“Intelligent Construction, Digital Modeling of the Future”
Internet + BIM Service EPC Project——Take the Exhibition Center of National Cybersecurity Center for Education and Innovation Project as an Example

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Abstract. This paper discusses the application of Internet and BIM technology to serve the construction mode of “PPP + EPC+ Fund” and management mode of “Executive Architect”. Taking the Exhibition Center of National Cybersecurity Center for Education and Innovation project as an example, relying on the CITIC Intelligent Construction Platform, BIM and digital technology such as cloud computing, big data, IOT, mobile Internet, chainblock etc., are used in the entire life cycle of the project, including design, procurement, construction and facility management. The data sharing and information management of the whole life cycle of the project are realized, which strongly supports the scientific construction and operation of the project.

1. Introduction
With the development of BIM (Building Information Modeling) applications, a single BIM technology cannot meet the needs of engineering projects, so Internet + BIM technology has become the mainstream way of engineering project construction. Because there are many participants in EPC (Engineering Procurement Construction) project, the construction period is long, and the amount of information is large, the management is complex and difficult. Therefore, it is necessary to make careful arrangements and effective integration of project management through a construction industrial internet platform based on BIM. Through data sharing, features such as sharing and alternation of project information are realized on the BIM platform. Combined with the process of project management, establish a complete basic data platform and technical service conditions for project management. Eventually, the management process of information creation, circulation, interaction, analysis, and decision-making can be fully monitored, which improves the quality and efficiency of project management.

In recent years, the research of industry internet platform based on BIM technology has attracted the attention of domestic and overseas. The main technology roadmap is based on building digitization, which utilize technologies of BIM and cloud computing, big data, the internet of things, the mobile internet, artificial intelligence, etc. to realize the digitized, networked and intellectualized management
of the process elements of building industry from design, procurement, production, construction to operation and maintenance.

Farzad J et al. [1] evaluates the implementation of BIM to identify the required number of points based on LEED V4 certification which is the first model that deals with almost the whole LEED v4 categories. They developed a plug-in to collect answers from BIM, google map, checklist questions and analysis results from Green Building Studio. Yang S C [2] introduces in detail how BIM uses its technical advantages to enhance the application value of lean construction in the construction industry from the perspective of multiple applications. He believes that lean construction system also provides a better application environment for BIM. Meanwhile, the lean construction system also provides a better application environment for BIM and fully realizes the technical value. Qin H et al. [3] pointed out that applying BIM in the model of EPC General contracting, the participants of the project can share resource which can achieve the project information, standardization, visualization, collaborative and ultimately make the project quality, schedule, cost, safety and other objectives to achieve maximum. Gong P et al. [4] proposed a research model of the acceptance of 4D BIM in EPC projects with eight latent constructs through a literature review of technology acceptance theories. Empirical evidence is collected from China, and implications to the developing countries facing the challenge of developing a technology-intensive construction industry are provided. First of all, adopting 4D BIM in the EPC project is beneficial. Secondly, the task-technology fit plays a leading role in technology acceptance. Finally, the management incentive is inefficient at the operational stage. Suggestions for future research on 4D BIM acceptance in complex construction projects with abundant data and alternative models are provided. Zhai Y et al. [5] developed an Internet of Things-enabled BIM platform (IBIMP) for a real-life Modular Integrated Construction (MiC) project located in Hong Kong. With the combination of advanced Internet of Things (IoT) technology and BIM technology, the barriers that hamper the possible functions of BIM can be overcome. The study demonstrates how problems encountered by independent stakeholders such as inconvenient data collection, lack of automatic decision support, and incomplete information can be addressed by the IBIMP. Xie Y F et al. [6] believed that smart material of BIM and RFID can be chosen as a new integration according to the characteristics of steel structure. This smart material can be used to solve the key technology of lifecycle management and information is shared, exchange with each other between participants during each stage. Zhang S et al. [7] introduced a work model of collaborative management using BIM technology for hydroEPC projects, and developed a BIM-based collaboration platform for the management of hydroEPC projects. The prototype system is applied in a selected case study of an ongoing project in southwest China to demonstrate the effectiveness of collaboration in a BIM environment. The results demonstrate that the prototype system can be used as a visual BIM-based collaborative management platform using BIM technology. Zhang X L et al. [8] based on BIM technology advantages and application value, using BIM design as an example for the design of pharmaceutical purification installation engineering, and the application of BIM technology in electron-mechanical installation engineering is analyzed in detail. Sun X L et al. [9] pointed out that BIM technology in project management proves to be good in Revit modelling, Naviswork 4D construction simulation, three-dimension field distribution, BIM 5D, reinforced-site management, templates, scaffolding, electrical and mechanical installation. With all the integrated use, it realizes fine and intelligent management of the construction projects. The construction enterprises can effectively control the construction organization, reduce rework, control cost schedule, and provide a strong support for the creation of low-carbon green construction aspects. Xu H E et al. [10] discusses the important role of BIM concept and related technology in the value chain of EPC project value based on the theory of BIM and value chain, and puts forward the BIM as the foundation to strengthen the activities of EPC project construction to improve the project quality and production efficiency. Zhao P et al. [11] claimed that the core of BIM technology is to create high-precision building information model relying on many information modeling software based on Revit. To create this model, we need to absorb all the relevant design, construction and procurement information, and then
use this model as the core to feed back the most reasonable and optimal construction scheme to the project builders.

