

Research on the Technology Integration of Building Industrialization Based on BIM Technology

Yingbo Ji^{1,a}, Xiaoshan Wang^{1,b}, Yuan Qi^{1,c}, Fuyi Yao^{1,d}, and Yiwei Wang^{1,e}

¹North China University of Technology, China

^ayingboji@126.com, ^b1498923423@qq.com, ^chu_xb1@sina.com, ^d2463605508@qq.com and ^e1367742386@qq.com

Keywords: Building Industrialization; Technology Integration; Building Information Modeling (BIM); Integrated Path

Abstract. On the basis of analyzing the main problems during the process of industrialization construction in China, such as no sufficient unified technical system and low integration degree, BIM technology is used to construct the technology integration model. Not only the characteristic that the information need to transfer to each construction phase of industrialized building and all the participants required to work collaboratively were included in the model, but also the key role of using BIM technology to determine the integrated path in the formation of technology integration system was revealed. Finally, by choosing 'A construction company group' as the example with the characteristics of the whole industry chain, the process, the path and the characteristics of its technology integration, and the contribution of BIM technology to the promotion of enterprise technology integration were analyzed. Then come to the conclusion that the enterprise need to consider the importance to combine BIM Technology with technology integration model in the process of building industrialization.

Introduction

In recent years, with the recognition of the prospects of building industrialization development in China, more construction enterprises join in the innovative practice. However, in the way of industrialized construction, there are a variety of problems, such as the technical information can't be effective delivery, the technical system isn't uniform, the participants can't effectively communicate. The technology integration of building industrialization with BIM technology is an effective method to solve these problems.

1. The Connotation of Technology Integration of Building Industrialization

1.1 Building Industrialization

The concept of building industrialization is refers to a industrialized construction methods which characterized by building design standardization, production of component factory plantation, improving the assembly of construction and production and management information, a complete set of integrated production technology is formed to achieve the energy, environmental protection and life cycle value maximization in the links of research, design, production, construction and operation [1]. Building industrialization emphasizes the transformation of the mode of construction industry, is an important way to promote the sustainable development of the construction industry.

1.2 Technology Integration

Combined with the characteristics of building industrialization, the technical integration of building industrialization can be concluded that in the whole life cycle of building industrialization, every stakeholder has the corresponding technologies and technological innovation, construction enterprises should choose and refine these technologies in this series, then according to the characteristic of the whole industry chain closely match in building industrialization, integrated these technology with the overall goal of maximizing the overall life cycle of industrial construction and

formed a complete and producible appropriate technology system which has the characteristics of the whole industry chain to promote industrialization production and promotion [2].

1.3 BIM Technology

BIM is refer to Building Information Modeling, is a management method which build a 3D model to express the physical features and functional characteristics of the construction project by digital information and continuously integrated all relevant information about the project in the whole life cycle and build a multidimensional data model to improve the value of the whole life cycle of the construction project [3].

BIM technology is an effective management technology, it can provide a convenient and practical ERP information platform for the technology integration of building industrialization to promote the cooperation and information transfer among the participants and to reduce the construction cost. In the design stage, by using the collision checking function, the collision points between buildings, structures, installation and other professional can be found in time to greatly reduce design changes and improves design quality. In the construction stage, the construction simulation function can be use to accurate and visually simulate the field construction. This can avoid the conflict and disjunction between various technologies in the construction process and reduce the reworks (Fig. 1).

