Research on the Development of the New-type Construction Industrialization Based on the Cloud & BIM

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ABSTRACT: With the accelerated pace of economic globalization, information technology has penetrated into all walks of life, while the traditional construction industrialization is lack of support and application of information technology. Based on the crowdfunding theory, the paper utilizes the advantages of BIM and cloud computing and proposes the use of Cloud & BIM technology to build information integration platform for the development of new-type construction industrialization. Furthermore, this paper studies how the related aspects of industry chain of project life-lifecycle cooperate and implement to realize the integrated and efficient management of the overall project, and realize overall and efficient management of the project full life cycle. It is of great significance to the sustainable development of the construction industry.

Keywords: Cloud & BIM; new-type construction industrialization; crowdfunding; information integration platform; industry chain

1 INTRODUCTION

At present, environment and resources have become the world’s concerns, while the construction industry is huge but not transparent, resulting in a huge resources waste, energy consumption and environmental pollution. According to the low level and efficiency of project management, the construction industry must integrate effectively with industrialization and informatization to realize its healthy development. Construction industrialization refers to the industrialization of the whole construction industrial chain, extending the traditional construction industrialization up to the project development, and down to the building materials and even the building use, which realizes the more optimized allocation of resources in the industry chain of the entire construction industry[1]. It can integrate construction project planning, design, component production, logistics, construction, operation and maintenance, recycling, achieving energy saving, environmental protection, and the maximization of the whole life-cycle value. Under the background of “Internet plus”, we will certainly promote the depth fusion of construction industrialization and informatization, we can call it the new-type construction industrialization.

2 RELEVANT THEORY SUMMARY

2.1 BIM

Construction industry has always been a depression of informatization and the Internet. As the digital basis of construction industry, BIM makes it possible for the construction industry to be informationalized. With its potential of improving the productivity of overall project life cycle being recognized by many companies, BIM has got growing in the construction industry[2].

Building Information Modeling (BIM) is defined as a digital model with the physical and functional characteristics, which can provide reliable resources of shared information for the construction project to make decision during the life cycle from cradle to grave[3]. According to the richness of information, BIM has upgrade from traditional 3D information (geometric information) to 4D (schedule simulation) and 5D (cost analysis)[4][5].

2.2 Cloud & BIM

The earliest thought prototype of BIM was proposed...
in 1960s by John McCathy, the famous computer scientist, who said that cloud computing would become a public infrastructure sooner or later. NIST defined it as a model to get computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal efforts or service provider interaction. In China Liu Peng’s view is representative “cloud computing distributes computational tasks in the pool of resources consisted of a large number of computers, so that all operating systems can get to computing power, storage space and a variety of software services on demands.” Cloud computing is an emerging computing paradigm which promise to provide opportunities for delivering computing services in a way that has not been experienced before.

Here, generally is referred as the public cloud provided for the user by the third party. Private cloud is also called internal or enterprise cloud. As the internal information platform of enterprise, it provides hardware virtualization, centralized management, and flexible resource scheduling services, and is more safe and reliable than the public cloud.

The combination of cloud computing and BIM technology can effectively satisfy the different participants based on the same BIM model to carry out cross regional cooperation and reduce the cost of equipment operation and maintenance. Enterprise private Cloud & BIM platform is a private platform for enterprise BIM applications. Enterprise sets BIM software and high-performance resources in the private cloud, the computers on the land needs not to compute and the common terminal computers connect with the cloud through the network, so you can carry out works related with BIM. Public Cloud & BIM platform can be used as a platform for information integration of all parties involved, which is connected with the private Cloud & BIM platform through the network to enable the real-time participation, cooperation and control of engineering progress for each enterprise.

