

Application of BIM Technology in Construction Project Cost Compilation

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Abstract. BIM (Building Information Modeling) has gained wide acceptance in the building industry in recent years. It is changing gradually from traditional 2D representation of building product and fragmented contributions, and from the stakeholders to 3D product model and stream lined lifecycle management in the near future. This research presents an overview on the required information criterion of cost compilation in different stages. The CBIM based on IFC is proposed according to cost compilation methods using BIM, and the project cost summary process is discussed.

Introduction

BIM (Building Information Modeling) is the process of the project design, construction and operation by using the digital model. Based on the relevant information data of the building construction project, the building model was established; the use of digital modeling software can improve the efficiency of the project design, construction and management, and bring the new added value to construction companies adopting BIM¹. If the application of CAD technology is regarded as the first revolution of building engineering design, the emergence of BIM will lead the second revolution of the whole building engineering field^{2,3}. BIM can fundamentally solve the information gap between the project planning, design, construction, operation and maintenance stages and application systems, and can achieve the engineering information management in the whole process and even BLM (Building Lifecycle Management,). Through promoting the sharing of data in various stages of the whole project life cycle, achieving closer cooperation and the integration of Architecture/ Engineering/ Construction professional data into the entire construction process, the barriers among the construction engineering enterprises will be gradually broken down⁴.

IFC (Industry Foundation Classes) launched by IAI (International Alliance for Interoperability) provides the data representation and exchange standards for building products for realizing BIM. It marks the maturity of the concept of BIM, promotes the development of BIM technology, and BIM has become the hot topic of IT research and application in the current construction field. At present, the application closest to BIM in china is project cost. The following parts of the paper will introduce the BIM based compilation method for project costs and the implementation methods so as to improve the work efficiency of the cost compilation and the accuracy, consistency and normalization of the information description. The organic integration of the project cost and project design can fundamentally change the method of information exchange in construction projects, and it can promote comprehensive information and modernization of the construction industry, with important application values and broad application prospects.

Information Standards Required for Cost Compilation at Different Project Stages

The project cost is one of the core indicators of the construction project management. The cost compilation depends on two basic jobs are calculation and price combination of quantities. However, at the different stages of the project, the cost compilation bases and methods are different, and the project cost becomes clear with the gradual deepening and refining of the project. At the preliminary stage of the project (project decision stage and program design stage), the project

investment estimates can be prepared based on the controlled detailed planning, program design drawings and estimate indicators. Working drawings are obtained from the deepening design based on the preliminary design and technology design. The project cost is the working drawing budget prepared after the project investment estimate and design estimate, as seen in Figure 1.

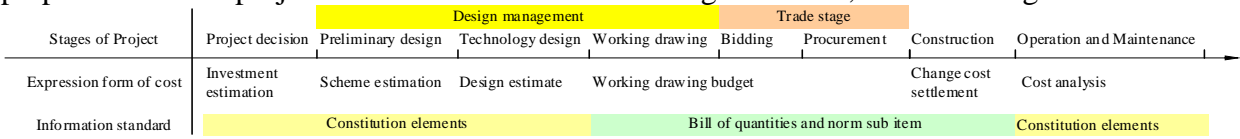


Figure 1. The required information criterion of cost compilation in different stages.

The working drawings are executed and refined for the building entity. The design components as the constitution elements of the building, such as walls, structural columns, holes and lintels will be gradually formed. Design components can be classified into catalog sheet and its property sheet, which is the classification standard for building elements, and it is the basic standard for estimate compilation, index accumulation, cost analysis, program comparison and other businesses. At the construction design stage, the definition of various components have been refined and determined. The cost data of materials, dimensions and construction technology, and working methods are no longer classified according to components, in instead, the cost data are organized based on the materials and types of work (i.e., project list or quota sub item classification), so it is conducive to the procurement, sub-contracting, etc., of materials.

BIM-Based Compilation Method for Project Cost

The cost compilation method in the traditional environment is that the cost engineer obtains the project information required for costs from the drawings provided by the architects and structural engineers, and then the cost compilation is made combined with the relevant provisions, information and expertise of the specialty. The artificial recognition of component information based on drawings will consume a huge amount of workload, resulting in potential errors. However, BIM is a database for storing the information of project components. The database can provide the information of project components required for cost compilation for cost personnel, thus greatly reducing the workload of the cost personnel.

