3D Design of Gravity Dam Based on Virtual Reality CAD Dynamic Interactive System

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Abstract. The virtual reality technology is applied to the dynamic graphic simulation of gravity dam construction in the CAD dynamic interactive system, and the efficient graphics rendering engine is adopted to describe the complex construction process with realistic THREE-DIMENSIONAL animation, showing the virtual construction scene with realistic sense and real-time interaction. It provides a quick way to fully master the complex CAD dynamic interaction system gravity dam construction process and greatly improves the modern level of construction organization and design of gravity dam with CAD dynamic interaction system. A three-dimensional design system of gravity dam which can dynamically interact with CAD is developed by means of limit state design method. The system realizes the three-dimensional parametric modeling of gravity dam through the secondary development of auto-CAD, and adopts the modeling method of two-dimensional graphics to restore the three-dimensional model, so that any type of dam can be modeled quickly and accurately. The structure calculation of the three-dimensional model is carried out, and the design and calculation are closely combined. Through dynamic interaction, the calculation of a large number of complex data is simplified, so as to achieve the purpose of accurate and fast section design. It has been proved by practice that the system greatly improves the efficiency of section design and has strong practicability, which is of great significance to the scheme comparison and selection in the feasibility stage.

Keywords: Gravity dam; Section design: 3D modeling; Virtual reality; CAD dynamic interactive system
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1 INTRODUCTION

At present, the design of gravity dam is still in the stage of two-dimensional level, but the original impulse of people in the design is three-dimensional, and the design result is a three-dimensional entity with related concepts such as color, shape, material, size, position and complex motion relationship [1]. At present, the design work in the hydropower industry is a process from 3D to 2D and then from 2D to 3D, which puts forward certain requirements for design engineers and construction workers: A) Designers abstract the original 3D design concepts and ideas into related three-dimensional plane views and display them in the form of two-dimensional plan. This design method is often difficult to fully express the designer's original design idea, prone to errors and omissions; B) The construction can only be carried out when the construction workers imagine the plane information as a three-dimensional form. Differences in expression and understanding between the designer and the construction workers often lead to errors. And 3D design can completely avoid the cumbersome process of 3D. According to the concept of 3D design, the output of 3D design results can be very intuitive and complete to express the designer's ideas. Only three-dimensional design can complete the unity of thinking process and design process, is the real sense of CAD, so three-dimensional design is the inevitable trend of water conservancy and hydropower engineering design.

In order to improve the level of 3D gravity dam design, a CAD dynamic interactive system for 3D gravity dam design based on virtual reality is proposed. Gravity dam with virtual reality technology for CAD and dynamic interaction system provide a new environment for construction design, management, the user can from one point of view, using the computer to browse the generated virtual scene construction and interaction, so as to explore new management methods and theories, to the construction of the project management review, It provides a demonstration and demonstration platform for novel design schemes, which plays a positive role in improving the level of project management, enhancing the competitiveness of enterprises and promoting the development of construction technology. This system is based on AutoCAD, which is the most familiar to engineering designers, and the secondary development of CAD is carried out with VB 6.0 programming language. It focuses on the dynamic data interaction between the system and CAD, reduces the human input of calculation parameters in the calculation process, and uses the dynamic interaction function to realize the calculation profile information and calculation.

2 RELATED STUDIES

In VR systems, virtual environment generating devices are mostly composed of one or more sets, which can be divided into three categories: virtual reality system based on high-performance generation, high-performance graphics workstation and distributed heterogeneous computer [2]. The latter two types are used for large-scale and complex immersive VR systems, while the VR systems based on the generation machine are usually called desk-based VR systems. In order to generate and display 3D high-realistic scenes, the so-called high-performance graphics with graphics accelerator and multi-graphics output functions are usually adopted [3]. Application, this article uses the desktop virtual reality system based on OGRE, and to the object graphics rendering engine) simulator virtual reality simulation system, the system simulation model of operation process of observation and statistics, to master the basic characteristic of the system model, find out the best parameters of the simulation system, the implementation of improvement or optimization of the real system design.