2.3 Crowdfunding

Crowdfunding, namely public financing or masses financing, consists of the promoters, investors and platforms. Regardless of the identity, occupation, age, and sex, anybody with ideas and creativity can initiate projects. Traditional crowdfunding products are generally relatively small and confine to the project level, equivalent to the diversified risk investment, with high returns and risks. In the process of the new-type construction industrialization, crowdfunding will play an important role. Building is large and complex, and we must cross five levels if we want to crowdfunding on it: product level-project crowdfunding; capital level-equity right crowdfunding; brain level-technology crowdfunding; relationship level-system crowdfunding; security level-law crowdfunding.

The key point of crowdfunding is service platform of third party which is only responsible for the activities of the project participants, provides the exchange and communication services of resources information, and has no interest relationship with participants in the project. As such a third-party platform, public Cloud & BIM converges various groups, such as consultation, design, production, decoration, building materials, labor and property on the same platform, which ensure the project of crossing the five levels and promoting the new-type construction industrialization.

3 INFORMATION INTEGRATION PLATFORM FOR THE NEW-TYPE CONSTRUCTION INDUSTRIALIZATION

3.1 Structure of the new-type construction industrialization

Traditional construction industrialization refers to industrial production mode of modern manufacture, transport installation and scientific management to replace the traditional construction handicraft production mode which is disperse, low level and low efficiency. Its main features are the standardized architecture design, industrialized production, mechanized construction and scientific management. The new-type construction industrialization emphasizes the deep fusion of the traditional construction industrialization and informatization, whose denotation and connotation are both higher, as shown in Figure 1.

Figure 1. Sketch map of the new-type construction industrialization structure.

3.2 Information integration platform

The new-type construction industrialization is a huge systematic project, involving many systems and enterprises. It is necessary to establish a unified infor-
In order to ensure the smooth running of the new-type construction industrialization, we must assemble all systems related to building system, such as government system, financial system, production system, etc. as the crowdfunding platform for the to-be-built project through the Cloud & BIM. Each participant in the system regards the project as investment objectives, and cooperates to produce a building product meeting the requirements of the smart city in a whole new and systematic thought, which is essential to the healthy operation of the proposed project during the whole life cycle. At the same time, the cloud platform enable the project of project processing during the decision-making, design, component production, construction, operation and maintenance process based on the same BIM model. Participants in different stages of the project build their own private clouds, through the network and the corresponding permissions to gain BIM application data from public cloud, and carry out effective management.

There are problems about cost, technical standards, talents and management in the process of cloud computing, BIM technology and construction technology, and the development of new-type construction industrialization needs to relay on the scientific and technological innovation activities of the field. Industry-University-Research collaborative innovation will solve these problems and is cooperation and integration of division of labor on the functions and advantages of resources in scientific research, education and production, which is composed by the construction enterprises, colleges and universities, scientific research institutions and so on.

4 CONSTRUCTION OF INFORMATIZATION INDUSTRIAL CHAIN

4.1 Integrated planning

Integrated planning is the main factors influencing the location of buildings. Administrator uses BIM to analyze the shape of the structure, clear out the area and volume of building, and make building performance simulation including sunshine, energy consumption, air, sound field. And through the BIM combined with 3D GIS, technicians build the building mode, sharing the building space information with the surrounding geographical environment, applied to the analysis of Smart City to determine new project site planning and organization relationship of the most ideal traffic flow and construction layout etc.

4.2 Standardized design

The core of the standardized design is to establish a standardized unit, at the same time it must follow the three “RE” design principles, Reduce, Recycle, Reuse, that is, resource conservation, resource reuse, resource regeneration. The Cloud & BIM technology break original limitations that only one aspect of the modular design and standard atlas is made, also is conducive to the establishment of standardized units, achieving the repeated use of standardized units in the construction process. Based on the private Cloud & BIM platform, design unit can realize various professional collaborative design based on the same model, three dimensional display and collision checking can make the coordination of different design professional more simple and efficient. At the same time, it can meet the interaction of BIM model data and analysis platform. Public Cloud & BIM platform allows the designer to communicate effectively with owner, contractor even operator in his work environment and display his design intent. It greatly shortens the communication time between designers and others involved in the stage, and avoids the misunderstanding of design. All of that can meet the requirements of the construction of the whole life cycle, and ensure managers of a global blueprint at the starting point.