2. Background
National Cybersecurity Center for Education and Innovation Project (hereinafter referred to as the “NCC”) is a major project approved by General Secretary Jinping Xi and supported by the office of the Central Cyber Security and Informatization Commission to promote the implementation of China's cyber security strategy. It is the first unique “Cyber Security Academy + Innovation Industry Valley” base in China. The total construction area of the project is 22,000 square meters. The main structure of the building adopts steel structure and reinforced concrete frame structure, with 2 floors above ground and 1 floor underground, with a total height of 17.55 meters. The total cost is about 500 million yuan. After completion, it will provide an important communication platform for the NCC for business invitation negotiations, conference services, summit exhibitions, and planning exhibitions, and become an important landmark building in the city of cyber security industry, as shown in figure 1.

![Figure 1. NCC Exhibition Center.](image)

This project uses Internet + BIM technology. By digital, online and intelligent services to the construction party and general contractor of the project, it ensures the smooth development of the project construction mode and assists the team of executive architects to carry out refined project management. The BIM application of the project adopted the “114” strategy, that is, with the help of “1” CITIC Intelligent Construction Platform, a “1” set of engineering project data with intelligent components as the core was established to serve the design, procurement, construction, operation and maintenance “4” Stages. Through the combination of BIM technology and Internet technology, the goal of “design visible, site controllable, and delivery available” is achieved.

3. Design
The design concept of the exhibition center project is “Do what you want, freedom has boundaries”. The executive architects use BIM to refine the design throughout the entire process, and finally form a digital delivery result.

3.1. Scheme Design
In the design stage of the scheme, parameterization and visualization methods are used to optimize the design. The curved surface reticulated shell adopts the parametric modeling method of Rhino+Grasshopper to perform fine modeling under the premise of satisfying the structural force and architectural modeling, as shown in figure 2. At the same time, we use BIM technology and 3D printing technology to assist designers in the design of the building. Using VR technology to simulate
the interior appearance of the building, assist the designer to grasp the architectural space and carry out refined design.

![Figure 2. Parametric design of the curved reticulated shell in the exhibition center.](image)

Figure 2. Parametric design of the curved reticulated shell in the exhibition center.

On the steel reticulated shell roof truss, a full-glass roof lighting curtain wall is adopted. The entire glass top curtain wall has a total of 2804 pieces of curved glass. Using parametric methods, the algorithm for the size of the curtain wall panels is designed so that the size of each panel can be calculated and adjusted by data. Through visual means, viewpoint verification is carried out. After optimization, the area of hyperboloid glass was reduced by 1,300 square meters, saving 2.45 million yuan in investment. In terms of building performance analysis, building performance analysis was carried out based on BIM data. BIM data is imported into Phoenics, Ecotect, PKPM and other software, and indoor ventilation simulation, light environment simulation, and acoustic environment simulation are carried out. Based on the simulation results, the design plan was adjusted to achieve the three-star green building target.