Simple 3D modeling software has a lot of, such as Chlebus introduced the parametric modeling technology based on AutoCAD platform [4], quickly and accurately realize the gravity dam 3D modeling, but this method is based on several typical dam section, the general is not strong, and the model can only be used for landscape, does not have attribute function, can't be edited and query. The emergence of 3D GIS (Three-dimensional Geographic Information System) provides a new way to solve this problem, because in this platform, the model not only has the function of display, but also can realize dynamic display, data analysis and so on.

At present, the technology of 3D modeling using GIS platform has become mature gradually, and some achievements have been made. Zheng and Hao [5] proposed terrain modeling is completed on the GIS platform, and three-dimensional terrain visualization is realized. Chen et al. [6] believed that modeling is carried out by citing third-party design software, and three-dimensional model modeling is realized on the GIS platform after format transformation. Many scholars have also done much research and development on three-dimensional modeling of gravity DAMS based on GIS platform. Sun and Ren [7] made an in-depth study on the three-dimensional visual modeling technology of large-scale water conservancy and hydropower engineering buildings, proposed object-oriented technology and structured modeling method, and studied the GIS-based three-dimensional visual graphic simulation method and application of water conservancy and hydropower engineering. Lin and Li [8] proposed a three-dimensional model construction method for DAMS based on perspective projection, which provided a new idea for the three-dimensional model construction of gravity DAMS. Wang and Liu [9] proposed a 3D gravity dam modeling method based on AutoCAD and ArcGIS Engine, which was modeled in AutoCAD in the form of 3D multi-section line frame, and then converted into THE Multipath format recognized by GIS, overcoming the connection defect between CAD data and GIS data. But this method has some limitations because the wireframe model could not carry out Boolean operation.

2.1 Construction Simulation Model of Gravity Dam Based on Virtual Reality CAD Dynamic Interactive System

The CAD dynamic interactive system gravity dam construction system can be decomposed into subsystems of various levels, including the construction subsystem of the main engineering such as gravity dam, the construction subsystem of temporary water retaining and discharging buildings such as cofferdam and diversion tunnel, and the subsystem of constantly changing water flow [10]. The subsystem models of each level are combined into the system model according to the specific relationship. See Figure 1.

As shown in Figure 1, because OGRE is able to deal with spatial topological relationships between objects distributed in different locations in a geographic space, each building entity can be modeled separately and then transformed into a unified virtual environment spatial coordinate system. The sub-models are coordinated in the virtual engineering environment with the same terrain background to form an ordered construction system at the macro level. At the same time, the geometric information of each building entity Object is connected with its attribute information through its ID, so that the mapping relationship between the geometric elements in the virtual space and each simulation entity can be established. The state changes of the simulation system will be transmitted to the OGRE system through inter-process communication and reflected. Similarly, the interactive operation of the natural form of geometric elements in the virtual space can change various boundary conditions and parameters in the construction process.

2.2 CAD Dynamic Interactive System Based on 3D Design

The system includes three modules: pre-processing, calculation and post-processing. The pre-treatment module realizes the establishment and timely preview of the dam three-dimensional model; Calculation module to achieve the design of the dam body shape calculation; The post processing module can output the 3D engineering drawing and generate the calculation report automatically. The detailed overall design structure of the system is shown in Figure 2.

In the construction system of gravity dam, the static entity model includes auxiliary engineering building, living house, geomantic electricity supply system and mixing building. The shape of the static model only affects the visual effect and can meet the requirements with a certain accuracy. For the establishment of static entity model, 3D model can be directly established through modeling tools such as AutoCAD, 3DS Max and so on, and then imported into

OGRE for processing, and the mapping relationship between the simulation entity and its ID can be established, so that in the process of visual interaction design, the platform based on OGRE can be used.