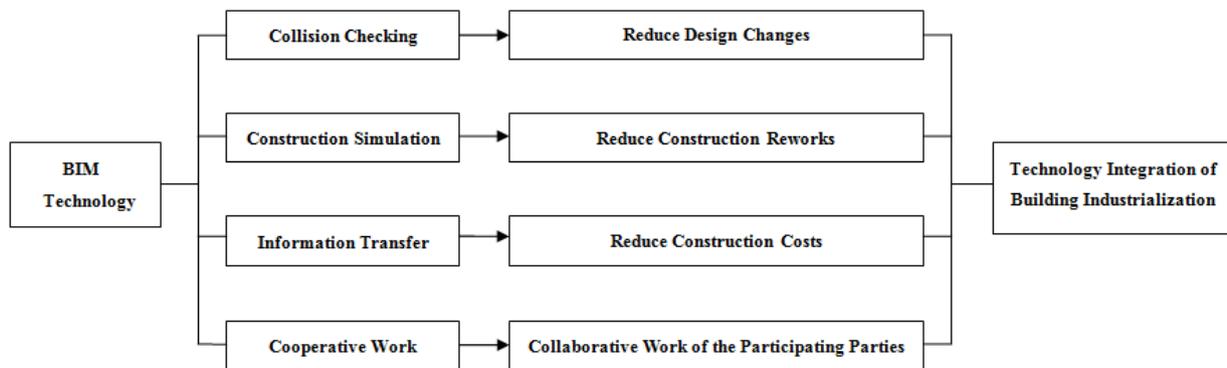


Fig. 1 The effect of BIM technology on the technology integration of building industrial

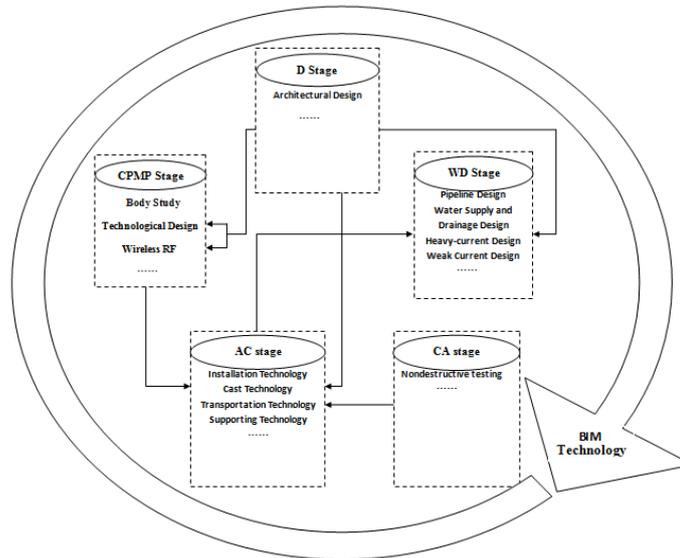
2. Technology Integration is the key to promote the development of Building Industrialization in China

In new round of the development of the Building Industrialization in china, the technology and management have been made great progress, and the development of industrial architecture has been greatly promoted. But there is still some cost and benefit problems which are caused by the low technology integration degree. The main reason is that in the way of industrialized construction, there are several integration problems, such as the technical standards are no sufficient unified, the technology system has not been formed, the technology information can't effectively pass in some stage, the quantity of design collision problems is very large, the construction management is inadequate and so on.

By analyzing the present situation building industrialization in china, it isn't hard to see that only the technology integration is the key to solve these problems. Only by using technology integration to effectively integrate the existing industrial technology and unified the construction technology standards, can we form a complete set of technical system, and provide technical support for the development of the building industrialization.

3. The Scheme of Technology Integration of Building Industrialization

There are a series of technologies need to be integrated in every stages of the industrial architecture, according to the characteristics of building industrialization, the technology integration model can be built (Fig.2).



Note: D Stage = design stage;
 CPMP Stage= component production and material preparation stage;
 AC Stage= assembly construction stage;
 WD Stage= the whole decoration stage
 CA Stage= the completion acceptance stage.

Fig.2 The technology integration model

Each rectangular area in the diagram represents a major stage in the process of industrialized construction, the integration of key techniques in this stage is represented by various techniques listed in each of the rectangular areas, while the arrow indicates that the technology in this stage needs to be considered and integrated into other stages.

By using BIM technology, we can not only achieve the collision checking in design phase, the virtual construction in construction stage, the digital management of logistics transportation and the effective information transmission at each stage of production, but also build a ERP information platform which combined with big data technology to realize the effective communication of multi participants.

This model will be introduced in five stages—design stage, component production and material preparation stage, construction of assembling stage, the whole decoration stage and the completion acceptance stage.