The division of labor in the construction industry is getting detailed, so the architects and structural engineers will not put the special information required for cost compilation into the BIM model during the design by using the BIM model. If the cost engineer wants to compile the project cost by using the BIM, the BIM provided by architects and structural engineers must be verified and modified. Generally, the special information required for project cost compilation is added or extracted to form a BIM-based cost information model (Cost-BIM, hereinafter referred to CBIM), as shown in figure 2.

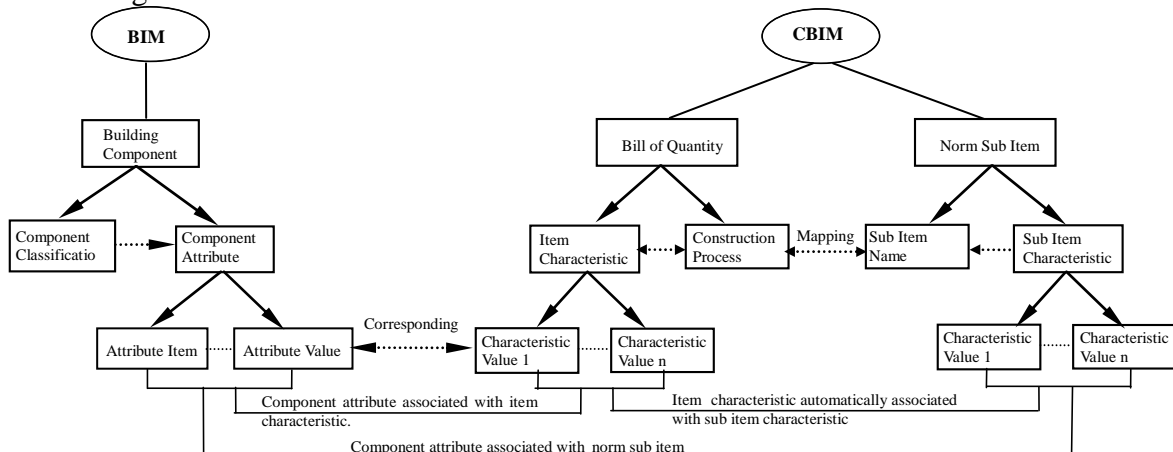


Figure 2. Relation between BIM and CBIM

The first method is to add special information (e.g., component fabrication method) required for cost compilation into the BIM file provided by architects and structural engineers. Because of high integration of design information and cost information, the modification of design information will automatically change the project cost, the changes in project cost information will also affect the design information, and the design model will make a response. For example, if a certain type of reinforcement is not available in the local area and another type should be used instead, so the information of such type of reinforcement shall be modified in the cost information, the design information model will re-adjust and replace the components using such type of reinforcement. The adjustment and replacement may cover the recalculation of the component cracks, which will cause the changes in component dimensions and concrete strength, and the changes will affect CBIM. It is clear that the method is a great challenge for BIM, it will easily exceed the current technology and hardware capability, and it has high requirements on the co-participants for design, construction, and cost compilation. A great effort shall be paid regardless of the realization of software technology or personnel workflow.

The second method is to extract the project information from the BIM model or to establish a connection with the existing cost compilation information. In this way, it will become relatively easy in terms of software products or personnel operations, but it will require manual management and operation for the cost changes caused by design changes or the design changes caused by cost changes.

CBIM Construction and Implementation

At present, BIM is widely applied to 3D design software, such as ArchiCAD, AutoCAD Architecture and Autodesk Revit⁵. The 3D models created by these software are not solid models for rendering or animation in AutoCAD, but they are model databases attached with much project information. The database stores all the geometric information of the architectural design and the corresponding engineering technical information. These design software can output IFC files. In the IFC files, the information is stored according to design components, and the data structure of these files contains the physical information, geometric information, extended geometric information, as well as linkage information of components, as the dotted lines shown in Figure 3. In order to meet the requirements of BIM follow-up project cost compilation, the costs/cost expansion information shall be added, the design components shall be classified according to classification standard, and the component attribute information and the information required for cost compilation shall be associated and corresponded, as the solid lines shown in figure 3.

