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Research and Application of the Whole Process Parametric Design of Radial Gate

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Introduction

The structural drawing is generally based on the two-dimensional CAD (Computer Aided Drawing) method. The disadvantages of this design method are:

1) The plane system method is used to analyze gate structure with spatial effect, which simplifies too much, and the calculation results are inaccurate, and there are certain safety risks, especially for large or ultra-large gate structures;

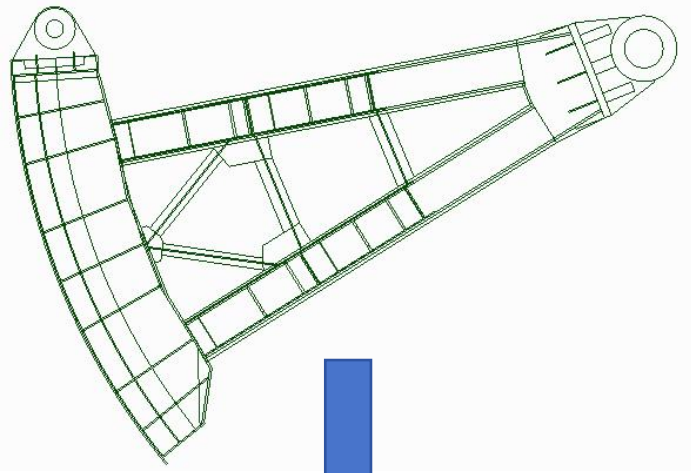
2) Designers generally use experience to replace the whole structure by calculating the local components. The structural design is unreasonable and uncoordinated, and it is difficult to achieve the reasonable layout of the whole structure;

3) The manual line-by-line drawing method is inefficient, the modification workload is large after the design conditions are slightly changed, and it is easy to make mistakes and not easy to find;

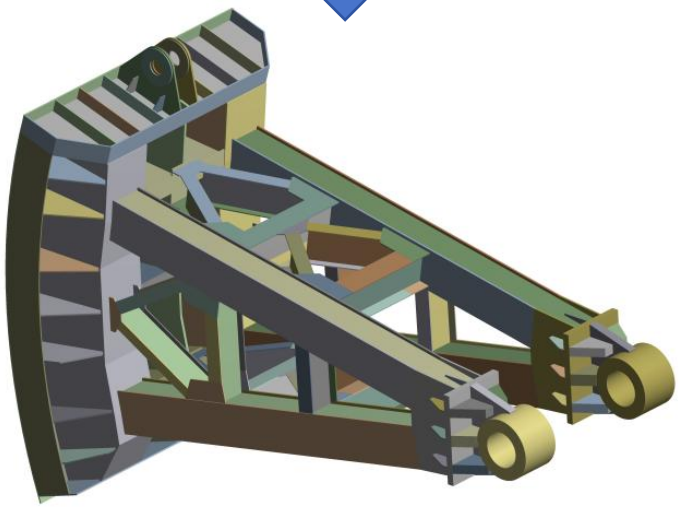
4) Structural design and structural drawing are independent of each other, and the information between them cannot be directly transmitted and fed back;

5) The quantities of the gate structure are required at different stages of the project, and it is inefficient and inaccurate to count the quantities one by one.

2D Design



3D Design



Parametric design framework of radial gate

The 3D parameterized geometric model of the radial gate is directly established by using the Workbench preprocessing platform SCDM (Space Claim Direct Modeler, short for SCDM). SCDM is a modeling method that edits the structure topology based on the direct modeling idea. It can directly build the 3D model and 2D engineering view. The 3D model has the characteristics of intuitive representation, realistic scene response, and high degree of visualization, It is convenient for professional communication and manufacturers to truly understand the design intent of designers.

The radial gate with reasonable structure should ensure that the overall structure layout of the gate is reasonable and the structure size is appropriate. The whole process parametric design process of radial gate is shown in figure 1.