4.3 Industrialized production

This is an important part of the new-type construction industrialization. With the promotion of it, more and more main building structures and equipment components are made on highly automated production lines in factory, and then are transported to the construction site for efficient assembly. In order to ensure the construction go with a swing, equipment must meet the requirements of design and quality, and construction management personnel must make real-time adjustment of supply according to the actual demands of the
construction site to ensure this components are transported to the construction site timely and effectively.

4.3.1 Component production
Under the background of the new-type construction industrialization, we need to achieve the industrialized equipment components, but the fundamental problem is the industrialization of main structure. One of the purposes of the industrialized production is to improve the precision of the components. The drawing information is imported into the prefabricated professional software through the constraint of the format specification by manufacturer based on Cloud & BIM platform. Machine automatically manufactures standard prefabricated components and comes with construction drawing, assembly drawing. This will improve productivity efficiency and leave more time for the transportation of the components and also ensure accurate and efficient construction on site.

4.3.2 Component supply
Usually the construction supply chain includes internal and external supply chain. Internal supply chain emphasizes the internal coordination among enterprise between financial, logistics, engineering and other departments, while external supply chain is beyond a single enterprise, including information flow, logistics, and capital flow network of all participants. Cloud & BIM platform enables information exchange no longer limited to the adjacent members, realizes the sharing of the information and is conducive to the establishment of a high quality, low cost and stable vendor cooperation mechanism.

Purchasing department develops procurement plans and quality standards in accordance with the BIM model, to achieve optimal combination of inventory quantity, location, order planning and transportation, and to improve the quality of procurement and reduce procurement costs. The combination of BIM technology and 3D GIS technology can quickly acquire the surrounding environment information, make the environment simulation analysis, and simulate the formation of optimal transport routes, combined with the path optimization algorithm. Simultaneously, it can optimize the location and method of the preservation of building materials and construction equipment, to a large extent, which can avoid the environmental pollution and waste of resources caused by the second transportation.

4.4 Prefabricated construction
The core of prefabricated construction is construction technology and construction management. As to construction technology, our country advocates delicacy construction and the combination with information technology, to realize the intelligent construction. As to the management level, the new-type construction industrialization differs from traditional forms, promotes integration of design, production and construction, which is conducive to the resource integration, technology integration, and the maximization benefits, so as to realize the transformation of production mode in the process of construction industrialization.

4.4.1 Intelligent site
Real time management system is based on the BIM model information and the effective information of building entities and the construction site, which can be subdivided into perception layer, transport layer, application layer and control layer. The core function of the perception layer is to capture the information of the construction entity and the construction site, using information capture technology such as GPS, 3D laser scanning, RFID, monitor, etc. Based on the communication environment, such as mobile Internet, local LAN and cloud platform, the transport layer mainly uses intelligent mobile phones, iPad and other portable equipments to achieve efficient circulation of site information. The application layer takes virtual reality and augmented reality as the core, and is combined with BIM technology to handle real-time information. The control layer is composed of the relevant personnel of the construction organization, and it is in need that them to fully understand the information identification, information transmission and operation process to achieve targeted, efficient construction management based on design and entity bidirectional information integration. This platform can effectively meet the information requirements of construction, and truly realize Intelligent Site, so as to promote the new-type
construction industrialization, as shown in Figure 3.

(1) Quality management subsystem
According to the project construction organization plan, technical personnel import the BIM model and environment information around construction site into professional software, and make fine simulation of each standard layer, locate the possible dynamic interference factors of project construction. Then managers plan the location and route of the crane in advance, and optimize the structure hoisting plan, make the lifting process more orderly and scientific. After lifting, technicians accurately locate component in building entity position with RFID technology, compare it with the position of BIM model in real time, and make real-time warning of abnormal situation to ensure the safety of building structures.