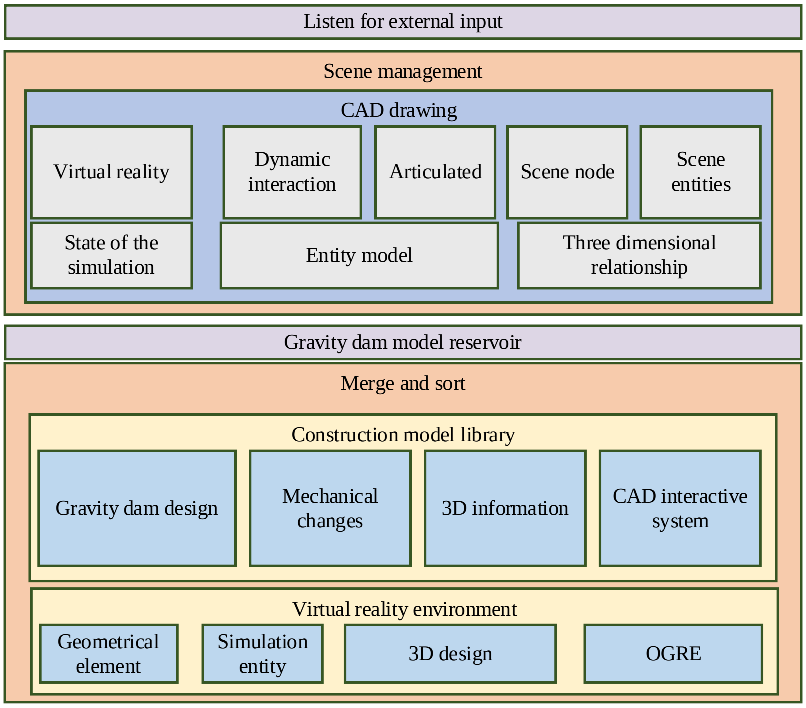

Figure 1: Rendering system working mode.

The model is moved, scaled, rotated and added to reduce, so as to change its spatial coordinates and dimensions to change the boundary conditions for simulation, to achieve the optimal design of the port. For example, in the process of dynamic construction demonstration, a mixing building or a pouring machine can be added to the scene to change the corresponding parameters in the simulation, that is, the boundary conditions of the simulation can be changed.

Dynamic solid model refers to the model established according to the simulation content, namely the dam model. CAD dynamic interactive system for gravity dam construction has many types of work, large quantities, complex construction relations and many control factors. In order to determine the optimal construction scheme, it is often necessary to modify some control conditions of construction simulation calculation. If different pouring methods (through silo pouring or column pouring) and different construction machinery (cable machine, belt machine, gate tower machine, dump truck) are adopted, the simulation results will change dynamically. How to build a dam model that can reflect the dynamic spatiotemporal information of gravity dam construction process is the basis of virtual reality technology in the simulation of gravity dam construction process.

Parametric digital modeling is a technique to represent geometric and topological information of objects by a series of data organization structures controlled by parameters. Because only the description of dam geometry is emphasized in the 3D dynamic demonstration of dam casting in CAD dynamic interactive system, the 3D data structure of dam can be described by the representation based on the slice structure and the boundary, that is, the solid dam block can be expressed as several curved bodies enclosed. At the same time, in order to reflect the dynamic process of dam construction, the data structure should not only describe the geometric characteristics and attributes, but also reflect the time characteristics.

