Comparative Analysis of Civil Engineering Quantity Calculation Based on Glodon GTJ and Revit

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Abstract: Diversified BIM software have been generated in recent years with the high-speed economic development and fast progress of computer technology in China. BIM technologies have been widely applied in construction engineering, e.g., the calculation of engineering quantities, where the modeling method and data importing method in 3D graphics quantity calculation software have been mainly used. In this study, the technical features of Glodon GTJ and Revit software as well as the possible errors of the two software in the engineering quantity calculation were analyzed. Taking the civil engineering of Ganglin C-01 Phase II high-standard plant as an example, the two software were used for the civil engineering modeling, the concrete engineering were calculated, the reasons for the errors in the engineering quantities were analyzed according to the calculation results, and through the extensive analysis and calculation, it was finally obtained that the errors were not only related to the limitations of two software but more correlated with the professional quality of technical personnel.

1. INTRODUCTION
The transformation & upgrading of construction industry, a pillar industry in national economy, is a very arduous task in China. As an important technical means of innovative and sustainable development of construction industry, BIM technologies, if applied and promoted, will bring about unprecedented changes to the industrial development, and meanwhile, provide an enormous impetus for the construction industry to forge ahead and achieve rocketing development, but higher and higher requirements have been proposed for the project cost management. The information-based development of engineering cost industry has also witnessed an evolution process of calculation of engineering cost from manual drawing, 2D computer-aided calculation in the 1990s to the 3D modeling calculation at the beginning of the 21st century and further to an engineering cost management phase with core BIM technologies. Various software like SJMS, THS WARE, Revit, Glodon, Lubansoft and PMS all can realize the high-quality cost management of engineering projects, effectively improve the efficiency, reduce the error rate of cost treatment and achieve highly efficient information fusion and sharing. Glodon software and BIM Revit software have been popular among the vast number of engineering cost users by virtue of their powerful parametric modeling and visualization functions. Meanwhile, they have further accelerated the development of construction industry in an effective combination with other technologies. In this study, Ganglin C-01 Phase II high-standard plant was modeled for the calculation of its engineering quantities based on Glodon BIM civil engineering quantity calculation platform GTJ2018 and Revit software, followed by a comparative analysis of the calculation results.
2. Technical Features of Glodon GTJ and Revit

2.1 Technical Features of Glodon GTJ Software

2D design mode is mostly adopted in the traditional building design to output plans, elevations and profile maps of buildings and express the buildings. However, Glodon GTJ establishes spatial building models by combining the abovementioned drawings, as shown in Figure 1. This platform, which contains built-in Standard Method of Measurement for Building Construction and Fitting-out Works, quota calculation rules for bill of quantities (BOQ) throughout China, and G101 series plane method rebar rules, establishes BIM civil engineering quantity calculation model by means of intelligent identification of dwg drawings, one-key importing of BIM design model, cloud collaboration, etc., helps engineering cost enterprises and practitioners to solve whole-process business—calculation, quantity collection, inspection and review—in various phases of estimation and rough calculation, bidding and tendering budget, change of construction schedule and settlement upon completion in the civil engineering industry, and realizes one-stop BIM civil engineering quantity calculation service.

![Figure 1 Model Rules](image1)

The model established by Glodon GTJ can accurately express the spatial position relation between members, while civil engineering quantity calculation software calculates the engineering quantities of various structures by following certain calculation rules, and conducts deduction processing among the structures using a program according to the model[1]. To facilitate the invocation of engineering quantities, the engineering quantities are provided in way of code, and the BOQ and quota can be directly invoked, as shown in Figure 2. Relative to manual calculation, the operation is more convenient and simpler, thus greatly improving the working efficiency and effectiveness.

![Figure 2 Glodon GTJ Calculation Platform](image2)
2.2 Technical features of Revit software

Based on 3D information digital model, building information modeling (BIM) integrates all information related to design, construction, building and later operation & maintenance to express the information of engineering project in detail. Presenting a building in a 3D digital model, BIM has diversified functions such as visualization, coordination, optimization, simulation and drawing output[2]. As a software widely applied in BIM, Revit is capable of establishing a spatial model rapidly, simulating the real engineering status through the rendering function and building complicated volumes, so as to satisfy the demands for all kinds of complex buildings. Moreover, it also can establish a model accurately and rapidly, realize the coordinated modification of 2D drawings and 3D models at optional position of project through the parameter adjustment, rapidly analyze and compare the changes in engineering quantities caused by the modification and compare different change schemes, thus reducing the cost.

3. Comparative Analysis of Engineering Quantity Calculation by Glodon GTJ and Revit

3.1 Project profile

Ganglin C-01 Phase II high-standard plant was taken as an example, it was a reinforced concrete frame structure, the total building height, number of building storeys and building area was 24 m, 4 and 13317.63 m², respectively, the height of the first storey was 7.05 m, that of both the second and third storeys was 5.9 m and that of the fourth storey was 4.95 m, the design service life was 50 years, the fire resistance rating was level II, and the seismic fortification intensity was 6 degrees. This building had an independent foundation, the concrete grade was C30.

