Research on the application of BIM technology in the whole life cycle of construction projects

CHEN Chang-liu¹, ², KOU Wei-wei¹ and YE Shuai-hua²

¹China Mobile Group Gansu Co., Ltd., Lanzhou, China
²School of Civil Engineering, Lanzhou University of Technology, Lanzhou, China
E-mail: 13993149388@139.com

Abstract. BIM technology can realize information sharing, and good BIM application will reduce the whole life cycle cost of construction projects. The popularization of BIM technology challenges the application of BIM technology at all stages of the whole life cycle of the construction project. It will give full play to the value of BIM, if developing a reasonable BIM project execution plan, defining BIM requirements, specifying Level of Development, determining the BIM quality control plan and clearing BIM application content of each stage, and will provide a unified method for project stakeholders, realize the whole life cycle of construction projects, and achieve the desired information sharing in construction project.

1. Introduction
The whole process of construction project from planning, design, construction, operation and maintenance to demolition is characterized by high technology content, long construction cycle, no duplication and multiple units.

The information communication of traditional construction project management is not smooth, and duplication is common, now the use of BIM technology achieve the unit collaboration and information sharing of the construction project.

BIM technology has the characteristics of sharing, visualization, coordination, simulation, optimization, and drawing. Making a reasonable BIM project execution plan will give full play to all the values of BIM and realize the expectations of the construction project.

2. Formulate BIM project execution plan
The building SMART International Application of BIM to the whole life cycle of the project is shown in Figure 1.

The suggestion of BIM project execution planning procedure from the National BIM Guide for Owners is shown in Figure 2.
Combining the above advantages of BIM and the relevant interpretation of the BIM application of international institutions, before the implementation of the construction project, according to the Owner’s Project Requirements, it is necessary to formulate the actual BIM project execution plan. It will be provide a unified method for project stakeholders, and project is expected to achieve through the sharing and continually updating information.

The BIM Project Execution Plan is the central document for BIM implementation. This plan should be authored and strictly observed by the Project BIM Team collectively.

The BIM project execution plan should generally include the following: clear BIM requirements, clear team roles and responsibilities, regulate level of development, determine the BIM standard model fineness quality control plan, clear the BIM application process, clear schedule and delivery requirements about the application of BIM model, determine the information exchange between the BIM application requirements, and develop various stages of BIM application content etc.

BIM requirements are defined by the Owner’s overall goals, business practices, and corporate culture. Making sure team roles and responsibilities will be conducive to the realization of project target; model fineness standards will help determine the development model and data requirements of the contract requirements; determining the BIM quality control plan will ensure the accuracy of model data; making sure BIM application process, model requires and scheduling BIM application are easy to achieve the implementation of the project and the overall goal; determining requirements of the exchange information between the BIM application can maximize future compatibility; making BIM application content of each stage is the focus of the BIM project execution plan.

The BIM project execution plan should be considered a living document and should be continually developed and refined throughout the project development life cycle.

The main contents of the BIM project execution plan should be reflected in the engineering contract and distributed to all project participants. Project participants should regard it as the part of the overall plan of the project.
3. Level of Development

The model is to serve the various professional tasks in the whole life period of the project, and different professional tasks may vary in the content and information requirements of the model elements. Different level of development can be formulated according to the requirements of different stages, and the level of development rule of the project BIM model is recommended for reference table 1. For each of the BIM Uses, the level of development should be identified in order to maximize the benefit from the BIM Use.

The model elements and their geometric and non-geometric information contained in each degree of the fineness of the model should meet the needs of the models for the various professional tasks at this stage.

Models generated during planning, design, construction, and operations continue to serve as information resources used to keep the building operating at optimal efficiency.

| Stage                  | Description                                                                                       | Level of Development |
|------------------------|---------------------------------------------------------------------------------------------------|----------------------|
| Plan/Programme         | The Model Element may be graphically represented in the Model with a symbol or other generic representation. Information related to the Model Element can be derived from other Model Elements. | LOD100               |
| Preliminary Design     | The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. | LOD200               |
| Construction Drawing Design | The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. It mainly reflects the design intent. The precise size, pipeline material, geometric data, location and usage of main equipment, as well as the specifications of various valves, can be completely reflected in the models. | LOD300               |
| Deepened Design        | The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems. The aim is to reflect the actual situation that may be encountered in the field construction in advance. | LOD350               |
| Construction Process   | The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, | LOD400               |
and orientation with detailing, fabrication, assembly, and installation information. All the equipment in the model will be built according to the actual sample, especially for the installation of the equipment and the end of the pipeline with the exact size and number of the equipment.