3.2. Construction Drawing Design

The project team used Revit software to complete the BIM construction drawing design of the architecture, structure and electromechanical professions, and carried out the fine decoration design, and simultaneously carried out the partial adjustment of the electromechanical profession to ensure the quality of the refined design. At the same time, virtual construction was carried out through BIM technology, and potential problems were discovered and resolved, avoiding the delay and cost increase caused by later construction changes.

In the curtain wall design, due to the design of the curved mesh shell, the size and curvature of each piece of glass in the daylighting curtain wall are unique. According to the parametrized algorithm in the early stage, the curtain wall node design is further deepened, and the digital model of all curtain wall panels is formed. In the later stage, the digital model is directly connected to the curtain wall production factory to assist in production and processing and precise positioning.

In the steel structure design, the steel structure is all exposed without secondary decoration. The special-shaped curved reticulated shell makes different areas of the same steel member have different cross-sectional dimensions. Therefore, the steel structure of the project adopts the prefabricated mode, and the designer uses the parametric technology to complete the BIM model of the steel component, which effectively improves the construction accuracy and efficiency in the later construction.

In the electromechanical pipeline design, the project team used Revit and Naviswork software to integrate various professional data models to form a collision detection report. According to the report, designers carried out comprehensive optimization of pipelines on important floors and areas. It not only optimizes the aesthetics of the pipeline, but also improves the clear height space, and realizes zero disassembly and modification of the pipeline design.

The whole design process realizes multi-discipline collaborative design. Firstly, designers rely on the intelligent component library to carry out the design and use the self-developed problem report recording system for verification. Secondly, the design team carried out a full-professional
collaborative design based on the CITIC Intelligent Construction Platform. The model is uploaded to the platform, and the designer integrates various professional models. Project drawings, models and related component information can be viewed online.

3.3. Delivery of Standardized Results
The BIM deliverables in the design phase are mainly divided into two parts, namely the drawings and the BIM database. As the traditional deliverables of the design results of the design institute, construction drawings are directly generated by the design BIM model. The drawing rate of each major of this project based on BIM model exceeds 70%, including 98% for construction, 80% for structure, and 70% for electromechanical. At the same time, with the help of BIM features, a large number of 3D drawings are completed.

4. Purchase
With the help of the CITIC Intelligent Construction Platform and the project BIM database, the executive architect team assisted the EPC party in completing the BIM-based online bidding and procurement work. Through the combination of BIM technology and list quota standards, the cost control of bidding and procurement is realized. Using the physical quantity list generated by BIM technology, combined with the “ChaoJiCai” bidding and procurement platform, online bidding and procurement based on components is realized.

Based on BIM calculation software, we extract BIM data to form a list of engineering quantities. The classification code and characteristic attributes of the components are associated with the national inventory quota standard, so that the BIM calculation software can automatically set the inventory quota to quickly generate the engineering quantity list. Then, with the help of the CITIC Intelligent Construction Platform, the characteristic parameters and physical quantity parameters of related components are automatically extracted. Initiated online procurement processes such as price inquiry and public bidding through “ChaoJiCai”. The exhibition center project completed a total of 6 online recruitments on the CITIC Intelligent Construction Platform, with a cumulative transaction amount of approximately 24.1 million yuan.

5. Construction
During the construction phase, the executive architect team continued to cooperate with the construction unit to carry out BIM-based construction deepening design, three-dimensional disclosure, Internet and digital technology, and assist the EPC party to carry out refined project management.

5.1. Construction Deepening Design
According to the construction plan, the BIM model is further deepened through model splitting, node deepening, structural detail drawing, etc., and the construction organization and construction details are solved to meet the needs of the construction process, as shown in figure 3. The steel structure roof adopts prefabricated assembly construction methods. The structural BIM model was imported into Tekla and Midas, the main nodes were analyzed and in-depth design, and the construction phase combination was added to guide the on-site construction. The curtain wall undergoes an in-depth review before the formal construction. The design BIM model is imported into the finite element calculation software, and the stress and deformation of the wall glass and roof glass are reviewed.