(1) Design Stage

In design stage, a variety of technology of other stages—such as field construction, loading and unloading, transport and stacking of components, pipeline design, water supply and drainage design, heavy-current design, weak current design and so on—must be considered and integrated effectively. In this stage, the BIM technology can be used to coordinate the other stages of the work effectively, and to ensure that the project objectives which formulated by construction unit can be maximized to achieve. While by using BIM's collision detection function, various collision problems in architecture, structure, water supply and drainage, electrical, HVAC and other professional design can be checked out, and the errors and omissions of design can be optimized to achieve the most reasonable layout plan in finite space, the conflicts caused by the unreasonable design of different stages are also reduced.

(2) Component Production and Material Preparation Stage

In component production and material preparation stage, the technologies—such as body study, technological design, Wireless RF and so on—need to be integrated to improve production efficiency. In order to ensure the convenience of installation and construction, the issues, include installation technology, cast technology, transportation technology, supporting technology, the loading and unloading of components, the prestore and stacking of components, in assembly construction stage should be fully considered and integrated.

In this stage, the BIM technology can be use to improve the efficiency of information communication with the design stage by introducing the BIM model of the design institute and factory production requirements into the software for conflict inspection together and timely communicating with the design institute.

(3)Construction of Assembling Stage

In construction of assembling stage, the construction of the building must be effectively integrated installation technology, the cast-in-situ technology, tower crane technology, transportation technology, supporting technology, etc., so as to improve the efficiency of construction and methodically to complete. Not only that, in the construction phase, various techniques, such as pipeline design, water supply and drainage design, high voltage design, and weak current design, need to be integrated as a whole when decorating. Due to the irreversible of the industrialized production, if not considering these technologies in the construction phase, will cause irreparable damage.

The BIM technology can be applied in the construction project before start working, to have an accurate and visually construction organization simulation, to avoid the conflict between various technologies in the process of site construction and disconnect, to reduce delays and the waste of investment. At the scene management, using the BIM model and 3D construction drawing instead of traditional 2D drawings to guide field construction hoisting, can avoid the field personnel error caused by drawing a misreading order or installation of fixed, etc. Enable managers have better to control project overall progress and realize the project goals.

(4)The Whole Decoration Stage

In order to carry out the "integration" decoration effectively, a series of technology such as pipeline design, water supply and drainage design, heavy-current design, weak current design , decoration scheme etc.must be integrated in design stage. By BIM technology, the collision checking function can be used to eliminate the conflicts between components and the original structure, water and electricity, machinery, and other profession. And the problems of program adjustment, rework, time delay etc.which caused by the inconsistent construction can be reduced significantly too.

(5)Completion Acceptance Stage

Based on the three-dimensional model of BIM, time limit for a project, price, contract and visa information changing can be stored in a central database, plus to ensure that the data integrity of a project whole life cycle. In the process of completion settlement, sensors can directly access to the central database and review all the relevant engineering data, which greatly shorten the preparation time of the settlement review and improved the efficiency of the settlement construction and quality.

At present, the industrialization construction also lacks a relatively complete system of technology integration in China. this is just explaining BIM technology integration application in the building process of industrialization from the angle of industrialization in different stages of the construction. In addition, the technology of building industrial integration also must be combined with management integration, such as the innovation talent training, demonstration project promotion and so on. In brief, construction of industrialization of technology integration is a multi-technology , multi aspect, multi domain and multi types of complex new technology mode, only this kind of technology can solve disjointing of various techniques in the construction of industrialization in China and to promote the development of building industrialization.

3.2 The Development Path of Technology Integration of Building Industrialization

Affordable housing as a main body with government investment and financing and high door model standardization degree, which is a major gripper construction and technology integration to promote the industrialization of construction in China. At this stage, because of the construction industrialization technology strength is weak in China, some key technologies are often needed to purchase from abroad by means of technology to purchase. This stage is to take the advanced technology to digest and absorb, into the enterprise, and then gradually improve the technical strength of the enterprise strategy by technology integration.

In occupied affordable housing market, the promotion of industrialization construction should be gradually to the commercial housing market penetration. At this stage, the way of technology alliance is used to cooperate with the foreign advanced industrialized construction enterprise, which gradually developed the the local breakthrough technical ability through the introduction, absorption and renovation approach of technology integration.