In this study, a spatial model was established for this project using the Glodon civil engineering quantity calculation platform GTJ2018 and Revit software, the engineering quantities of column, beam and slab were summarized and calculated, and the calculation results were comparatively analyzed in the end.

3.2 Civil engineering quantities calculated by Glodon GTJ

The 3D model of column, beam and slab members in the high-standard plant was built via Glodon BIM civil engineering quantity calculation platform GTJ2018, based on which their concrete engineering quantities were summarized and calculated in accordance with Standard Method of Measurement for Building Construction and Fitting-out Works (GB50854-2013), and all contents of each group of members were respectively processed according to the following construction sequence: building first and roof second, indoor first and outdoor second. First, CAD drawings were imported into Glodon GTJ software, the corresponding members were defined and explained according to the drawings before drawing[3]. To be more specific, the members on the drawings could be compiled using member administration dialog (the names given on drawings should be used as far as possible), and the drawing sequence could be determined according to the structure type. In this study, three members—beam, slab and column—were mainly drawn in Glodon GTJ software based on the calculated engineering quantities of the project, and their 3D model is displayed in Figure 4, and their concrete engineering quantities were summarized and calculated accordingly as seen in Table 1.
Table 1  Concrete Engineering Quantities of Column, Beam and Slab Members

| Structure type   | Texture                  | Concrete strength grade | Unit | Engineering quantity |
|------------------|--------------------------|-------------------------|------|----------------------|
| Frame column     | Cast-in-place concrete   | C30                     | m³   | 756.59               |
| Frame beam       | Cast-in-place concrete   | C30                     | m³   | 2603.50              |
| Floor slab       | Cast-in-place concrete   | C30                     | m³   | 1368.35              |

According to the concrete requirements and detailed descriptions in the drawings, other accessory members like masonry wall, window and door hole and stairs of this high-standard plant were drawn, and 3D high-standard plant model (Figure 4) was obtained through the review and check.

4. Civil Engineering Quantities Calculated by Revit

The 3D model of column, beam and slab members in the high-standard plant was established via Revit software, their concrete engineering quantities were summarized and calculated, and meanwhile, the daylight simulation of high-standard plant building was conducted to display the real status of this building under the daylight in different time periods.

Similar to the modeling steps of Glodon software, the CAD drawings were firstly imported into Revit software, and the concrete positions of beam, slab and column members in the 2D drawings were identified. Second, the height, size and nature of members were determined according to the plan, elevation and profile map, the corresponding structure attributes were set, drawn in Revit software.
successively and then modified according to the concrete drawing descriptions so that the model could be more accurate\cite{4}. The 3D model of beam, slab and column members is shown in Figure 5. After the model was established, the detailed BOQ of beam, slab and column members could be created in Revit software. Not needing data transmission, this BOQ could export the corresponding engineering quantities directly by drawing and adding formulas, as seen in Table 2. After other accessory members were drawn, the overall 3D model (Figure 6) of this plant was acquired through coloring.

| Table 2: Concrete Engineering Quantities of Beam, Slab and Column Members |
|-----------------------------|-----------------|-----------------|-----------|
| Structure type              | Texture         | Concrete strength grade | Unit | Engineering quantity |
| Frame column                | Cast-in-place concrete | C30              | m3   | 756.59               |
| Frame beam                  | Cast-in-place concrete | C30              | m3   | 2603.50              |
| Floor slab                  | Cast-in-place concrete | C30              | m3   | 1368.35              |

The engineering quantity of column member, that of beam member and that of slab member calculated by Glodon software were 6.7 m$^3$ more, 291.03 m$^3$ more and 26.83 m$^3$ less than those calculated by Revit, respectively. The concrete error analysis is presented in Table 3.

| Table 3: Comparison of Engineering Quantities |
|----------------------------------------------|
| Software type Member name | Glodon GTJ | Revit | Error (%) |
| Frame column                | 756.592    | 749.89 | 0.89      |
| Frame beam                  | 2603.50    | 2554.733 | 1.91     |
| Floor slab                  | 1368.35    | 1659.38 | -17.54   |

Revit software can be used to simulate the building status in the daylight. The daylight study helps designers to decide the building shape, orientation, appearance and other important information and reduce the loss brought by the later modification by displaying the influences of natural light and shade on the project. The simulated status of this plant in the daylight at 10:10 on April 5 is shown in Figure 7.

