Research on the Virtual Geological Applications Based on Three-Dimensional Modeling Method

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Abstract. In order to carry out the research program of geotechnical engineering investigation application based on three-dimensional modeling methods, and to deeply explore the application of aboveground and underground structures construction and integrated fusion and integration methods in engineering geology, geotechnical engineering investigation and other engineering construction stages, the ground surface model, aboveground structures model, and three-dimensional engineering geology model of the example project were constructed and integrated by using the method of combining multiple modeling techniques with a variety of model elements and The virtual geological applications such as virtual foot survey, pit excavation, engineering quantity statistics, virtual roaming numerical simulation and analysis based on the resultant model of the model were carried out. The results show that the construction of the 3D model can effectively carry out the virtual application based on geology, provide geological support for the optimization of engineering design and dynamic simulation in the construction stage, and has important practical application value.

Keywords: 3D modeling, engineering geology, virtual geology applications, geotechnical investigation

1 Introduction

The birth and development of geographic information technology has already played an important role in data analysis, knowledge management and decision-making assistance in many fields, such as urban planning, land management, environmental protection and public safety. With the rapid development of Internet technology, geographic information technology has gradually shifted to three-dimensional and has been rapidly and widely applied in various industries.

At the same time, three-dimensional modeling theory has gradually begun to improve, three-dimensional modeling methods toward integration, a large number of three-dimensional modeling and visualization software began to appear, and a large number of scholars in China also began to devote themselves to the study of three-

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dimensional geologic modeling and visualization[1-6]. The main direction of the study is in the application of 3D model visualization, application of engineering quantity, application of BIM platform engineering survey and application of survey information system [7-9]. On this basis, 3D collaborative design of various specialties based on 3D geological models was carried out in China at an early stage and has mature applications[10]. On the basis of the spatial information of strata, structures, etc., which contains the traditional engineering 3D geological model, the geotechnical investigation information model is constructed by combining the geotechnical characteristic indexes, bearing capacity, strength, deformation, and hydrological parameters obtained from geotechnical engineering investigation, so as to provide coordinated and internally consistent information for carrying out calculations for engineering design, construction, and operation, and to realize the geotechnical engineering foundation pit support modeling, base elevation information query, etc. Function.

This paper focuses on the construction of three-dimensional models of ground and underground terrain, structural building models, three-dimensional engineering geological models and other three-dimensional models and the integration and integration of model results to carry out virtual geological applications based on the three-dimensional modeling method with engineering examples, so as to provide geological support for engineering design, construction and operation management.

2 Methodological techniques

2.1 Modeling of surface structures

The modeling of surface structures mainly includes tilt photography 3D live model, 3D fine model, BIM model and so on. Inclined photography modeling obtains image data through UAV flight operations, and then obtains the live 3D model, digital elevation model and orthophoto data through feature point matching, photo alignment, camera position solving, feature point position calculation, null three encryption, grid construction, and texture mapping. The fine model is mostly constructed through high-precision mapping topographic maps, field surveys, and high-resolution texture images, and then through 3dxmax, SketchUp and other software to build the model, which generally only contains data such as the building's contour and texture, and does not react to its attributes and internal architecture information; BIM technology is based on the construction project's various relevant information data as the model basis for modeling, model building, with highly visualized, integrated, texture-mapped data. It has the characteristics of high visualization, integration, parameterization, simulation, coordination, and chartability, which can effectively guarantee the reasonable control of resource information and the effective transmission and communication of data and information between personnel. This paper mainly adopts tilt photography and fine modeling as the surface structure medium.

2.2 Engineering Geological Modeling

The construction of 3D engineering geological model can be divided into the modeling method based on borehole, the modeling method based on profile, and the modeling method of multi-source data according to the different data sources; according to the different modeling methods, it can be distinguished into the level method, the layer-by-layer method, and the three-prism method; and according to the different ways of human-computer interaction, it can be differentiated into the explicit modeling and the implicit modeling. In this paper, the construction of 3D engineering geological model is carried out through the collection of multi-methods.

By collecting and organizing the regional geological data, borehole data, profile data and terrain data of the study area; pre-processing all kinds of data before constructing the 3D model, processing the data format according to the software requirements, generating the 3D ground surface according to the terrain data, coding the strata of the soil layer and rock layer, and setting up the texture image standard of different strata; based on the processed borehole and profile data, constructing the 3D geologic profile grid of the study area according to texture and coding standards; creating all kinds of strata from top to bottom by means of the 3D geologic profile grid, and constructing the final 3D engineering geologic model (Fig. 1).