(2) Security management subsystem
Construction enterprise can build the safety information subsystem of the site, based on the real time management system in Figure 3, take Cloud & BIM platform as basic platform, use a variety of digital technology to collect information, establish information system center, combine the personnel positioning technology and risk source recognition system organically, and carry out unified management of the construction site, so as to realize the “five clear”, namely clear number of mechanical, clear number of personnel, clear attendance record, clear payroll records, clear time for import and export.

4.4.2 Project crowdfunding management
On the basis of the private cloud platform, the construction unit connects with the public cloud through the network. Taking public Cloud & BIM as crowdfunding platform, project participants can achieve management of three plannings and five levels, as shown in Figure 4.

(1) Business management
It provides people in the project with functions such as contract management, schedule management, quality management, safety management and procurement management, associating the business management data with objects related to BIM. And this can satisfy the linkage and control between the business, to achieve crowdfunding at product level and capital level.

(2) Real-time control
It can provide project manager functions such as real-time data query, statistical analysis, and real-time early warning, also achieve professional real-time data query and allow the management personnel in professional field to realize remote supervision and guidance, to achieve crowdfunding at technical level.

(3) Decision support
It can provide project planning, duration analysis, change management and other functions, and can provide analysis and support for the management of the decision-making, to achieve crowdfunding at technical level at relationship level and security level.

4.5 Integrated decoration
Integrated decoration is that from the design phase construction decoration is integrated with components production, manufacture and prefabricated construction. That is to achieve the integration decoration with the main structure, the personalized design, and scale construction. The arise of information technology such as BIM, virtual reality, augmented reality, cloud computing makes the integration of renovation problems solved, as shown in Figure 5.

In the process of integrated decoration, collaborative design, visualization, facilities management, analysis and simulation functions of BIM technology can achieve personalized housing design easily and quickly, and better meet the individual needs of customers. Developers can give prospective buyers certain permissions, so that customers can gain the developer’s Cloud & BIM information through internet and participate in part of design according to their individual requirements. They can freely choose, mix, adjust the decoration menu as well as combine it with architectural design to realize integrated design. A 3D model of real-time housing renovation will be generated in this process including relevant information of...
architecture, construction, mechanics, water supply and drainage, circuit and decoration along with all kinds of drawings the construction needs. This will avoid secondary rectification caused by later decoration and save cost and time. BIM technology can also analysis customer’s decoration program such as conflict detection, lighting and ventilation simulation, comfort analysis and energy consumption simulation, providing customers with personalized service.

Integrated renovation of the housing design and display with VR can enable customers to carry out the decoration design, virtual roaming and resource management in the virtual scene, fully meeting the individual demand of customers. Before the house is built, the customer will get the intuitive feeling. The cost of show reduces significantly and the effect improves. VR technology is to make users completely immerse in the virtual environment generated by computers, and AR (augmented reality) technology is a seamless integration of virtual objects, scenes or system prompts information generated by the computer and the real scene users see with the aid of display technology, interactive technology, a variety of sensing technology and computer graphics and multimedia technology. AR emphasizes a continuum that flows from the virtual facility to the physical one. AR can be a practical unified platform to project management that allows the views to be represented, inter-related, accessed, and utilized in an efficient manner by all project participants. Based on AR technology, customers have an immersive experience for the display effect of integrated renovation program that they participate, which will greatly promote integrated decoration, accelerate the process of our country’s construction industrialization.

4.6 Intellectualized operation

The scope of intellectualized operation management mainly includes five aspects as shown in Figure 6, space management, asset management, maintenance management, safety management, and energy management.

(1) Space management, mainly used in lighting, fire system and internal facilities spatial visualization. The using of BIM will establish a 3D visualization model, and all the data and information can be obtained from the model. Such as decoration, we can quickly get the relevant attributes of pipeline cannot be removed, load-bearing walls and other building elements.