Aiming at the dense areas of on-site pipelines, combined with construction and installation space and procedures, a second deepening of BIM-based electromechanical pipelines was carried out. Using Revit and related plug-ins for electromechanical deepening, deepening work such as pipeline segmentation, optimization of reserved holes, casing design, and comprehensive support and hanger layout were completed. The clear height analysis report, reserved holes and construction drawings of supports and hangers were formed to assist the completion of the on-site construction.
5.2. Three-Dimensional Visualization Communication
With the help of virtual reality software, the site layout, earthwork excavation, steel structure construction process, etc. are simulated, and the existing conditions, construction sequence, complex technology and key difficult solutions of the construction site are demonstrated in advance. All parties involved in the construction discussed issues on the same platform and the same idea. This can assist the project management team to control the on-site construction schedule and quality and achieve the goal of reducing construction costs and reducing construction period.

5.3. EPC Project Management.
Applying the project management function of CITIC Intelligent Construction Platform, the project participants use the Internet and BIM technology to carry out the visual management of project schedule, cost, safety, quality, risk and resources, providing real-time data support for the refined management of the project.

5.3.1. Cost Management. In the construction preparation stage, the deepened BIM model is decomposed to form the model decomposition structure MBS. According to the construction plan, it is associated with the work breakdown structure WBS, so that the BIM data is linked with the construction data. Combining with the online recruitment and acquisition of CITIC’s intelligent construction platform, it realizes refined cost management.

5.3.2 Schedule Management. According to the association between WBS and MBS, combined with the construction plan and the actual progress of the construction site return, calculate the EV (Earned Value) to compare whether the construction period is delayed. This can provide a decision-making basis for the project management team to adjust and dispatch the human resources machine plan.

5.3.3 Quality and Safety Management. Using Luban collaborative software, project quality, safety, construction, etc. are managed. Project staffs use the mobile APP to obtain project photos, complete project data, and associate them with BIM components. Transplant the traditional offline workflow to online completion, help relevant personnel to trace the problem, complete approval, reply, report generation and other tasks.

5.3.4 Equipment and Material Management. In order to control the quality of the key processes of the project, the team of executive architects combined BIM technology with digital technology and recorded relevant information through a QR code. In the process of steel structure production and
installation, two-dimensional codes of components are made according to MBS. The QR code is pasted on the construction materials and is associated with the corresponding engineering construction platform to track a series of processes from production, storage, transportation, stacking to installation of components in real time.

5.3.5. Engineering Index Analysis. Through the construction BIM model, the engineering quantity index is analyzed, and the project bidding, the refined construction management, and the cost analysis and calculation are comprehensively dissected, and the risk analysis results can be reflected in real time.

6. Operation and Maintenance
Based on the data assets on the CITIC Intelligent Construction Platform, combined BIM technology with BAS and Internet technology to build the operation and maintenance management system of the exhibition center, and build a digital twin model that combines the physical model of the exhibition center with the virtual digital model, as shown in figure 4.

![Figure 4. Digital Twin System based on BIM.](image)

The operation and maintenance management system of the exhibition center was constructed by Dongfeng Design and Research Institute based on the self-developed DGP digital platform. On the premise of considering the operation and maintenance requirements in the early stage of the project, the design BIM model includes detailed electromechanical equipment information, weak current point information, etc. The deepening of the BIM model during the construction phase updates the agreement information of each electromechanical equipment and sensors. Through the application mode of BIM+BAS, the in-depth application of virtual visualization technology in the field of building automation is formed. The project uses Internet technologies such as cloud computing and the Internet of Things to realize data interconnection, connect digital models with control strategies, and realize real-time interactions between models and data, data and processes, processes and strategies, and platforms and users. Through virtual reality visualization, the data monitoring and facility maintenance of 12 subsystems such as video surveillance, air conditioning and lighting, and parking space control are displayed in real time.

7. Conclusion
The project executive architect team used Internet + BIM technical services to carry out refined management of the whole process of the project. Under the premise of meeting the needs of operation and maintenance, with intelligent components as the core, collaborative design is carried out to advance problems, reduce construction losses, and shorten the construction period. The CITIC Intelligent Construction Platform is used to carry out EPC project management based on BIM, and digitally assist all parties involved in the construction of the whole process management. It could play a good role in promoting the design and creativity-led general contracting construction model and the application of BIM technology in the whole life cycle of the project throughout the country.
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