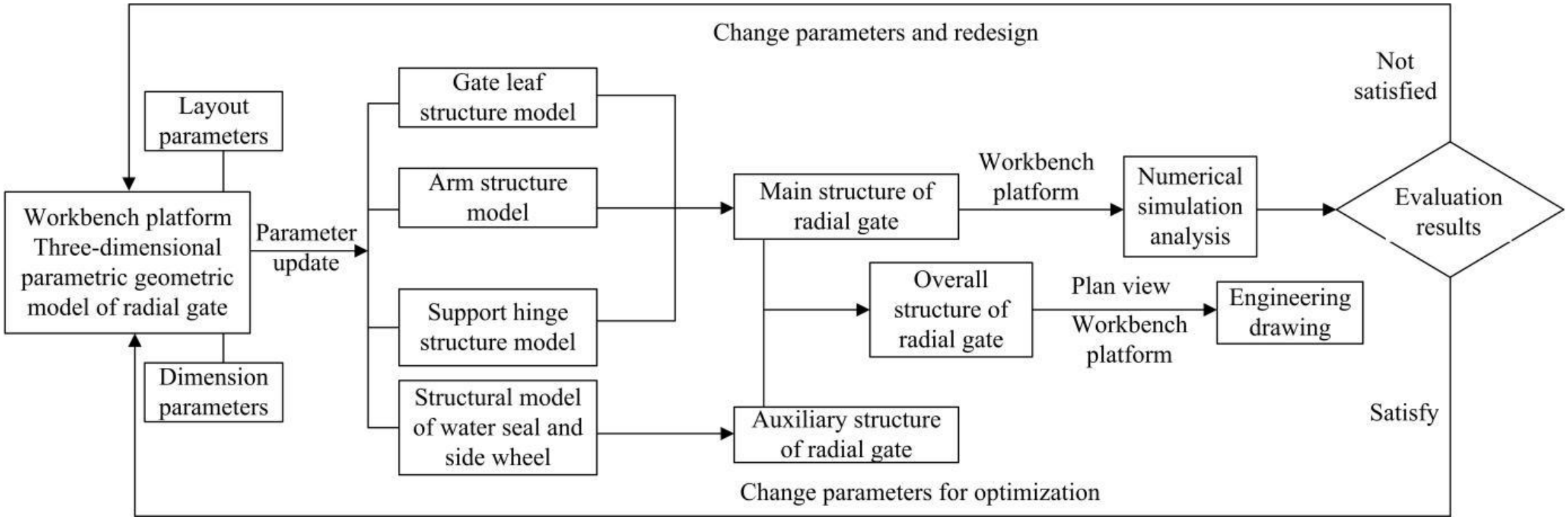


Figure 1. Whole process parametric design of radial gate

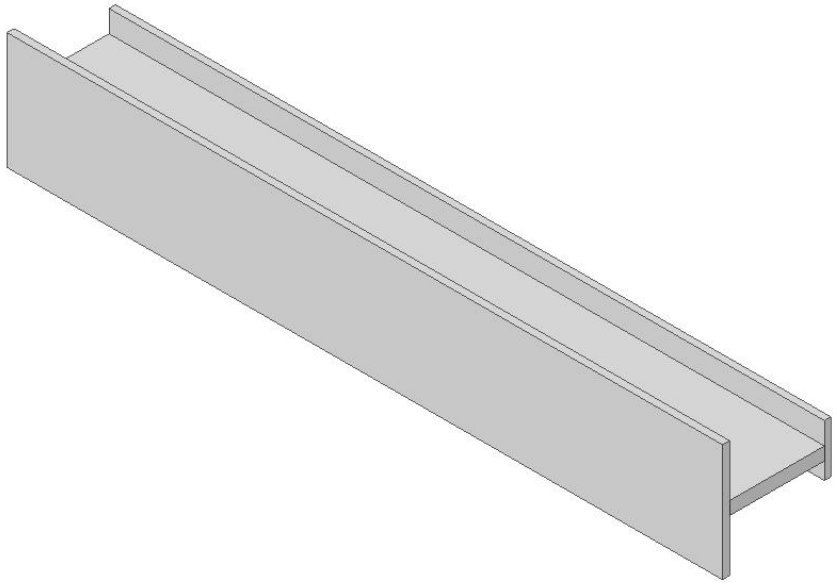
Three-dimensional parametric geometric modeling of Radial Gate

Taking the beam structure commonly used in the gate structure as an example, the basic idea of using SCDM to establish the three-dimensional parametric model of the structure is explained. The specific process is as follows:

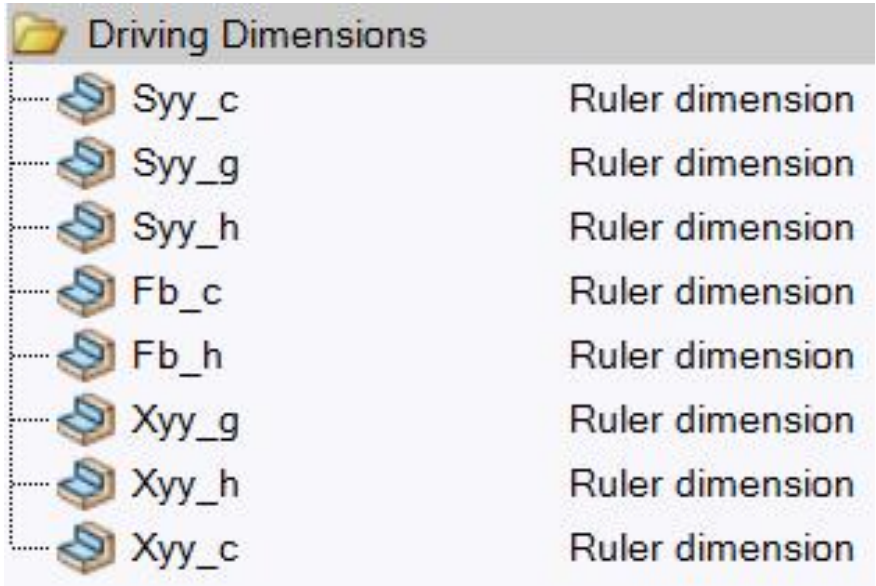
1) Establish the three-dimensional geometric model of the beam structure (see figure 2a);

2) Parameterize the flange plate and web of the beam structure (see figure 2b);

3) The 3D parametric beam structure generates a 2D parametric drawing (see figure 2), and the 3D geometric model is associated with the 2D drawing, that is, the 2D drawing can be directly driven by modifying the parameters of the 3D beam structure model. In figure 2, the upper flange plate length (Syy_c), the upper flange plate height (Syy_g), the upper flange plate thickness (Syy_h), the web plate length (Fb_c), the web plate thickness (Fb_h), the lower flange plate length (Xyy_c), the lower flange plate height (Xyy_g) and the lower flange plate thickness (Xyy_h) are parameterized, and each parameter is independent of each other. Different beam structure models can be obtained by changing the parameters.



(a) Three-dimensional parametric geometric model of beam structure



(b) Parameterization of geometric dimensions of beam structure

Figure 2. Three-dimensional parametric model of beam structure

Three-dimensional parametric geometric modeling of Radial Gate

In order to more intuitively represent the dimensional parameters of gate structure, the 2D model drawings of the main components such as the panel (figure 3), the top beam (figure 4), the main beam (figure 5)are given respectively.

