Application and Study of 3D Parameterization in Standardized Design of Sluice

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Abstract: Sluice is the most important and commonly used control building in water conservancy engineering system. In order to improve the design level of sluice and the utilization rate of social public resources, and facilitate the management of sluice project, it is necessary to carry out 3D collaborative design with Revit parametric family in the application research of sluice standardized design. The goal of design parameterization, construction standardization and management unification is expected. The common sluice project in water conservancy project is adopted as an example in this paper, and the method of building parametric sluice on Revit platform is studied, which provides a reference for the parametric engineering of the basic design industry.

1. Introduction
At present, 3D design technology is used by more and more design companies to increase the technical content of design and improve design efficiency and reduce errors and omissions in the design process and improve the quality of design products. Revit is a 3D design software developed by Autodesk company, which has a very perfect parametric design function of architecture and structure. Family parameter model plays an important role in the parametric modeling of 3D design, which provides the computable structural information of coordination, reliability, high quality and internal consistency. Parametric modeling can easily and quickly coordinate all graphic data and other data.

Sluice is the most important and commonly used control structure in water conservancy engineering system, which plays an important role in flood control, tide blocking, waterlogging removal, irrigation, waterlogging reduction and water transfer. The disunity of sluice design standards brings great difficulties to the later management and maintenance, which seriously affects the operation efficiency of sluice. In order to improve the design level of sluice and the utilization rate of social public resources, and facilitate the management of sluice project, it is necessary to carry out 3D collaborative design with Revit parametric family in the application research of sluice standardized design. The goal of design parameterization, construction standardization and management unification is expected, which provides a strong support for the social and economic development of our country.

Taking the parameterized modeling process of a small sluice as an example, the method and application of parameterized family model are studied in this paper, including parameter setting and parameterized modeling process, and then applies the created parameterized model to the project, demonstrating that it is easy to modify the design and efficient management of the project by modifying the parameters of the parameterized family model.
2. Geometric features and parameter setting
The small sluice consists of gate body section, upstream and downstream wing walls, upstream and downstream river sections, etc. The layout plan is shown in Figure 1.

![Fig.1 Structural layout plan of the sluice](image)

Parametric description of 3D solid objects is the basis of parametric modeling. After the sluice chamber structure, upstream and downstream transition section and upstream and downstream channel section are analyzed, the main parameters to be parameterized are following: Length, clear width, side pier thickness, pier wall height, bent thickness, width and height of sluice chamber structure; The width and height of the opening at both ends of the transition section; the bottom width and elevation of the river channel, slope ratio, etc.; The wing wall is cantilever retaining wall, segmented length, width and thickness of the base plate, length of the front toe, height and thickness of the front wall, etc. The above parameters and their positions are shown in Figure 2-3.

![Fig 2 Geometric parameter of sluice](image)

![Fig 3 Geometric parameter of wing wall section](image)

3. Parametric Model Creating

3.1 Problems considered during creating family
During creating family, the issue should be consider the following aspects:
1. Selectting the appropriate family template

All Revit component families (.rfa) are made beginning from the file of model template file (.rft), which defines the family added ways, such as based on the surface, based on the line, based on the wall, and some other basic settings. Family template has specific default contents, such as specific parameters, reference planes and sub-categories. Choosing appropriate family template is not only conducive to the establishment and parametric model, and determine the characteristics of the application of the family.

According to the characteristics of building, the family template of "Metric Structural Framing - Complex and Trusses.rft" is selected to start creating the family.

2. Family Category and Parameters

After choosing family template, "Family Category and Parameters" need to be setted at family editing interface. Family category determines the location of the family in the project browser and the operating characteristics of the family in the project. The family of sluice should be set as "Structural Framing". The "concrete" or "Prestressed Concrete" option should be checked for model behavior as family parameters, this option enables the family to display the proper characteristics of concrete in each view of the project.

3. the form of loading the family into a project and the insertion point

The forms of place family in the project have many changes: whether vertical, horizontal, tilt and rotation, or combination of a variety of placement forms. There are great influence to the method of create a family, improper family modeling method will increasing the steps editor and placement in the project which will affect application efficiency, what is serious the family can not normally be used in the project. General the top of the front wall of sluice is a continuous curve with the same height, so that the front wall can be inserted into the front line of endpoint as a reference point elevation.