The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. All construction information, including installation information of mechanical and electrical pipelines, manufacturer's information of equipment and materials, equipment type and final size of the connector, input into the model, and a good database is established for the basic work of later operation management.

On the basis of the completion model, we should add information about operation and management, including information about facilities and equipment maintenance and management, property management and related public services.

4. BIM quality control plan
The entire Project BIM Team is responsible for quality control. The quality control plan should be used to ensure the accuracy of the model data. The BIM application coordinator should be the BIM application process management and work quality supervision. We should coordinate the BIM collaborative process, delivery time and standard, and supervise the quality inspection of each participant's delivery model.

The quality standard for the model activities should be determined at the early stages of the project. Before the initiation of BIM project, we should clarify the way of collaborative work, collaborative workflow and standard, data format and naming principles of model files. In order to ensure the unity of all units of BIM model standards, meet the late model maintenance and data sharing needs, on the model of the colour standard required uniform requirements, building, structure, and other related professional mechanical and electrical component appearance colour; BIM model and BIM application should follow the consistency principle of software version and data format; the life of construction project in each stage of the BIM model should consider naming stage, profession, easy identification and operability.

At the same time, quality planning should be made, and quality assurance and quality control measures should be clearly defined before model activities, so as to meet project management requirements and BIM deliveries to meet owners' requirements. The quality assurance measures should include at least the fineness requirements of the relevant models for whether the models

LOD200 and later model fineness standards, non-graphic information can also be attached to the model elements.
conform to the deliverables, and the quality control measures should include at least the coordinate system, file types, naming rules, software version and so on.

5. The application of BIM in each stage
The essence of BIM technology is information sharing, which allows different owners to use the model in a variety of ways.

As the project moves from phase to phase, the information contained within the BIM grows in both quantity and specificity.

According to the different implementations, the implementation of BIM can be divided into the construction unit BIM and the contractor BIM. The construction unit BIM refers to the construction unit to complete the project construction and management, applying BIM technology by themselves or the third party specialized agencies achieve the project goal. Contractor BIM refers to the design, construction or related units apply BIM technology to fulfill their own projects achieving design, construction or other related project objectives. Of course, the best way is to the construction unit BIM, which is led by the construction unit. The BIM technology is applied by all participants in the whole life cycle of the project, which can give full play to the maximum benefit and value of BIM technology.

The application of BIM at all stages of the whole life cycle of construction projects mainly includes essential BIM uses, enhanced BIM uses and operation and maintenance stage BIM uses. The application of BIM should consider consistent with project objectives and clearly recorded in the BIM project execution plan.

At present, the main application of BIM model, include existing conditions model, cost estimation, phase planning, programming, site analysis, design reviews, design authoring, energy analysis, structural analysis, lighting analysis, mechanical analysis, other analysis, LEED evaluation, code validation, 3D coordination, site utilization planning, construction system, digital fabrication, 3D control and planning, record model, maintenance scheduling, building system analysis, asset management, space management/tracking, disaster planning etc.

The operation and maintenance model should be derived from the completion model. According to the functional requirement and data format of the operation and maintenance system, the completion model is transformed into a preliminary operation and maintenance model, and the completeness of the operation and maintenance model is checked according to the operation and maintenance model standard. The acceptance of qualified information and related information should be associated with or added to the initial operation and maintenance model to form a final operation and maintenance model. Building information and operation and maintenance information based on building information model can realize operation and maintenance management based on model, and realize assets, facilities, emergency and space management, reduce operation and maintenance costs, and improve operation and maintenance management level.

The operation and maintenance stage BIM uses include space management, asset management, facilities and equipment maintenance management, emergency management, energy management, disaster planning and management etc. Some applications span the various stages, such as the mode of status, cost budget throughout the whole life cycle of the construction of project planning, design, construction, and operation.

6. Conclusion
The rapid development of construction information technology, especially the rapid development of Internet of things and BIM technology, makes it possible to share information in the whole life cycle of construction projects. The formulation of reasonable the BIM project execution plan, will give full play to the value of BIM, and provide a unified method for project stakeholders. Stakeholders play their respective advantages with better cooperation, realize information sharing the whole life cycle of construction projects, and achieve the expectation in construction project.

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