Under the premise of the solid commercial housing market, the technical ability of the construction industry has become increasingly mature. At this stage, all of the key integrated technologies in different stages is building in the industrial way with independent innovation. It will form the core technology system of the construction of industrialization, and with a highly integrated technical ability in our country's public buildings market penetration, so as to market development and upgrading of technology step towards a virtuous cycle and to speed up the construction of industrialization in our country.

Anyway, in the process of building industry promotion, technology integration is an important strategy to quickly occupy the domestic construction market , to form their own core technical ability by mastering the key technology and powerful means. Corresponding technology integration path of building industrialization is shown in Fig 3.

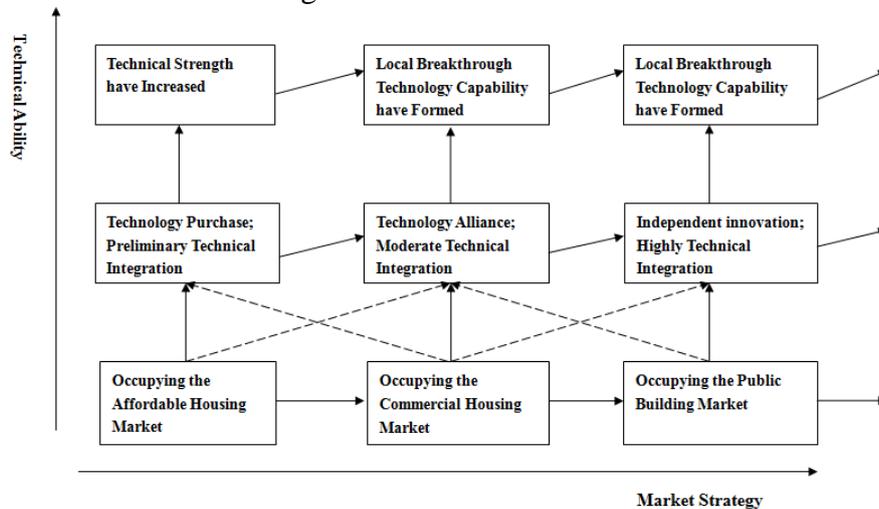


Fig. 3 technology integration path of building industrialization

4. Case Analyses: Research on the technology integration of building industrialization of 'A Construction Group'

4.1 The Development of the Whole Industrial Chain to Promote Technology Integration

'A Construction Group' is a total housing construction project contracting qualification enterprises; the company's residential industrialization base is composed of five plates: including two grade A Design Institute, the provincial R & D center, the whole renovation of the housing market, residential performance research and development base and building environment test laboratory. Company's business involves: the total contract construction, real estate development, industrial production and financial investment, etc.

From the point of view the whole industry chain of the construction industrialization, the group residential industrialization base contains Design Institute, component factory, advanced prefabricated assembly technology which can be engaged in the general contracting of construction, decoration engineering professional construction, and editor of the interior decoration engineering standard, also have the detection acceptance ability.

The group characteristics of the whole industry chain management configuration follows the developed ideas technology integration model, this paper effectively reduced the participants in different stages of the industrialized production of disjointed phenomenon, formed the whole life cycle of enterprises of the whole industry chain technology integration system, and can promote industrialized production efficiency and quality.

4.2 Technology Integration Path Analysis of 'A Construction Group'

4.2.1 The introduction of foreign technology by the integration of the existing technology, and the technology alliance to accumulate technical capabilities

The construction group of construction industrialization can be divided into two stages: "the study and practice of CSI residential system" from 2008 to 2015 and "the research and practice of prefabricated building" from 2010 to present.

In the first phase of 2008-2015, the enterprise has a leaping progress by buying the way technology, introducing SI residential system in Japan, and connecting with the company's own technical characteristics, continuously exploring and constantly perfecting CSI residential system.

In the second phase from 2010 to present, the main structure of the prefabricated is studied by the cooperation with Japan's Kashima technology alliance formation. Using the integration of technology, the two kinds of structure systems of residential buildings and public buildings are formed. During this period, 'A Construction Group' has accumulated valuable technical experience and the 'Shenyang B project', 'Shenyang C project' and other assembly structure projects have been completed.

