Application of BIM modeling technology in Bridge Engineering

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Abstract. BIM (building information modeling) is a new engineering technology which appears at the beginning of this century. It takes the relevant information data of the project as the model basis, establishes the building model, and simulates the real information of the project through the digital information simulation technology. In recent years, China's BIM Technology has gradually extended from the construction industry to the transportation industry, and has achieved good application in rail transit, bridge design and other aspects.

Keywords: BIM Technology; bridge engineering; modeling technology; application.

1. Introduction
The application of BIM Technology can run through the planning, survey, design, construction, operation and maintenance of transportation infrastructure, realize the data sharing of all participants in the whole life cycle of the project on the basis of the same multi-dimensional building information model, provide technical support for fine design, industrial construction and industrial chain connection, and support the improvement of engineering environment, energy consumption, economy, quality and safety. The analysis, inspection and simulation of the project can provide the basis for the scheme optimization and scientific decision-making of the whole process of the project; support the collaborative work of various disciplines, the virtual construction and fine management of the project, and create conditions for the improvement of quality and efficiency, energy conservation and environmental protection of the transportation industry.

Figure 1. Life cycle intelligent construction business logic
The core of BIM Technology is based on two-dimensional drawings, using three-dimensional modeling software to establish a virtual three-dimensional model, and using digital technology to realize the visualization effect of the project [1, 2]. With the development of China’s construction industry in recent years, BIM Technology has been fully applied in housing construction, large-scale buildings and station tunnels [3, 4]. For example, in the construction of Chengdu Metro Line 8, the three-dimensional model of BIM has been used to solve the problems of pipeline crossing and line optimization, realizing the efficient utilization of resources [5]. The application of BIM Technology in the bridge has also been greatly developed, and large companies in the domestic bridge construction industry have also successively promoted BIM Technology, which will open a technological revolution in the construction industry [6-8]. With the development of bridge industrialization and standardization, the application scope of BIM Technology in transportation industry is wider and wider, and the application level is deeper and deeper. However, the application of BIM Technology in bridge engineering is not perfect, and the problem of BIM standardization is increasingly prominent. Based on the software of Revit, this paper explains the BIM standard component library of bridge and its application according to the modeling ideas and implementation steps of conventional bridge.

2. Standardized configuration of bridge BIM components

BIM information technology can promote the good convergence of design standardization and construction standardization, improve the quality of the project, and its application in the field of transportation has been highly valued by all parties involved in the construction. In order to effectively improve the modeling efficiency and enhance the quality of conventional bridge model, it is necessary to unify the naming methods and coding rules of parametric modeling of common bridge components.

2.1. The establishment of component library is the key of BIM modeling application

Highway and municipal conventional bridges are assembled by components, and driven by size parameters and location parameters through the program. The standardization of component naming, parameters and positioning points is helpful to the writing of general program, so as to improve the efficiency of bridge modeling. The quality of component development is directly related to the depth of BIM application. The research of component library management and parameter standardization is an important work.

2.2. Content of BIM component library of bridge

Conventional bridges can be divided into three parts: superstructure, substructure and subsidiary structure according to different structural functions. The standardized family library manages related components according to this classification.

2.2.1. Superstructure. Superstructure: refers to the main bearing structure of the bridge across the valley and river. In order to speed up the construction speed and reduce the project cost, for ordinary bridges, most of them adopt the superstructure form of on-site prefabricated beam and cast-in-place construction. Among them, prefabricated simply supported beam bridge has many advantages, such as large-scale prefabrication construction in advance, fast hoisting speed, good structural stability, simple construction technology, etc., which can effectively shorten the construction period, ensure the construction quality and safety. The superstructure of conventional simply supported beam bridge mainly includes fabricated reinforced concrete hollow slab, fabricated prestressed concrete T beam and fabricated prestressed concrete small box beam: fabricated reinforced concrete hollow slab has 6m, 8m and 10m spans; fabricated prestressed concrete small box beam has 13m, 16m, 20m and 25m spans; fabricated prestressed concrete T beam generally has 25m, 30m, 40m and 50m spans. The basic requirements of superstructure family library are as follows.