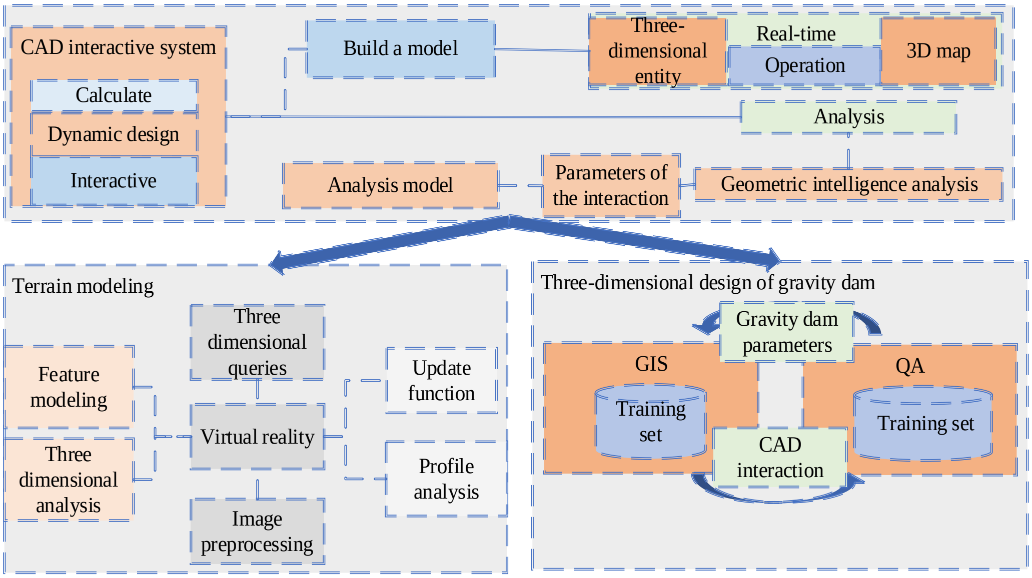

Figure 2: Overall structure of CAD dynamic interactive system based on three-dimensional design of gravity dam.

Each will first dam section as composed of many casting block () is controlled by the simulation results, each casting piece formed by multiple, then each dam section of the attribute data (including geometry size, slope, control point position, boundaries, etc.), set up the database and the attribute data according to certain logical order in the library. According to these properties, dam body features to create a parametric equation and the corresponding time and a description of the kind, encapsulation defined parameters, using the OGRE's own graphics programming language program, generated by the simulation results and call the attribute data real-time calculation, drawing, and then will be formed by casting piece, composed of casting pieces of each dam section again, This allows a three-dimensional simulation model of the dam to be drawn. Finally, the drawn model is stored in the model library and called directly from the model library when used.

2.3 3D Design and Simulation of Gravity Dam in CAD Dynamic Interactive System Based on Virtual Reality Technology

The three-dimensional dynamic demonstration of the three-dimensional gravity dam casting appearance of the virtual CAD dynamic interaction system is the reproduction of the dam casting simulation appearance at any time, it shows the actual situation of the three-dimensional gravity dam construction of the CAD dynamic interaction system, namely the dynamic process of the dam block casting. It reflects the dynamic change process of the data field inside the simulation system, which is shown on the computer screen: the pouring dam block graph is formed, jumps into the next warehouse, forms the next pouring dam block graph, then jumps into the next, so the reciprocating cycle begins to go on, producing a continuous animation process.

In the dynamic 3D environment, 3D virtual sound can be parallel with vision, so that users can get more information from the virtual environment with both visual and auditory feelings, so as to enhance the sense of immersion and interaction. This paper uses Direct3D Sound to realize, it can simulate 3D positioning effect, including effect, etc. After obtaining the format and data size of the sound file, establish a buffer, load the sound resources, establish a sound source, and then assign each sound source to the voice in the scene, such as machinery, so as to control the 3D sound, create a realistic virtual environment sound.

Dynamic interaction in virtual CAD system of the gravity dam 3 d gravity dam construction process, we often need to query some information of object, because in the modeling of the virtual scene space geometric form and its corresponding property one-to-one correspondence, so the dynamic interaction in virtual CAD system of the gravity dam 3 d gravity casting process, It can easily query the object information by 3D visualization. The so-called two-way query is to click any point on the screen with the mouse, then the corresponding property information can pop up with the point; or query a record in the model database to get the corresponding geometric shape in the model. However, since there is no unique correspondence between the image points on the screen and the three-dimensional space, the core problem to be solved is the intersection operation between the line of sight and the object in order to ensure the uniqueness of the query object. We use the typical ray point fetching method. Firstly, the picking direction is determined. Usually, the direction M of the current camera is taken to obtain the set P of all entity objects in this direction and the set D of the distance between the entity objects and the camera. In (D), the corresponding result of the picking is obtained, so that the visible points on the screen captured by the mouse are in one-to-one correspondence with the spatial points of the actual model.