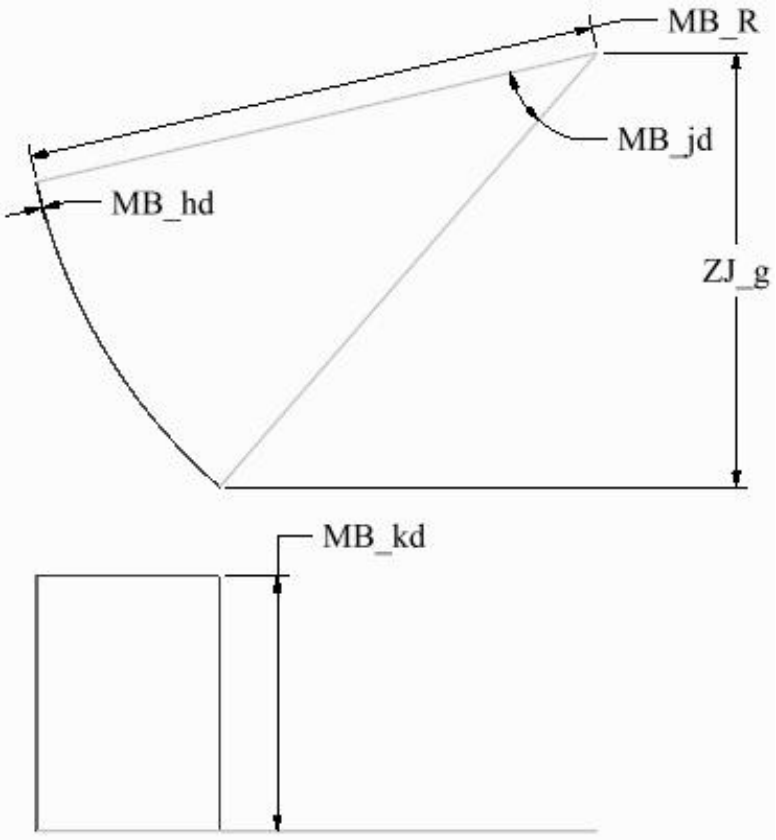


Figure 3. Parametric geometric model of panel structure

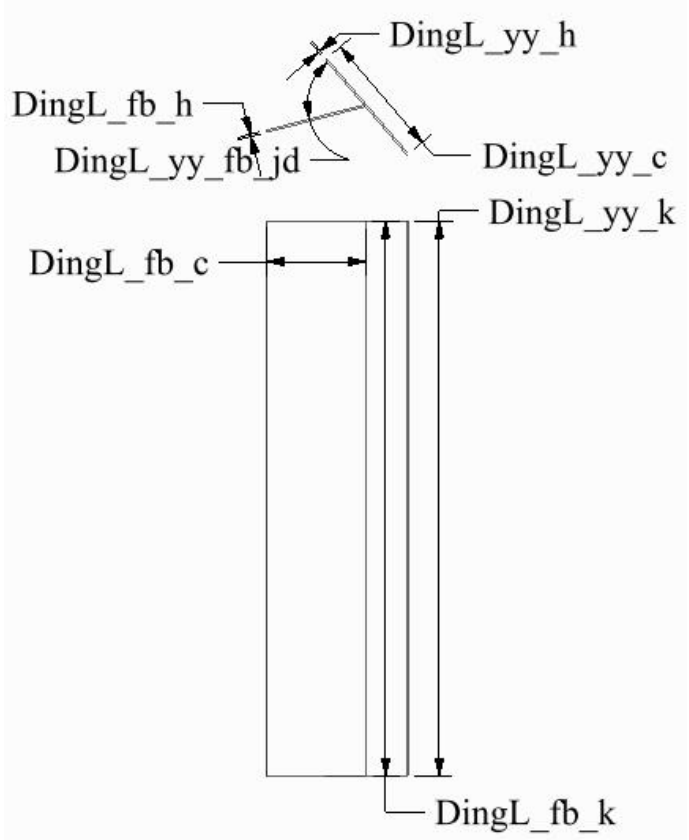


Figure 4. Parametric geometric model of top beam structure

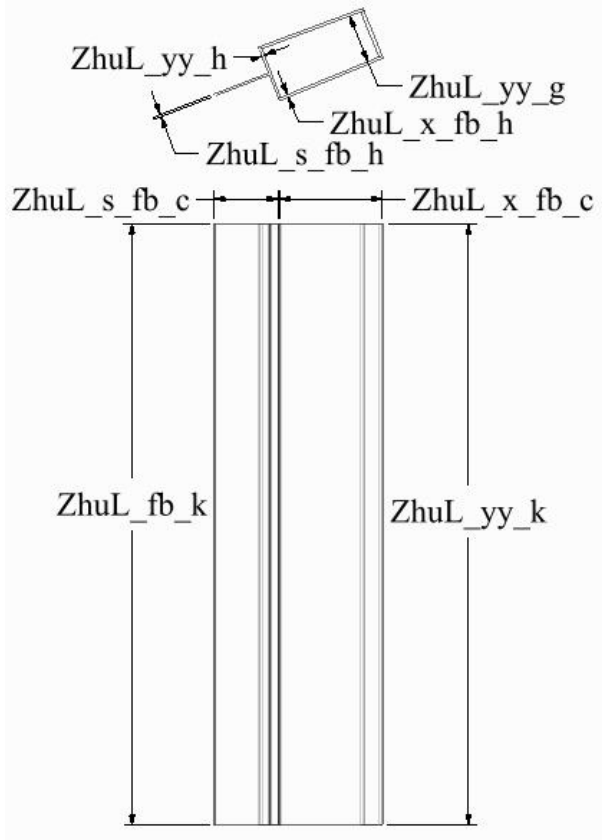
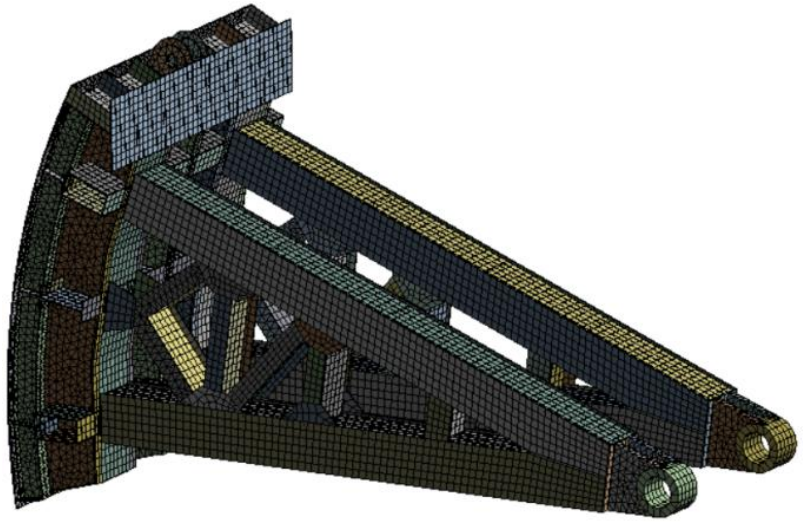


