Research on the Collaborative Running Mechanism Oriented to Reverse Designing Services of Engineering Projects Based on Revit

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Abstract. With the application and promotion of BIM technology in the field of building construction, the role and position of construction companies in adopting BIM technology to serve building construction activities is becoming increasingly important. Due to the unidirectional nature of the current BIM technology resource’s dominant behavior, the 3D modeling design, involved in the visual display of BIM technology, is mainly undertaken by construction companies, and it brings the asymmetry of building information’s management and interaction. Taking the application of Revit designing software as an example, in order to communicate with project designers and construction contractors on the interactive questions of reverse designing, and achieve the application effects of BIM technology resources, this paper designs the collaborative running model of engineering project’s BIM technology services from the perspective of building service collectivization, and expounds the collaborative running mechanism oriented to reverse designing services, so as to effectively serve the engineering project’s construction activities including bidding quotation, commencement preparation, construction process and completion and delivery.

1. Introduction
For the engineering application of BIM (Building Information Model) technology, it can be divided into three levels: task level, project level and enterprise level[1], which is from the perspective of information integration and people involved. Among those, building project is the basic unit of the application of BIM technology. At the same time, project-level BIM application is the foundation of enterprise-class BIM application. In order to introduce, promote and realize BIM technology, construction companies must adopt the following measures in raising their internal running efficiency and quality.

Step-a: an enterprise-level BIM center should be established at the macro-management layer of the construction group company;

Step-b: a project-level BIM leader, represented by the corresponding project manager, should be appointed at the promotion layer of the project department;

Step-c: the basic-level BIM team, which consists of technicians and foremen as the implementer, should be formed and determined at the realization layer of the construction site.

From the perspective of all members including corporate leaders, management departments and project departments, how to accurately recognize the true value about BIM technology and reflect the technical contribution of BIM resources, it is necessary to correctly understand that BIM technology is not only a novel software technology product, which just belongs to a sort of the virtual three-
dimensional showing product for project bidding, external publicity, leadership visit, superior inspection, and so on, but also a new advanced working way to apply the BIM technology to execution process and practice link for each building project. According to the above cognition about the application of BIM technology, the project-level working process is really the engineering application and the project implementation based on the BIM technology platform. Therefore, it is necessary to build a collaborative operation environment and working mechanism for the BIM technology resources oriented to the project-level working process.

2. Analysis of engineering requirements
When talking about the initial stage of the engineering project’s BIM application at the present situation, the three-dimensional modeling work, carried out by the construction company based on Revit designing software, is very large and complicated, which is equivalent to the building drawings’ reverse designing. For construction enterprises, the reverse designing of three-dimensional modeling work, based on Revit designing software, is a passive, obedient and unidirectional behavior only serving for the engineering project’s bidding quotation. Due to the difference of technical level of construction enterprises participating in the project bidding, the integral quality of three-dimensional modeling work is not higher, which will result in the greater systematic problems and executive difficulties in the later work of the engineering project’s BIM application. The root causes of the above situation are as follows.

① The working separation between project designer and construction contractor cannot effectively establish the service relationships including communication, interaction, and negotiation;
② As these tasks for reverse designing are mainly finished by construction contractor itself, it will make the BIM application more passive and unidirectional, which can deeply bring the loss of the interactive nature relative to project designer;
③ The project parties do not treat the systematic requirements of BIM application from the perspective of collaborative working, so as to cause the asymmetry relative to construction contractor’s BIM application.

With the deepening promotion of the fabricated building projects, whether the lightweight running mode of the prefabricated construction can be successfully realized is not only the transformation tendency of professional division and refinement of the prefabricated construction enterprise, but also the development direction of structural adjustment of the prefabricated construction industry. At the present background of the new and old kinetic energy conversion, traditional construction companies and design units will experience more profound progress of the industrial restructuring and reforming, including the reduction of enterprise numbers under the survival of the fittest and the expansion of enterprise services under the business integration. Taking China State Construction Engineering Corporation, a large-scale construction group with the professional design qualification, as an example, such collectivized development between construction company and design unit in the future will further deepen the collaborative integration about the complex building services of each other. At the same time, in order to meet the intrinsic requirements of BIM technology services, such a comprehensive construction group will effectively promote the ability, depth and strength of the positive application of BIM technology, which can scientifically realize the sustainable development.