A three-dimensional gravity dam of a rolling CAD dynamic interaction system has a crest height of 1428m, a maximum height of 165m and a crest length of 64m. The dam is divided into 21 dam sections, from left to right are CAD dynamic interaction system gravity dam three-dimensional key way section, left bank non-spillway section, riverbed section, left bank sand flushing bottom hole section, power station inlet section, right bank flood discharge (sand flushing) bottom hole section, right bank spillway section and right bank non-spillway section. The non-spill-dam section has a crest width of 13m. The upper and lower reaches of the dam are the three dimensional impermeable layers of the gravity dam with the abnormal CAD dynamic interaction system, and the middle part is the three dimensional gravity dam with the rolling CAD dynamic interaction system. The three-dimensional gravity dam quantity of dam CAD dynamic interaction system is 3.34 million, among which, the three-dimensional gravity dam of normal CAD dynamic interaction system is 770,000 m, and the three-dimensional gravity dam of flying roller CAD dynamic interaction system is 257m. According to the results of simulation calculation, the total pouring period of the dam is 39 months. The characteristics of the dam project are as follows: CAD dynamic interactive system of gravity dam three-dimensional categories; Pouring scheme; The actual use of pouring machinery; Large construction interference. On the premise of effective graphics kernel and established the dynamic interaction of the whole dam CAD system of the gravity dam during the process of the casting process in real-time 3 d simulation animation, and added in the virtual scene skybox plants and trees, construction machinery and other entities, for a variety of simple natural scenery such as the dynamic simulation of upstream and downstream water level change, simulated 3 d sound effects, etc., To achieve a realistic hydropower construction scene, users can roam freely in the virtual scene and fully understand the construction condition. In addition, three-dimensional visual information management and visual query are realized in the virtual scene, as shown in Figure 3.

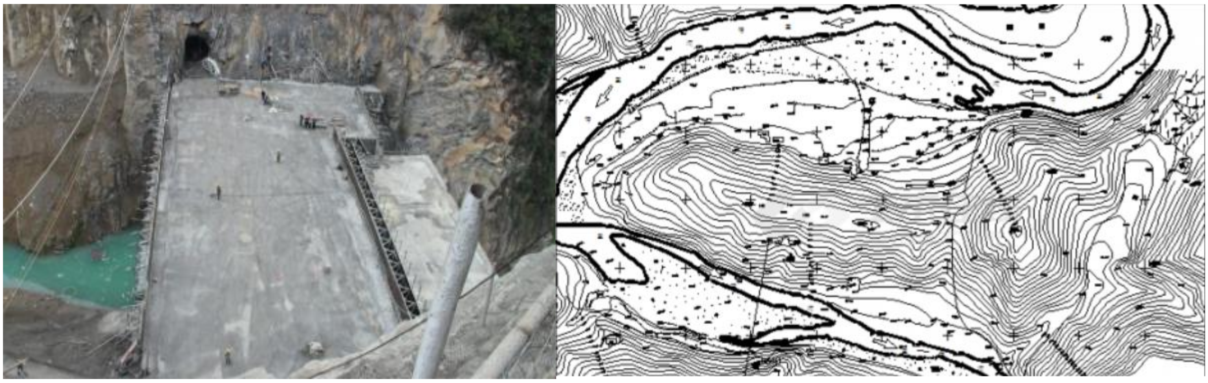

Figure 3: Virtual scene screenshot of three-dimensional gravity dam project construction of a rolling CAD dynamic interactive system.

3 ANALYSIS OF RESULTS

The maximum height of the dam body is 202.0 m, the width of the dam section is 20 m, the length of the dam foundation is 163.35 m, the width of the dam crest is 16m, the upstream break slope is 78. The backward arc Angle is 35.280, and the downstream slope is 1:0.75.