3.2 Parameterized model building steps

After several modeling exploration, parametric building modeling process can be divided into six steps, shown in Figure 4:

![Parametric modeling flow chart](image)

3.3 Build parametric models

According to the geometric characteristics and parameter setting analysis of the proposed model, the bottom plate is obtained by solid lofting. First, the lofting path is drawn on the reference elevation working face, which is along the front of the base plate. The length of the path is dimensioned and a parameter is added to the dimension, which is the width of the base plate. Then the base plate contour is drawn, and the top corner of the base plate is drawn at the origin, which is the anchor point when the family is inserted. Parameters should be added for the dimensions that need to be parameterized as determined in Figure 1. After the path and contour are drawn, the editing mode can be exited, and then the parameterized 3D model of the bottom plate can be obtained. The pier wall can be gotten by the stretching method, and the stretching start point is the top surface of the base plate, while the stretching end point is the top of the pier wall, and parameters is set for the end point. Use the same method to model the bent frame.
In order to consider the diffusion angle of the gradient section, it is necessary to establish a parametric hollow stretching body to shear the model and form a three-dimensional model of the pier wall with diffusion angle control.

In this way, the three-dimensional parametric modeling process of the lock chamber and the transition section is completed. By changing the driving parameters, the length, width, height and thickness of each part of the lock chamber structure can be changed accordingly. The parameters and the parametric model is shown in Figure 5.

According to the geometric characteristics of cantilever retaining wall, the front wall and bottom plate are obtained by solid lofting. First, the lofting path is drawn on the reference elevation working face, which is the front line at the top of the front wall. The length of the path is dimensioned and a parameter is added to the dimension, which is the segment length of the retaining wall. Then the front wall and base slab profiles are drawn, and parameters such as thickness, height, width are added. The parameters and the parametric model is shown in Figure 6 after the model is built.

The 3D model of river slope can be created by lofting or extruding command, and corresponding parameters need be added to the profile and path.

4. Testing and Application of the parametric model
A new project is created and the parametric lock chamber, transition section, slope and wing wall are loaded into the project. In the project drawing environment, a new section is created and the view mode should be set to fine. The plan and section are marked in line with the custom of Cooperative Drawing and industry standard. The visual style of the 3D view is set to realistic with borders. A new sheet is created, and the plan view, section view and 3D view in the project are loaded into the sheet. The appropriate scale should be set. The plan view, section view and 3D view sheet are shown Figure 7-8).
Fig. 7 Layout plan of sluice

Fig. 8 Sectional drawing of sluice structure and model
In order to test whether the parameterization of the model can operate correctly, the elevation of the bottom plate surface is changed from -0.5m to 0.5m, the height of the pier wall is adjusted from 5.0m to 5.5m, the clear width of the gate hole is adjusted from 5.0m to 4.0m, the length of the gate body is adjusted from 8.5m to 8.0m, and the height of the wing wall and the width of the bottom plate are increased by 0.5cm respectively. After a series of modifications, we can directly obtain plane and sectional drawings of various types of scales (see Figure 9-10). It can be seen that the parameterized model has a good adaptability.

5. Conclusion
All elements in Autodesk Revit project is based on the family, and create a parameterized family is the basis of three-dimensional parametric design, which determines the quality and efficiency of three-dimensional design of the project, so the master of the family is very important to create a parameter, so it is very important to predominated the way of creating parametric family. The common sluice project in water conservancy project is studied as an example, and the establishment method and application of parametric model on the Revit platform are studied. All these were done to provide a reference for the 3D collaborative design and building parametric model in the engineering design.
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Reference
[1] GhangL, RafaelS, CharlesME. Specifying parametric building object behavior (BOB) for building information modeling system. Automation in Construction, 2006, 15(6): 758-776.
[2] Huan Guosheng, Wang Haijun, Shen Guohua. Comparison and application of 3D information model technology platform in water conservancy engineering [J]. Jiangsu water conservancy, 2015 (01): 41-43.
[3] LI Yuwei, ZHANG Haili, WEI Hui, et al. Application of 3D reinforcement technology in Jiepai hub. Jiangsu Water Resources [J]. 2018(7), 39-43.
[4] ZUO Weilong, LV Dawei. Study on Parametric 3D Design of Butressed Retaining Wall Based on Autodesk Revit. Jiangsu Water Resources [J]. 2019(6): 52-55.