3. Collaborative running mechanism

3.1 Collaborative running model
In accordance with the above requirements of BIM technology’s development platform, as the deepening reform of the running model and business management of China’s construction industry in the future, the large-scale collectivized construction enterprises will gradually become dominant in the engineering project’s construction market. As a result, such construction enterprises will be transformed from the traditional business mode of the single specialized design or construction to the multi-professional integrated business mode including investment, development, design, construction, opera-
tion, service, and so on. Under the vertical integrated management mode of engineering project, multi-professional engineering business will be attributable to the internal management range of the same group company, which is very beneficial and efficient for the integration and circulation of BIM technical resources. Through such operating and running business mode, it can be convenient and proactive for treatment and feedback of miniature BIM services, which is aimed at BIM services proposed by the project participants in the construction process. Combined with such management notion for BIM technical resources, collaborative running model of engineering project’s BIM technical services, based on miniature eco-design environment, is shown in figure 1.

3.2 Collaborative running mechanism

Based on the above ecological designing environment and service distribution, the group company becomes an unified business agent that can forcefully ensure uniformity of the whole working action and goal across its different departments. As two important professional components of a large-scale construction group, construction company and design unit should not only emphasize the ecologicalized development trend of its own professional service, but also form an external working characteristics relative to its unified professional service system for the whole group company, in which all the engineering parties can collaboratively participate in the construction process. In order to establish the friendly interactive environment oriented to all the engineering parties participating in the construction project, such interactive environment of BIM service also need to be based on the concepts of eco-designing environment, such as harmonious coexistence, green environmental protection and sustainable development.

In the process of carrying out the management of BIM Technical services, the engineering parties should give all play to the technological advantages that come from the above-mentioned collaborative eco-designing environment. At the same time, the above collaborative running mechanism need to combine with the system architecture of intelligent networks and the technical capabilities of active computing, and client nodes in the network cluster have presaved some local input codes of service management. According to client-side service instruction, it is generally restricted to the whole engineering group company’s total authority and other parties’ limited authority, which is existed in the above collaborative eco-designing environment, BIM Technical service will be executed and treated according to the following steps. Firstly, the client’s active application can directly load the local management code to achieve the function of reading, changing, adding and deleting to the relative application of BIM technical service, so as to correspondingly realize the distributed collaborative working

![Figure 1. Collaborative running model of engineering project’s BIM technical services](image-url)
mode between the project designer and other parties. Secondly, other parties will preferentially choose the default download location from the nearest neighboring node according to history record, and actively execute the corresponding application management; or else the participating node will report the new miniature building service about BIM technology to the unified business agent, then it can call and execute the corresponding management application from the unified business agent again, which can complete the miniature BIM technical management after loading. Finally, through the collaborative approval of project designer and construction contractor, the implementation of miniature building BIM technical service will be realized in order to meet the interactive needs of other expert systems for engineering design business outside the field of professional design.

Through such a distributed collaborative working mechanism, construction company and design unit, affiliated to the same group company, can proceed from the unified economic interests and work objectives of the group to jointly treat the relevant information of the BIM technical services. In this way, the engineering application of BIM technology, whether from the reverse designing behaviour of construction company or the top-down designing behaviour of design unit, will enable both parties to sensitively execute and achieve the three-dimensional modeling work based on Revit designing software, which can collaboratively help the engineering project work to realize better quality and efficiency goals of building product in terms of design, construction and maintenance. In addition, Revit designing software is the working condition to accurately create the building information model, and it is also one of the most widely used software in BIM system of construction industry. Thus, only on the basis of doing well in-depth 3D modeling work of Revit, construction company can successfully carry out all kinds of technological tasks involved in BIM services, so as to complete the project system’s simulation analysis and optimized design in advance, and realize the guidance function of preview for complex construction.