(1) It contains complete geometry information of superstructure;

(2) The key dimensions of the structure should be parameterized to meet the requirements of different standard drawings and span sizes;
(3) The length of the beam, the cross slope of the beam, the angle between the head and tail of the beam end, and the cantilever of the edge beam need to be adjusted and matched according to the actual beam layout.

![Simply supported T-beam](image1)
![Simply supported small box girder](image2)
![Simply supported hollow slab](image3)

**Figure 2.** Family library superstructure

2.2.2. **Superstructure.** Substructure refers to the superstructure supporting the bridge, including piers, abutments and foundations. The piers mainly include cylindrical piers, rectangular hollow (solid) piers and hollow thin-walled piers, and the abutments mainly include pile abutment, ribbed slab abutment and gravity abutment; the dimensions of various types of abutments are closely related to span, pier height, construction technology and seismic intensity. All kinds of substructure standard family libraries are established in the substructure standard family library, including pier family library and abutment family library. Among them, the pier family library mainly includes four kinds of double column circular pier, double column rectangular pier, double column hollow thin-walled pier and single column hollow thin-walled pier, and the abutment family library mainly includes three kinds of pile column abutment, ribbed slab abutment and gravity abutment. According to the change of span, pier height and seismic intensity, a series of different pile size family types can be set for each pier and abutment family. The basic requirements of the substructure family library are as follows.

1. The key dimensions of the structure should be parameterized to meet the requirements of different standard drawings and span sizes;
2. The substructure should adapt to different cross slope setting requirements. The skew angle, back wall forward and backward, ear wall side wall longitudinal slope and other dimensions should be adjusted and matched according to the actual design parameters of the bridge.

![Rectangular cap beam double column circular pier circular pile foundation](image4)
![T-shaped cap beam double column circular pier circular pile foundation](image5)
![T-shaped cap beam double column hollow thin-wall pier square pile foundation](image6)
![T-shaped bent cap double column hollow thin-walled pier pile cap](image7)
2.2.3. **Subsidiary structure.** Auxiliary structure of bridge mainly includes bearing system, expansion joint, deck pavement, deck drainage system, anti-collision barrier, lighting system, etc. Bearing system is an important component connecting the superstructure and substructure of bridge, which transfers all kinds of loads of superstructure to piers and abutments, and can adapt to the displacement caused by live load, temperature change, concrete shrinkage and creep and other factors. Hollow slab, T-beam and small box beam generally adopt GJZ series (rectangular) and gyz series (circular) plate rubber bearing and PTFE sliding plate bearing. The dimension parameters of the bearing include transverse dimension, longitudinal dimension, diameter and thickness, which are selected according to the specific bridge span, bearing force, length of each joint and calculation value of expansion. Basic requirements of support system.

1. The bearing components need to include the bearing itself and the bearing leveling steel plate and other related accessories;
2. The key dimensions of bearings need to be parameterized;
3. The expansion joint device needs to include the expansion device itself and embedded reinforcement and other related accessories;
4. The key dimensions of expansion joint device need to be parameterized.

![Figure 3. Family library - substructure](image)

![Figure 4. Family library support system](image)

![Figure 5. Family library - expansion joint device](image)
3. Parametric bridge layout
Dynamo software is mainly used. Dynamo is a powerful and easy-to-use visual programming software developed by Autodesk company. It realizes the visualization of programming by means of node process, and enhances the operability of establishing the model of Revit.

3.1. Introduction to main nodes of dynamo Bridge
Dynamo provides a large number of built-in nodes, which can basically meet the needs of simple bridge modeling. Through the modeling analysis of a large number of bridge models, the common nodes are summarized as follows.