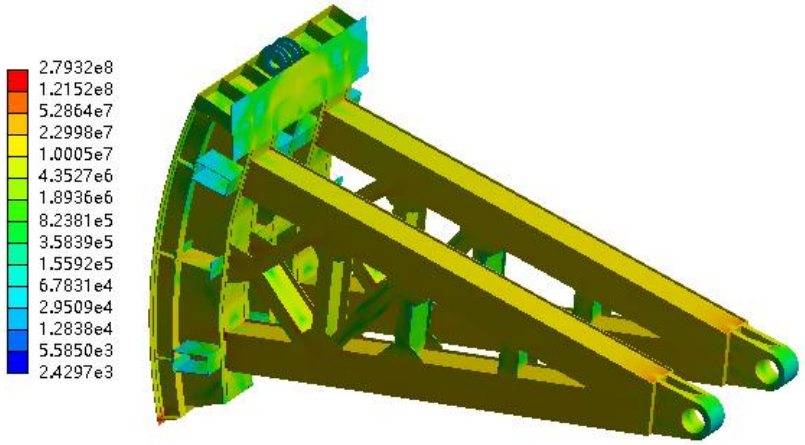
Figure 5. Parametric geometric model of main beam structure

Structural Analysis of Radial Gate

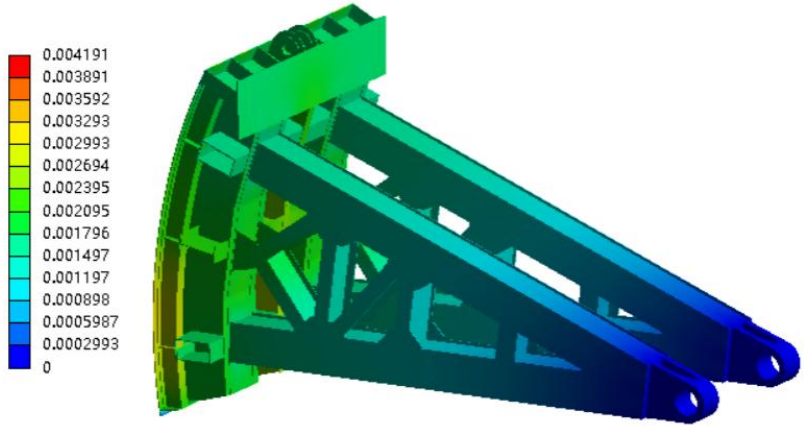
According to the relevant principles of structural analysis of radial gates and engineering experience, taking a radial gate of a project as an example, the SCDM is used to establish a three-dimensional parametric geometric model, and the Workbench platform is used to directly import the three-dimensional parametric geometric model into the structural analysis module for mesh division, constraint and load application, and result analysis. Limited to the length of the article, only the mesh division results (figure 6a), equivalent stress results (figure 6b) and structural deformation results (figure 6c) are given.



(a) Finite element model (elements 263316, nodes 838862)



(b) Result of equivalent stress (Pa)