4.2.2 Forming the Enterprise Key Core Technology by Independent Innovation

In order to build form a complete set of prefabricated structure system, reduce the workload in the stage of prefabricated line embedded, easy renovation in the future, 'A Construction Group' has been perfected CSI residential technology and modular structure system integration by independent innovation, and practicing in 'Jiangsu D project'. After the old project is completed, it will achieve the first domestic using of CSI system for internal decoration, the overall assembly rate reached 88%, and the prefabricated construction height reached 80 meters. Also the public buildings are domestic first "five in one" including exterior finishes, structural layer, insulation layer, outside the window, the interior decoration.

From the point of building industrialization development of 'A Construction Group', the companies introduced Japan's advanced industrialized production technology by buying in the form of technology and cooperated with Japan's Kashima by technology alliance. During this period, the company has accumulated a large number of advanced industrialized production technology. Then, the company applies the method of technology integration and the existing technology to enterprises all kinds of technology integration, which gradually forms the enterprise local breakthrough technology ability. In the practice of 'Jiangsu D project', 'A Construction Group' integrated perfectly CSI decoration technology and assembly type structure system by independent innovation, and ultimately formed theirs' own core technology system (Fig.4). This with the paper puts forward the development path of the integration of building industrial technology is also a lot of similar places. It should be noted that, due to the characteristics of the whole industry chain of a construction group, the market strategy does not necessarily choose to protect the development path of the housing-public buildings.

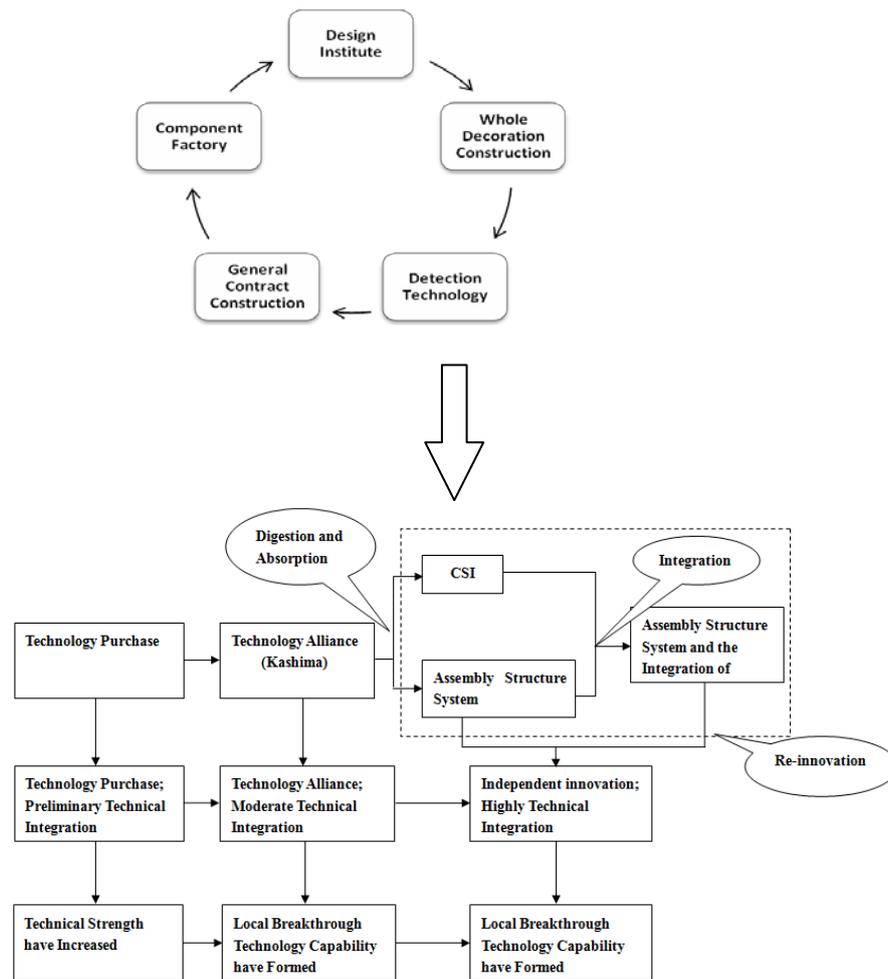


Fig.4 The whole industry chain and technology integration path of 'A Construction Group'

In this process, BIM technology has always been the primary means of information for the 'A Construction Group'. Using BIM technology, all enterprises in the whole industry chain of 'A Construction Group' can cooperatively work, and all the information in the process of industrialization can be effectively delivered. A variety of technologies have been well controlled, thus facilitating the technology integration.