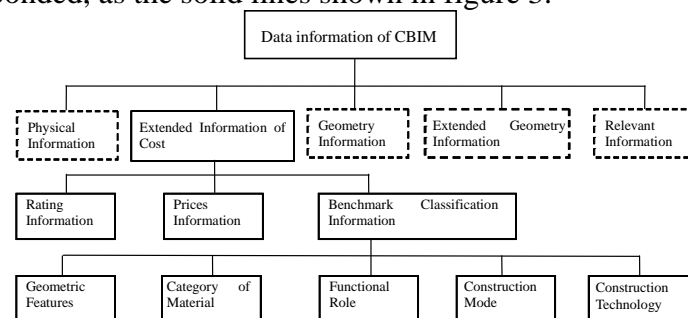


Figure 3. The data structure information of CBIM

The basic methods and the main features of the construction cost pricing are carried out by WBS (Work Breakdown Structure), which is determined by the inherent characteristics of the project (such as different volumes, different shapes, complex contents, various resources, etc.) After the decomposition of the whole project to the basic sub-items, the costs of the basic sub-items can be easily and accurately calculated. The more the levels of breakdown structure are, the more the basic sub-items are, and the more accurate the calculated costs are. The total cost of the project can be obtained by aggregation of calculated costs of basic sub-items. The calculation process of project

costs uses the method of "from top to bottom, from bottom to up". The project cost compilation process is shown in figure 4.

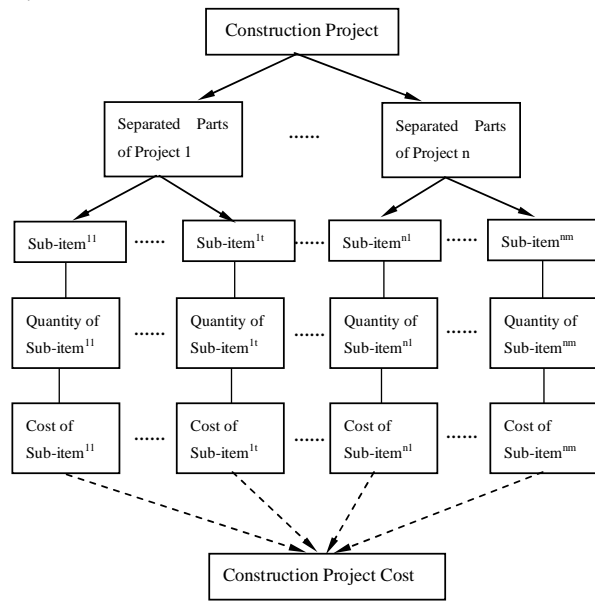


Figure 4. The project cost compilation process.

Aimed at the physical information of each component in the model, the quantity statistics of CBIM are to specify an output rule for the relevant geometric information, extended geometric information, and association information of the component object (CObject). When the system conducts the quantity statistics, the related property values of components should be automatically added to the corresponding basic sub-items (CBIPProject), then the arbitrage sum of all data (quantities) of the basic sub-items can get the data of final project cost, and the data of project costs can also be selectively output based on the input of cost personnel (CIOInput).

Take the beam for example, CBIM develops a basic sub-item about beam concrete for the volume property of the object beam (CBeam). During quantity statistics, CBIM will first call CCalculation module to calculate the volume attribute value of the beam. In the calculation process, the modules in the resources layer will be called as the calculation basis and data sources, and then based on the classification baseline data of the column object, the attribute value will be automatically added to the basic sub-item of specified beam concrete. The volume attribute value of beam object in the class/object layer (C/OL) will be added to the basic sub-item layer (BIL), and finally the arbitrage sum of basic sub-items can be completed to obtain the final project cost through invocation of Calculation module.

Conclusions

BIM is a new concept, and it involves a series of innovations and revolutions from the planning and design theories to the construction and maintenance technologies, which is a development trend of information of construction industry. The addition of cost/cost expansion information into CBIM can facilitate the real-time simulation and accounting of cost compilation at different construction stages, and it can be used for the management work of the construction stage, so that the collaborative design can be conducted between architects, engineers, cost engineers, construction units, and owners. It can easily foresee the construction costs and the construction progress, it can solve the problem of the stage fragmentation and professional fragmentation, it can avoid the separation between design and cost control, the separation between design and construction, and frequent changes and other problems.

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