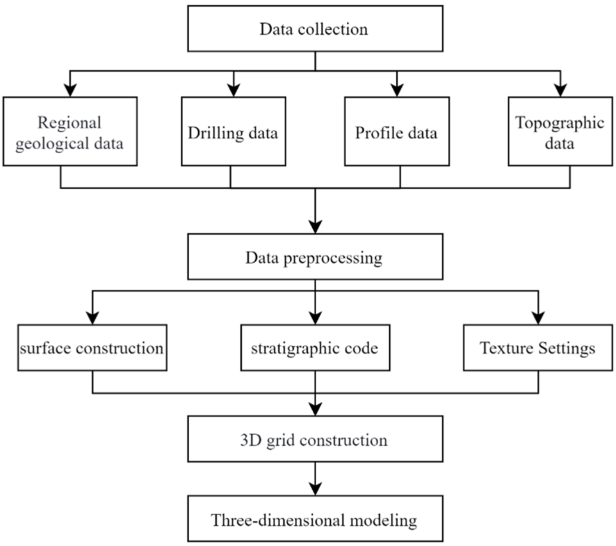

Fig. 1. 3D Engineering Geological Modeling Process

3 Project Examples

3.1 Project Overview

In this paper, a subway station in Chongqing is chosen as an example, the project is constructed by open excavation, the pit slope height is large (there is a rocky slope larger than 30m), and the maximum height of the slope formed by the project (pit slope + environmental slope) is about 91.19m, and the use of the traditional means of geotechnical engineering investigation will result in the lack of intuition in the expression of geologic information and the lack of precision in the analysis of the engineering geological evaluation, and other problems. Therefore, a three-dimensional engineering geological model and a model of the surrounding structures were constructed for the project to carry out the virtual geological application research based on the three-dimensional modeling method, which mainly involves three-dimensional modeling of engineering geology, engineering geology auxiliary analysis and decision-making, and so on.

3.2 3D geologic modeling

Through the processing of the original mapping topographic map to build a three-dimensional topographic surface, using the surface data and drilling data to build a three-dimensional lattice frame, three-dimensional auxiliary layering, three-dimensional rock surfaces and various types of lenticular body modeling, and ultimately build a three-dimensional engineering geological model of the study area (Fig. 2(a), Fig. 2(b)); combined with the orthophotos (Fig. 2(c)), the texture image of the structure, and the high-precision geometrical contours of topographic maps, to build the model of the structures in the project area, as well as the model of the environment (Fig. 2(d)).

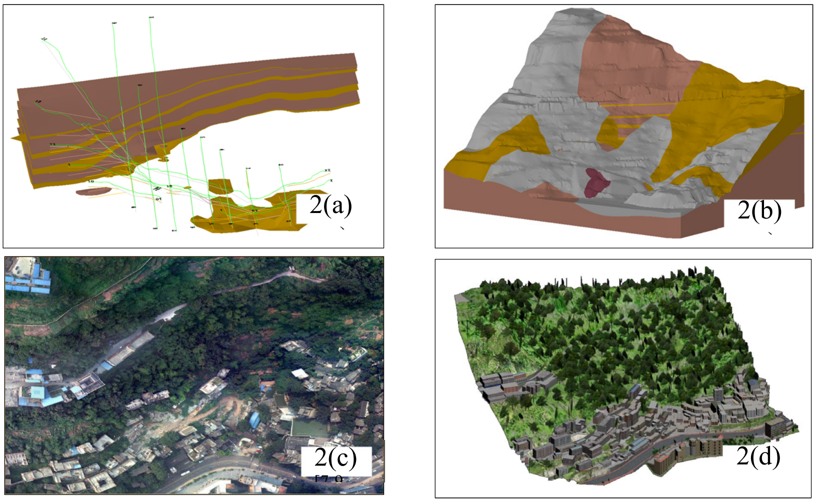

Fig. 2. Three-dimensional modeling results:2(a) Geologic level and lenticular body data, 2(b) Results of the 3D Engineering Geological Modeling, 2(c) Orthophoto data of the study area, 2(d) Model of surrounding structures and environment

3.3 Integration Convergence and Integration

Through data conversion, direct access, data interactive operation, GIS middleware and other ways to analyze all kinds of data in the coordinates of multiple sources, heterogeneous, multi-temporal, multi-scale, different coordinate systems and other complex diversity of problems, in the spatial form, geometric relationships, attribute characteristics and thematic applications and other levels of the underground three-dimensional engineering geological model, surface orthophoto, surface structures, and other models of the integration and integration fusion, to obtain the final model of the results (Fig. 3).