'A Construction Group' has successfully used the method of technology integration and BIM technology to solve the problems which the key link cannot be unified effectively in the process of industrialized production, and to breakthrough the bottleneck of efficiency and cost in their enterprise. The example of 'A Construction Group' has provided reference for the development of technology integration theory of building industrialization in China.

Conclusions

Technology integration is a kind of scientific management method, which can effectively integrate many kinds of technologies in the process of industrialization, and form a unified technical system. And BIM technology is the most effective means to realize the integration of technology. Established ERP information collaboration platform based on BIM can effectively solve the design collision checking, construction stage of virtual construction, design, production, construction, operation and maintenance of information transfer and to communicate effectively on the platform with the participants. In this research, we use BIM technology to construct the technology integration model. The model takes the industrialization construction of all phases of construction information need to transfer and to participate in collaborative work and management characteristics into account,

proposed to determine the key role of the integrated technology system in the integration path for the formation by BIM Technology. Finally, 'A Construction Group', which has the characteristics of the whole industry chain, is chosen as the example. Analyzing of its technical integration process, path and characteristics, as well as the process how BIM technology to promote the contribution of enterprise technology integration. Finally, the paper analyzes the importance of the technology integration path, the model and the application of information technology in the process of building industrial technology integration.

Funding

Subject “Research on greenhouse standards and different constructions’ standards in different regions” (2012BAJ10B01) sponsored by Ministry of Science and Technology “Twelfth Five”. Subject “Research on installation key technology and scale application demonstration” (2011BAJ10B06) sponsored by Ministry of Science and Technology “Twelfth Five”. Subject “Research on collaborative innovation mechanism construction industrialization among stakeholders: Based on dynamic social network” (71401002) sponsored by national natural science foundation of china. Subject “Comparative Analysis of Applicative Technology in Construction Industrialization at home and abroad” (2014-2015) sponsored by Ministry of Housing and Urban-Rural Development. Subject “Research on Annual Report of Development in Construction Industry Modernization” (2015) sponsored by Ministry of Housing and Urban-Rural Development. Subject “Establishing Visible Corporation Working Platform Used to Simulate Construction in Industrialized Building” (PXM2015_014212_000063) sponsored by Beijing Municipal Commission of Education. Subject “Establishing Simulation Experiment Platform for Construction Project Management” (PXM2015_014212_000065) sponsored by Beijing Municipal Commission of Education.

References

- [1] Yingbo Ji. New Building Industrialization has a Long Way to Go [J]. Enterprise Construction Management, 2012,06:34-36.
- [2] Yufeng Long, Yang Jiao and Hong Ding. Application of BIM Technology in the Industrialization of Residential Building [J]. Housing Industry, 2012,09:79-82.
- [3] Yu Gu and Xiaoming Ma. Research on the Innovation System of Industrial Cluster Technology Integration [J]. Science and Technology and Economy ,2006,01:15-17.
- [4] Ying Cao and Juan Pu. Application of BIM in Whole Process Engineering Cost Management [J]. Henan Science and Technology, 2006,01:15-17.
- [5] Kun Yang and Yang Zhang. Study on Precast Procurement Process Based on BIM [J]. Shanxi architecture, 2010,27:367-368.
- [6] Shuhua Yang. Application and Case Analysis of BIM in the Design Stage of Construction Drawing [J]. Civil Engineering Information Technology, 2013,02:64-69.
- [7] Jing Cai and Rong Chen. Research on the Application of BIM Technology in Interior Decoration [J]. Modern Decoration (Theory), 2013,08:29-31.