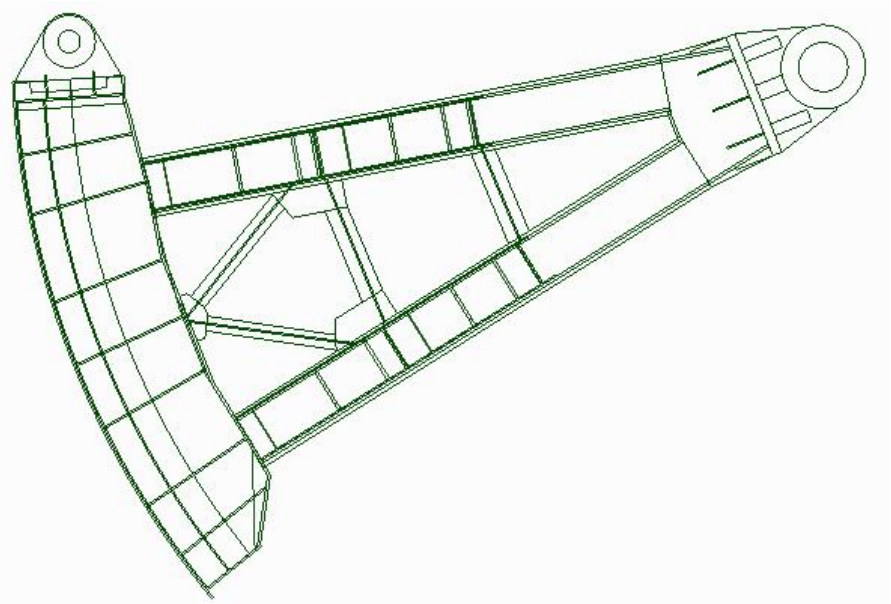


(c) Deformation result (m)

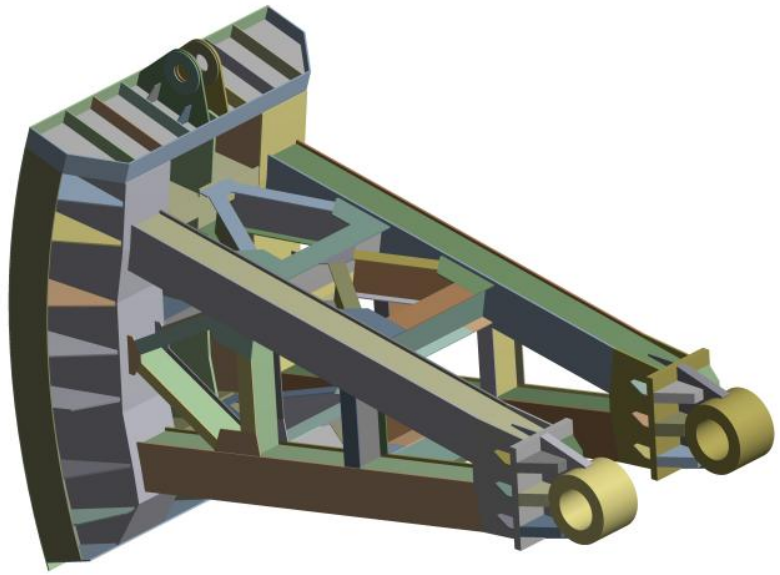
Figure 6. Finite element model and analysis results of radial gate

Application in Practical Engineering

The proposed three-dimensional parametric design method for the whole process of radial gate is applied in practical engineering. Bottom outlet discharge gate of a water conservancy project (5.0×6.0-80.1, Width×High-Water head, m), the weight of the radial gate (see figure 7a) directly obtained in the feasibility study stage is 77.4 t, the overall structure of the radial gate is directly analyzed in the preliminary design stage, and the three-dimensional model (see figure 7a) and two-dimensional engineering drawing of the radial gate structure of the manufacturer can be directly delivered in the construction drawing stage (see figure 7b, limited to space, only two-dimensional front view). The structure of the radial gate produced by the processing manufacturer is shown in figure 7c.



(b) 2D delivery front view of radial gate



(a) 3D delivery model of radial gate

(c) Processing and manufacturing structure of radial gate

Figure 7. Model and engineering structure of radial gate

Conclusions

The three-dimensional parametric design and application of whole process of the radial gate in hydraulic metal structure are systematically studied, and its feasibility, efficiency and practicability have been verified by projects. The main conclusions are as follows:

- A three-dimensional parametric design method for the whole process of radial gate is proposed. The successful application of this method provides a reference for the whole process parametric design of hydraulic metal structures.
- A complete and efficient digital design process of radial gate has been developed, which deepens the digital application of gate structure, reduces the repetitive workload caused by design changes in the design process, and lays a foundation for the optimization of gate structure layout and size.
- Three-dimensional parametric design of the whole process of the gate makes the radial gate structure transition from plane design to space design. The design process is more intuitive and visual, improves the quality and efficiency of the design, and creates conditions for the informatization, intelligence and assembly design of the gate structure in the future.

Acknowledgement

Thanks for the Supported of the first-class scientific research project of Yellow River Design Company (Grant NO.2023KY012)