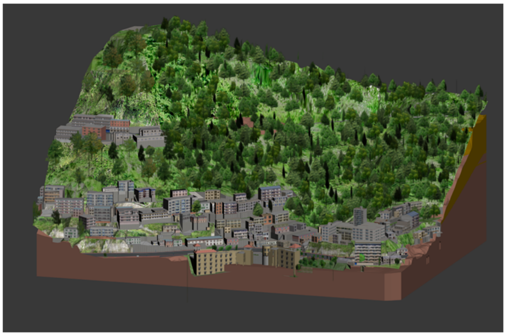

Fig. 3. Integrated fusion of above and below ground model data

4 Virtual Geological Applications

4.1 Virtual On-site Survey

In the pre-preparation stage of the engineering geological investigation survey, the use of already established ground surface data, live images and environmental models such as surface structures can be realized to virtually step on the surrounding environmental conditions of the proposed site as well as the drilling arrangement in the pre-preparation stage of the engineering geological investigation process (Fig. 4 (a), Fig. 4 (b)).

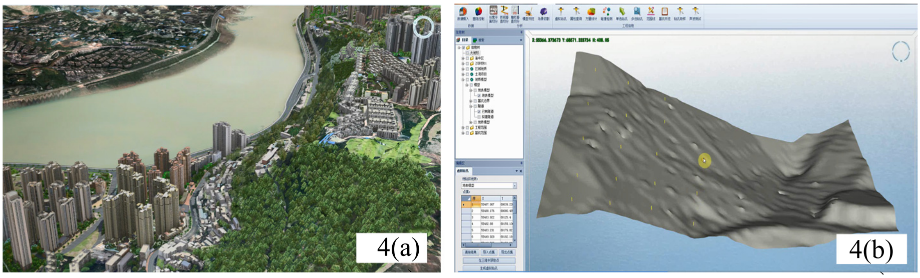

Fig. 4. (a) Scenario of virtual application in the study area: 4 (a) Scenario of virtual trekking in the study area, 4(b) Virtual borehole arrangement for 3D ground surface modeling

4.2 Virtual Excavation and Roaming

Through the three-dimensional engineering geological model for virtual pit excavation, set the slope rate, can be the actual engineering excavation of rock and soil volume calculations, the excavation of the pit after the effective simulation of the geological situation, and at the same time for the construction unit to formulate the basis of the disposal of soil treatment program (Fig.5). Through the customized perspective, entering the excavation pit, you can freely carry out roaming more intuitive understanding of the geological situation inside the tunnel for the design and construction of the building to provide a scientific basis and analysis.

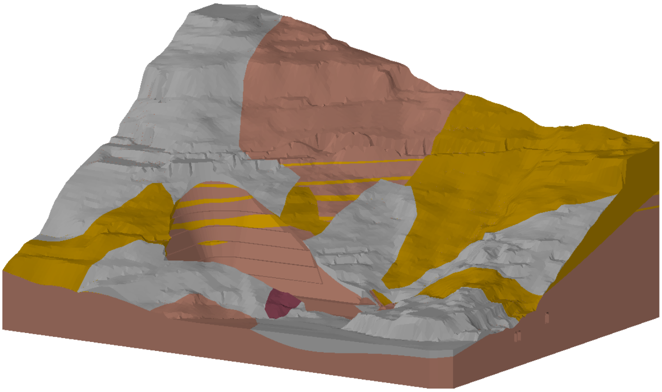

Fig. 5. 3D engineering geology model sloping excavation scene

4.3 Numerical simulation analysis

In terms of simulation, the 3D finite element numerical analysis of the construction process is accomplished by grid conversion of the 3D geological model. The finite element numerical model mainly contains the existing and proposed tunnels, foundation pits, slopes and corresponding support structures. The results of the 3D finite element numerical analysis can visualize the changes of the ground stress field during the construction process, the impact of the construction on the existing tunnels, as well as the stress and deformation of the supporting structures. (Fig.6)

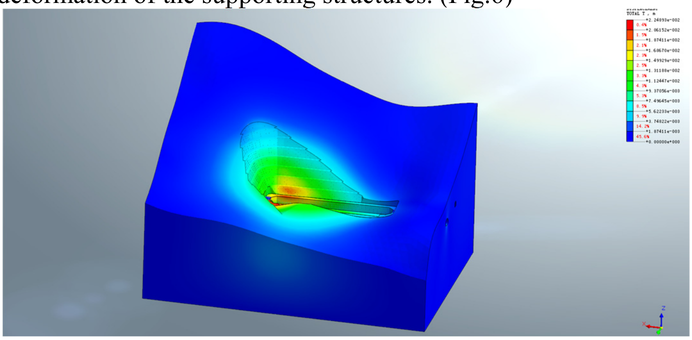

Fig. 6. Numerical simulation of overall site displacement

5 Conclusion

Through the construction of high-precision surface, three-dimensional engineering geological grid, soil layer, rock layer and borehole data in the field area, and the integration with the model of the proposed structures on the surface, various kinds of virtual geological application analysis based on the three-dimensional model have been realized, including the virtual footpath survey, pit excavation, engineering quantity statistics, numerical simulation analysis, etc., which further verifies that the virtual geological application scenario based on the three-dimensional modeling method can be of great significance in guiding the optimization of the engineering survey and design work.

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