More concretely, Revit 3D modeling work, carried out by the construction unit, can achieve the following engineering goals. On the one hand, through its own reverse designing stage, the construction unit can actively find the potential problems of engineering drawings in advance from the three-dimensional scenes, and greatly reduce the design changes in the construction stage, which will make the project designer’s results have the very best engineering practicality, and gradually form the deepening cognitive links of the two sides’ cooperative interaction from the angle of the construction unit. On the other hand, in the process of its own modeling based on Revit designing software, the construction unit can achieve the dynamic visual presentation of design drawings, intuitively understand the designing scheme, and further inspect whether there are contradictions, no data information, and data errors in the design drawings, so as to facilitate the discovery of the design problems before its own construction action, and truthfully record the design problems. In the meanwhile, the construction unit classifies according to the problem properties and the engineering specialty, points out the location of the problem, and gets a clear reply from the project designer in time, so as to serve as the basis for correctly making the construction plan and guiding the scientific construction process[2].

Taking the reverse designing work based on Revit designing software as an example, this paper shows and expounds some sample use cases and application scenes of the interactive working mechanism oriented to the collaborative reverse-designing services.

3.3 Collaborative running services oriented to the construction contractor’s reverse designing

In the preparation phase of BIM software application, BIM Designers, that come from the construction contractor, enter the designing interface of Revit designing software, and then carry out the following steps.

a. Click on the building model to set up a new project, and complete the establishment of the base point;

b. Select the elevation in the project’s browser property box, and draw the required level in accordance with the building drawings;

c. Click the command button of the axis net after completing the above operations, and draw the axis net based on the columns’ structural drawings.
According to the standard designing process of three-dimensional model working, the construction contractor’s BIM designer should correctly set the parameters such as the material and elevation used, which are combined with the foundation engineering’s CAD drawing provided by the design department, and draw the three-dimensional structural drawing of foundation engineering. The modeling result is shown in figure 2.

![Figure 2. 3D model of isolated column foundation.](image)

In order that the reverse design is completed, BIM designer of the construction contractor should firstly insert CAD engineering drawings strictly corresponding the data of the design elevation, and draw the model of the column according to the structural construction drawing of each layer. To deal with the modeling work of reinforced concrete beam, the drawings of the column are hidden, and the drawings of the beam are inserted again. Finally, the model of reinforced concrete slab is drawn in the same way. Taking reinforced concrete frame structure as an example, the modeling result is shown in figure 3.

![Figure 3. 3D model of reinforced concrete frame structure.](image)

Figure 4. The rendered drawing of external walling.
After the three-dimensional model designing of structural part is completed, the designing work of the internal and external walling will be carried out. When architectural construction drawing is inserted into the floor corresponding to the elevation in the same way, BIM designer can choose and determine the material and width of the internal and external walling, which are combined with the architectural designing parameters, and then pick up the wall lines on the drawing, so as to draw the external walling and roof section of the building. Finally, Using the material editor to render the model, the rendered drawing is shown in figure 4.

Under the condition of the completion of walling section’s three-dimensional modelling, BIM designer can choose the correct part of the door and window, and then edit the sizes of the door and window, which are based on the construction drawing’s requirements. Secondly, the location of the door and window will be strictly set according to the architectural construction drawing. Finally, the roof section can be drawn. By the next step, BIM designer may choose the rendering module in the view options, and successfully achieve the rendered model for the architectural construction drawing. The rendered drawing is as shown below.

3.4 3D modeling work oriented to the electromechanical deepening design
On the other hand, the project’s BIM designer can adopt the function of BIM software’s collision detection in expressing the designing details about some construction difficulties, which can effectively guide the project’s technical process, improve the quality of construction activity, and reduce the risk of construction working. Through such optimization designing of collision detection for the electromechanical pipelines, the existing pipelines’ different elevation will be comprehensively adjusted according to the professional pipeline specification and avoidance principle. Based on the function of BIM software’s collision detection, the three-dimensional detail designings, oriented to some complex locations about construction drawings, are as shown below.

Figure 5. The rendered drawing of architectural construction drawing.

