building production, operation and maintenance systems for system elements, and we should focus on restructuring the system structure and the way in which all elements collaborate.

### III. PROSPECTS FOR THE FUTURE DEVELOPMENT OF BIM TECHNOLOGY

The realization of the collaborative work method of BIM technology is the best way for the construction industry to achieve industrial upgrading, but it is definitely not the goal of the industrial upgrading and development of the construction industry. BIM technology is a tool, a holistic way of thinking, and cannot be independent of the construction profession. The existence of knowledge is an interdisciplinary technology between architecture and information, and information without architectural expertise has no value. Therefore, we have to withdraw from blindly optimistic and blindly powerful BIM technology. At this stage, the internal mechanism of my country's construction industry enterprises cannot be solved with BIM technology. BIM technology itself still has many immature and imperfect places due to various problems such as software.

However, the development of BIM technology will accumulate a large amount of basic data for the future construction industry and urban management. With the gradual development of my country's economy and the continuous deepening of my country's reforms, the development focus of BIM technology applications is bound to shift to the existing The direction of research, operation and maintenance of buildings (including architectural ruins) has come up.

Now in the field of architectural design, there has been an artificial intelligence AI library. So in the construction production operation and maintenance system we are studying today, with the development, maturity and

perfection of 3D printing, assembly, VR and other technologies, construction production The artificial intelligence of the operation and maintenance system will definitely become the ultimate goal of the future development of BIM technology.

The learning of BIM technology must not be limited to the learning of software, but should first be familiar with one or more elements of the building production operation and maintenance system in order to be able to play an active role in the system. Jumping out of the BIM technology itself and seeing the development of BIM technology from the construction production operation and maintenance system or even a larger system, we can see the future development direction and get more development ideas.

#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

#### AUTHOR CONTRIBUTIONS

This paper is completed by the author Xiaomeng Zhang independently. Thanks to Professor Shuen Wang for his guidance.

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**Xiaomeng Zhang** was born on May 27th, 1984. She is a PhD candidate in the School of Architecture, Tianjin University. She received the master of engineering degree from Tianjin University, received the bachelor of engineering degree from Nanchang University, China. Her research field includes architectural education, architectural design, building information modeling technology.

She was awarded the excellent communist party member of 2019, excellent teacher and excellent communist party member of 2017, excellent counselor of 2016, and obtained Autodesk Global Certified Teacher Qualification in 2016. In 2015, she was awarded the honorary title of excellent teacher of the academy. In 2012, she was awarded the honorary title of Outstanding Communist Party Member, and in 2010 she was awarded the award of Shandong Polytechnic Vocational College. She led students to participate in the 10th National Innovation and Entrepreneurship "Invention Cup" Contest, and won 1 national second prize in the entrepreneurial group, 3 national second prizes in the creative group, and won the honorary title of excellent entrepreneurial instructor of the

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Ms Zhang has published 1 paper in international conferences (collected by EI), published 4 papers in national academic journals, published 1 paper in provincial level, participated in the completion of one school-level excellent course construction, and a textbook for the 13th Five-Year Plan "Building Information Management". She has completed 4 national-level patented inventions and 1 school-level research project.