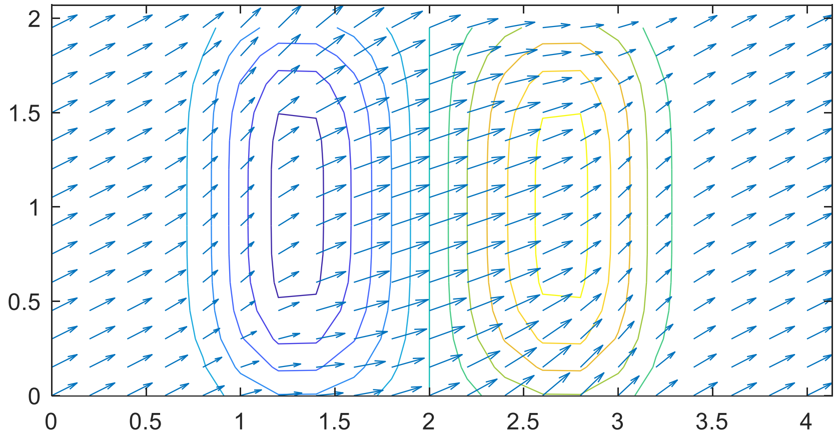

Figure 4: Screenshot of CAD distribution of calculated load.

In Figure. 4, the triangular filling represents the water pressure distribution on the upper and downstream sides respectively. Four squares represent uplift pressure distribution; Parallel line filling indicates the distribution of sediment pressure on the upstream side. As can be seen from the CAD diagram, all loads area closed surface area, and the system uses area and area through dynamic interaction. The Entroid property function returns the coordinate values of its area and centroid, which can be calculated after simple decomposition. The horizontal line in Figure 4 is the dividing line of horizontal strip before the solution of the mode decomposition method. The geometric information of each dividing line is required when the seismic load is calculated with this method. Through dynamic interaction, the system returns the coordinates of several intersection points of each dividing line and the contour line of the dam body from CAD, according to which all the calculated data can be obtained conveniently, which shows a great advantage over other methods.

The discharge process of dam-break flood is shown in Figure 5.

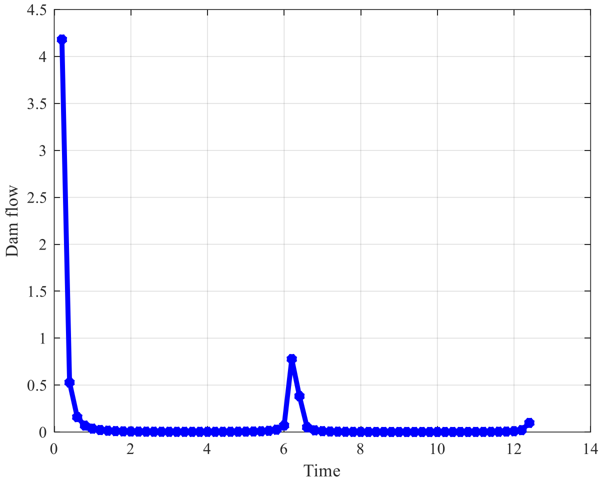

Figure 5: Discharge process of gravity dam break flood.

The peak discharge was 196.71m /s and the peak arrival time was 0.95 hours. This flow process line can be used as the boundary condition of MIKE21 to provide data basis for flood evolution.

The change of submerged area and water depth over time within the basin is shown in Figure 6.

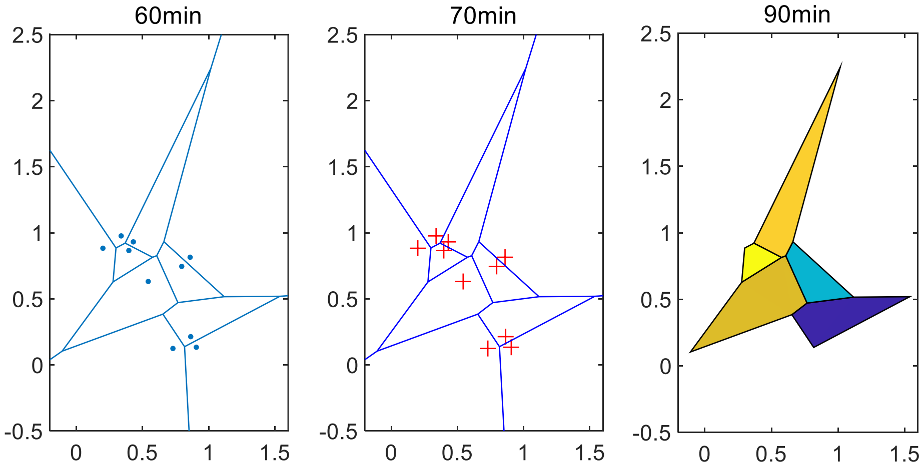

Figure 6: MIKE21 shows the change of submerged area and water depth with time.