![Figure 5](image_url)

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![Figure 6](image_url)  ![Figure 7](image_url)

Figure 6. Collision detection before optimization.  Figure 7. Collision detection after optimization.
3.5 Collaborative running effects

On the macro management level, this kind of interactive working mechanism, oriented to collaborative reverse designing service, is carried out on the basis of the collectivization of construction business, and it can better play the role of transition and bridge of the general contracting management of housing construction projects in the future, that is, the project contractor carries out the general contracting for the stage of engineering design, procurement, construction or design and construction according to the contract signed with the project owner, and is fully responsible for engineering quality, safety, time limit and cost[3].

In order to achieve this kind of general contracting mode, the general contracting unit should simultaneously have the engineering design qualification and the construction qualification corresponding to the scale of the project, or the engineering consortium should be formed by the design unit and the construction unit that also have the corresponding qualifications. At the same time, the general contracting unit of the project should have the corresponding project management system and project management capabilities, financial and risk-bearing capabilities, and similar design, construction, or general contracting achievement as the contract work. In addition, the consortium, formed by the design unit and the construction unit, should reasonably determine the lead unit according to characteristic and complexity of the project, and very clearly define the responsibilities and rights of its members in the consortium agreement. In this case, the parties to the consortium should jointly sign a general contracting agreement with the project owner, and be jointly and severally liable for the general contracting project.

At the micro level of service operation, the building practice is characterized by its loose organization of the different participants, that each perform a specific role in a building project and have a specific view on the building project data[4]. Because of the above characteristics, these make the traditional building service management more discrete and passive. Combined with the above general contracting mode, the client layer’s expert system, based on the collaborative running mechanism, is professionally classified according to the various parties’ professional scopes, wherein either the design unit or the construction unit is separately distributed on a respective communication network, or the design unit and the construction unit are simultaneously distributed on the same communication network. As an integral part of the whole engineering group enterprise, both of them should take the common project action and goal as the foothold of the business cooperation, and establish the friendly environment and interactive channel of the two parties to participate in the construction activities. On the other hand, project designer and construction contractor can serve the same engineering group company, which will bring more convenient and positive interaction to help them to face the reverse designing work. This kind of expert system is characterized by collaborative processing of the problem to be solved, that is, a problem to be solved is divided into the several sub-problems, which are solved by each party collaboratively. And then, each party can communicate with each other and cooperate closely in the process of solving sub-problems. Finally, the complex problems can be solved through cooperation, reasoning and integration, which should combine with the principle of a certain choice or compromise.

Further speaking, such running mechanism effectively reflects the idea of computer network’s collaborative computing about the reverse designing work. And from the perspective of the construction contractor, it can collaboratively assign a part of management function of the designing services to participating nodes, which is authorized limitedly by the client layer’s expert system, and make useful connections between ideas about the reverse designing and how they link to the projects. At the same time, the participating nodes can collaboratively initiate and solve the reverse designing services through their own computing abilities, which gives expression to cooperativeness and extendibility for the customized management functions and the reverse designing services. Based on the above collaborative running mechanism for the engineering project’s BIM technical services, the reverse designing work of the construction contractor can not only be brought into sharp focus by the project designer, but also be applied to the inspection and verification of the engineering design results.
4. Conclusion
With the profound development of science and technology, the continuous improvement of building hardware and software equipment, and the active guidance of management policy, the construction engineering industry has gradually carried out the deep application of BIM technology resources from the trial stage to the extension stage, which also includes Revit designing software. In order to communicate the interactive questions of reverse designing between project designer and construction contractor, and achieve the application effects of BIM technology resources, the paper designs the collaborative running model of the engineering project’s BIM technology services, and expounds the collaborative running mechanism oriented to reverse designing services. Through this kind of interactive working mechanism oriented to reverse designing services, the Revit designing services originated from the construction contractor can be concerned by the project designer, and applied to the inspection and validation for the engineering project’s designing results, which can realize the purpose of simulating and optimizing the performance of the engineering project in advance, and pre-rehearsing complex construction process[5]. In this way, the construction engineering industry can effectively take steps to promote balanced development of both the project designers and the construction contractors, ensure a free yet orderly flow of both internal and external factors of production, improve the efficient allocation of the engineering resources, and deepen integration of the building markets.

Acknowledgements
This research was financially supported by the Teaching Reform and Research Project of Taishan University 201744; the National University Students’ Innovation and Entrepreneurship Training Plan Project of China 201810453021.

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