Table 1. Common nodes for bridge modeling

| Serial number | Node name                          | Node parameters | Parameter type   | Node usage                                      |
|---------------|-----------------------------------|-----------------|-----------------|------------------------------------------------|
| 1             | Data.ImportExcel                  | file            | var             | Read data from Excel                            |
|               |                                   | sheetName       | string          |                                                 |
|               |                                   | readAsString    | bool            |                                                 |
|               |                                   | showExcel       | bool            |                                                 |
| 2             | PolyCurve.Bypoints                | Point           | Point[          | Generating curves by connecting points          |
|               |                                   | connectLastToFirst | bool      |                                                 |
| 3             | StructuralFraming.BeamByCurve     | curve           | curve           | Create beams from curves                        |
|               |                                   | level           | level           |                                                 |
|               |                                   | structuralFraming | FamilyType   |                                                 |
| 4             | StructuralFraming.ColumnByCurve   | curve           | curve           | Create columns from curves                      |
|               |                                   | level           | level           |                                                 |
|               |                                   | structuralColumnType | FamilyType |                                                 |
| 5             | FamilyInstance.ByPoint            | familyType      | FamilyType      | Place family based on coordinate points         |
|               |                                   | Point           | Point           |                                                 |
| 6             | Element.SetParameterByName        | element         | Revit.Element   | Setting element parameters                      |
|               |                                   | parameterName   | String          |                                                 |
|               |                                   | Value           | Var             |                                                 |
| 7             | Translate                         | geometry        | Geometry        | Translate the geometry in a given direction     |
|               |                                   | direction       | Vector          |                                                 |
| 8             | Geometry.Rotate                  | geometry        | Geometry        | Rotates the specified object by a specified    |
|               |                                   | origin          | Point           | angle around the origin and axis               |
|               |                                   | axis            | Vector          |                                                 |
|               |                                   | degrees         | Double          |                                                 |

3.2. BIM modeling cases
Taking simply supported beam as an example, BIM modeling steps are as follows.
(1) Data extraction of bridge modeling. Dynamo parametric modeling supports the import of multiple data formats (such as CSV, sat and excel). Considering the convenient operation and wide application of Excel in data processing, the editor recommends the use of Excel. Before modeling, we need to extract route data from civil 3D or latitude route design files, and then extract bridge design data according to bridge design drawings.

The data to be extracted include route design line data, left and right side line data, bridge center stake number, bridge span parameters, upper and lower structure form of bridge and design parameters of each component, etc. Among them, the information of the route design line and the left and right side
lines should be extracted according to the route data, and the span information can be obtained directly from the bridge layout.

The parameters such as beam type, beam number, beam cross slope, angle between head and tail and cantilever length should be extracted from the superstructure of bridge. These parameters are mainly located in the layout of bridge type and the layout of main beam parameters in the design documents.

(2) Run the program. The modeling program is written according to the upper structure and the lower structure respectively. Except for the file read in node, the rest are edited by Python node. First, click the Browse button of the file read in node, select the parameter file import of route data, superstructure data and substructure data in turn, and then click the run button in the lower left corner of dynamo or Python node to create the bridge BIM model successfully.

(3) Running results. The program is not only suitable for conventional double span bridge modeling, but also suitable for single span bridge, staggered span bridge and skew bridge. The modeling results are shown in the figure below.

4. Conclusion
Through the good three-dimensional rendering effect of BIM Technology, the construction unit cuts the engineering object from multiple directions, fully understands the engineering design intention, shortens the time for the construction personnel to learn the drawings, and effectively controls the construction accuracy; according to the construction site conditions, the construction simulation can effectively reduce the time cost and management cost due to improper construction organization, reduce the waste of resources, and improve the quality of the enterprise. In the construction process of complex project structure, BIM Technology is used to simulate the construction method and process, control the construction progress, reduce the construction risk and ensure the construction safety. The application of BIM Technology in construction units can greatly improve the construction organization level and technical strength, enhance their own international competitiveness, and enhance the sustainable development ability of enterprises.
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