The output of MIKE21 is not intuitive, and you cannot view the specific geographical location of the flood. The results of NBKE21 can be processed into SHP files of Arcgis platform. Combined with the ortho projection obtained by aerial photography, the flood evolution process can be visually observed.

The calculation results show that the sliding stability structure coefficient of the foundation surface is 0.960 and the sliding stability structure coefficient of the deep layer is 0.935, both of which are greater than the allowable value of 0.65. Figure 7 shows CAD screenshots of the most dangerous sliding surface combination automatically searched by the system.

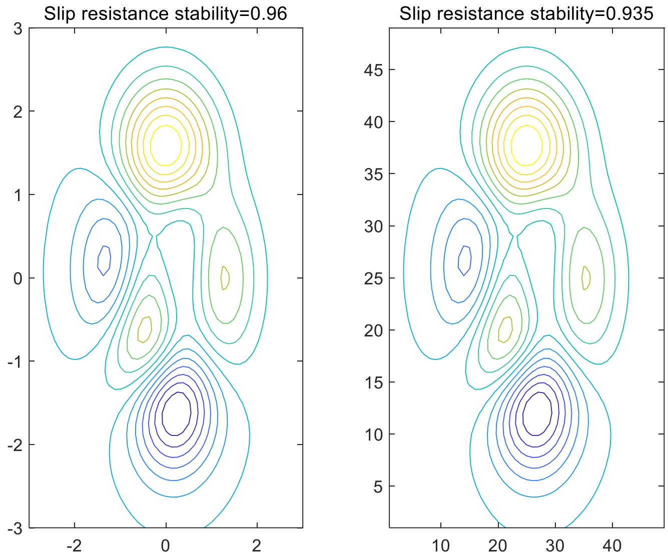

Figure 7: CAD display of the most dangerous sliding surface combination.

Through dynamic interaction, it can automatically extract and identify the contour line of the section from the three-dimensional solid model of the dam body, and avoid the input of a large number of tedious geometric data. By mapping the model elevation and the real elevation, it can calculate various external loads conveniently and quickly, and can query and display instantly. The calculation results are displayed dynamically in CAD, which is not only easy to use and good interaction, but also high in calculation accuracy, which greatly improves the design level and efficiency of gravity dam, and has strong generalization. Based on virtual reality simulation technologies such as 3D MAX and realflow, accurate three-dimensional ground models, urban streets and buildings are integrated to reproduce the field situation of warps. In the virtual warping dam scene, the warping dam break process is simulated, which shows the development of the burst, the collapse of the slope and the evolution of the outburst flood.

4 CONCLUSION

In this paper, the virtual reality technology is applied to the dynamic simulation of gravity dam casting of CAD dynamic interactive system. Based on AUTOCAD 2004. 3DS M AX 5.0 and graphics rendering engine, a 3D visualization simulation model of dam casting of CAD dynamic interactive system is established, so that the decision makers can quickly and directly grasp the construction status of the project. It laid a foundation for optimizing the construction design of the project. Based on the 3D design method, 3D parametric solid modeling technology can be used to quickly establish the 3D solid model of gravity dam body, and meet the needs of each design stage, provide designers with an intuitive design result, and greatly enhance the degree of visualization of design. The section design of gravity dam can be realized quickly by the three-dimensional parametric design, and the rapid comparison and selection of many schemes can be realized by the dynamic interactive calculation system, which provides convenience for designers. The dynamic interaction function is used to realize the effective combination of design and calculation system. The human intervention of a large number of complex data is reduced by the dynamic interaction function. The purpose of completing the section design quickly and intelligently is achieved by the dynamic interaction between the calculation results and section information, so that the designers can improve their work efficiency.

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