(2) Asset management, building asset includes buildings entity, surrounding environment, facilities and equipment. The management for that is to meet the users’ requirements and continuously increase, maintenance, use, update and scrap at the appropriate minimum cost. We can use the fine building model provided by BIM as a carrier, and use GIS to manage the location of building internal assets and other information to improve the level of automation and accuracy of asset management.

(3) Maintenance management, the combination of BIM model and operation management system can make full use of the advantages of spatial location and data recording, establish reasonable maintenance plan, assign special person for maintenance work, establish equipment basic information database and account to reduce the probability of emergent situation in the process of use.

(4) Security management, fire, illegal intrusion, natural disasters are the main factors that endanger the safety of people’s lives and property. BIM technology can integrate the building equipment automation system (BAS) with building entity information through the wireless connection. Emergency equipment can be automatically triggered in the event of an emergency to prevent the deterioration of the accident. BIM combined with GIS technology can clearly show emergency evacuation location in building, distribution map of route and mark any other hazardous locations in the building achieving maximum management without blind area. The building can be connected with emergency rescue unit system through the cloud platform.

(5) In energy management, each household is equipped with electric meter, water meter, and gas meter with sensing functions. Management system automatically collects and analyzes energy consumption information in time through BIM and Internet, and identifies or warns abnormal energy usage. Cloud computing platform will combine building energy consumption with energy management system to format a total management system in order to make it operated and managed simply by household and property personnel.

Figure 6. Intellectualized operation management based on Cloud & BIM.
4.7 Greenized recovery

China’s construction industry is developing rapidly, and the amount of construction waste is also increasing. It is necessary to handle the construction waste properly, in the context of “Internet plus”, with the continuous development of the new-type construction industrialization, the disposal of construction waste will also form a complete industrial chain, which can be called construction waste disposal industrialization. That is before generation of construction waste, the professional team use information technology to assess the demolition of the building and propose removal scheme, in order to improve the recovery rate of waste and reduce environmental pollution. After generation of construction waste, it must be transported to special construction waste treatment plants based on emerging logistics information platform, then it will be handled in a scientific and rational manner by workers with professional knowledge and skills to realize effective treatment of resources.

Construction waste disposal industrialization not only can make the construction waste reused and recycled, but also play a role in protection of the environment. At each stage we should do following works:

1) Develop a reasonable dismantling scheme

According to the actual situation of the project, it is very important to make a reasonable removal plan for the construction project in the late process of the construction project. Based on the Cloud & BIM platform, professional personnel can understand the internal structure of the building clearly, and combined with GIS make it possible to define the relationship between the building and surrounding environment. Then, we can develop a reasonable removal program with low cost, high efficiency and small impact on the environment.

2) Classification and collection of waste

Relying on BIM and RFID technology, we will be able to locate and count recycling resources accurately, and we can classify and collect the resources and wastes in the process of building demolition.

3) Rational transportation of waste

Generally, construction waste transportation refers to departments including transportation, urban management, public security, environmental protection, municipal amenities and so on. These departments must cooperate with each other to ensure the normal work. Cloud computing platform can realize the multi-sectoral collaborative governance. Through the cloud computing platform combined with vehicle positioning system, we can control the dynamics of all the garbage transport vehicles in real-time and make vehicle trajectory can be found so as to reduce illegal activities such as road leakage, chaotic dumping, not closed transportation, running a red light and so on.

5 CONCLUSIONS

The new situation of economic and social development in our country in the new era provides an unprecedented opportunity for development of the new-type construction industrialization. We should grasp the “Internet plus” development tide to accelerate deep integration of the construction industrialization and informatization, and promote the development of the new-type construction industrialization, to solve the problems that extensive mode of development of the construction industry and achieve value maximization of the project life cycle.
ACKNOWLEDGEMENT

This paper is sponsored by the Natural Science Foundation of Hubei Province of China (2013CFB346); the Fundamental Research Funds for the Central Universities (WUT: 2014-IV-122).

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