![Figure 5: 3D Model of Beam, Slab and Column Members](image1)

![Figure 6: Overall 3D Model of Plant](image2)
5. Comparative Analysis of Engineering Quantities

The engineering quantities of frame column, frame beam and floor calculated by Glodon civil engineering software were 756.592 m³, 2603.50 m³ and 1368.35 m³, respectively, and those calculated by Revit were 749.89 m³, 2554.73 m³ and 1659.38 m³, respectively. Through the comparison, it could be obtained that:

By comparatively analyzing the error results, the two software showed small errors in the engineering quantity calculation of frame beam and frame column, and the errors fell into a reasonable range, but the error of floor slab engineering quantity calculated was relatively large. By combining the drawing information, drawing method and calculation rules, the floor slab engineering quantity was repeatedly calculated, and the following reasons could be figured out:

(1) Inconsistent deduction rules

Great errors were generated in the concrete engineering quantity calculation of floor slab due to the inconsistent deduction rules of the two software[5].

Glodon civil engineering software conducts the specific calculation of each member in accordance with the latest quota engineering quantity calculation in China. During the calculation process, the software automatically sets the corresponding rules according to the usage of each member, and the result according with the reality is obtained through the manual rectification. For instance, the slab and column cap should be simultaneously calculated in the manual concrete engineering quantity calculation of beam-free slab, the sum of the two is taken as the concrete engineering quantity of slab, which is fully embodied in Glodon software. This software executes the calculation in strict accordance with the standard, and automatically deducts the volume of some beams, but this essential is not used yet in Revit, which calculates the engineering quantity of single member, and moreover, a detailed list of members should be created in this software in order to obtain their concrete engineering quantities. Through the above analysis, one of the reasons for the calculation error of floor slab engineering quantity is the inconsistent calculation methods adopted by the two software. In practical application, the slab engineering quantity calculated by Revit is larger than that by Glodon software due to its limitation in this aspect.

(2) Inconsistent drawing methods

Because of different drawing methods adopted by technical personnel, errors existed in the calculated concrete engineering quantities of different members even if they acquired a consistent overall 3D model of this building.

Revit implemented the concrete engineering quantity calculation of a single member each time and did not deduct the overlapped part, for example:

The beam, slab and column members were set to the same texture and attribute, where the sectional size and height of column were 500 mm × 500 mm and 3300 mm, respectively, the sectional size of beam was 300 mm × 600 mm, the thickness of floor slab was 150 mm, the floor slab was drawn in different ways, and the concrete drawing routes are shown in Figure 8. Method I: The slab profile was drawn along the external side boundary of beam, and the area of column cap was deducted; method II: The slab profile was drawn along the external side boundary of beam and column, while the area of column cap was not deducted. The 3D models acquired were consistent in appearance, so were the calculated concrete engineering quantities of column and beam, but the concrete engineering quantities of floor slab were inconsistent, and the error results are listed in Table 4. Glodon software
implemented the automatic deduction or combination according to the standard no matter the slab member was drawn along the slab edge or beam edge, so the concrete engineering quantities of slab calculated by this software were identical. Based on the above analysis, the volume error of floor slab was affected by the drawing methods of technical personnel besides the inconsistent deduction rules.

Fig.8  Different drawing paths of the board

| Table 4  Error results of different drawing methods |
|---------|--------|--------|--------|
| Structure type | Deduction (m³) | No deduction (m³) | Error |
| Frame beam | 0.92 | 0.92 | No |
| Floor slab | 1.350 | 1.404 | Yes |
| Frame column | 3.3 | 3.3 | No |

6.Conclusion
After the beam, slab and column members were respectively drawn using Glodon GTJ and Revit, the 3D model of this high-standard plant was acquired, the concrete engineering quantities of the members were calculated and comparatively analyzed, and the following conclusions were drawn: Small errors existed in the engineering quantities of beam and column members calculated by the two software, falling within a reasonable range, but the error in the calculated concrete engineering quantities of slab members was large, and the reasons were analyzed as follows: First, lacking quantity calculation plug-in, Revit software failed to follow the latest standard of quota engineering quantity calculation in China, while Glodon software could select the quota calculation rules of corresponding province since being installed, so the deduction results of concrete engineering quantities obtained by the two software were different somehow⁶. Second, Revit software had its own limitations, the member drawing method varied among different technical personnel, so the calculated concrete engineering quantities were different even if the obtained 3D model of slab member was consistent, and as a result, errors existed in the finally obtained data⁷.

With a relatively mature system in the quantity calculation, Glodon software can save unnecessary troubles for cost personnel and improve the working efficiency⁸. Though being of certain limitations in quantity calculation, Revit software is capable of obtaining more accurate engineering quantities by installing quantity calculation plug-ins, including the existing relatively mature software in China like Dawn and THS WARE⁹. Moreover, Revit also has many powerful functions besides modeling-based quantity calculation. For designers, Revit integrates various functions like rendering, daylight simulation, pipeline collision and electrical equipment overhaul, thus making it convenient for the follow-up modification.

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