BIM Geological Structure Computer Modelling and Software Simulation in Building Foundation Model Testing

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Abstract. In view of the difficult calculation and complex construction procedures in the large-area complex foundation treatment plan, based on actual engineering projects, the BIM application plan of foundation treatment in the whole life cycle of design and construction is studied. The article first visualizes the drilling data of geological survey in three dimensions. Then, on this basis, we use the Kriging algorithm to interpolate and fit the three-dimensional geological layer data with the borehole data as the sample data. The results of the experiment show that the three-dimensional model of geological bodies constructed by BIM technology can directly express the distribution of geological layers. This method realizes the information exchange between the BIM model and the numerical simulation software, and improves the accuracy of the calculation results.

Keywords: BIM, geological structure, modelling and simulation, foundation model, experimental test.

1. Introduction

Under the call of national policies, BIM technology has swept the entire construction industry, and the application of BIM in engineering shows a situation where housing construction takes the lead and highways, railways, municipalities, and other fields are coordinated. BIM technology is still in its infancy in the field of wharf engineering, and many scholars have carried out application research in related design, construction, operation, and maintenance. Some scholars used BIM technology to manage and control the important and difficult problems of EPC petrochemical terminal general contracting management, and realized applications such as collaborative design, collision inspection, and construction dynamic simulation [1]. Some scholars have developed a 3D visualization application for the dock on the Android platform, using Revit to build a dock model as a data source, and Unity3d as a 3D development platform to realize the integrated management of system data and system operation. Some scholars have studied the 5D-BIM-based high-piled wharf construction schedule-cost real-time control system, which makes the project cost estimation faster and more accurate. This article takes the actual engineering project as an example, based on the series software of the Autodesk platform, simulates, and analyses the foundation treatment plan in the project. At the same time, the article combines BIM technology with traditional 3D geological body construction ideas, and proposes a 3D geological body construction method based on BIM technology.
2. Three-dimensional geological body construction

In this paper, BIM technology is used to construct a three-dimensional model of a geological body. The process is divided into three stages: drilling BIM model construction, geological boundary layer interpolation generation, and geological body model extraction [2]. According to the construction ideas proposed in this paper, combined with BIM technology to construct a geological body BIM model, the technical flow chart is shown in Figure 1.

![Flow chart of BIM model construction of geological body.](image)

The factor that affects the accuracy of the geological boundary layer is the interpolation algorithm. General interpolation algorithms include inverse distance weighted interpolation, Kriging interpolation, minimum curvature method, nearest neighbour interpolation, multiple regression, etc. This paper chooses the Kriging interpolation method for the fitting interpolation of the geological boundary layer. The basic idea of the Kriging algorithm is to assign different weights to the attributes of each sample according to the different spatial locations of the samples and the degree of correlation between the samples, and perform a sliding weighted average to estimate an attribute of the point to be interpolated. Kriging algorithm is widely used in groundwater simulation, soil mapping and other fields, and it is an effective geostatistical grid method [3]. For a series of sample point data in the area where \( x_1, x_2, \ldots, x_n \) is, the sample value \( Z(x_1), Z(x_2), \ldots, Z(x_n) \) can be obtained. According to the Kriging principle, the value \( Z^*(x_0) \) of the point to be interpolated can be estimated by a linear combination, and its expression is:

\[
Z^*(x_0) = \sum_{i=1}^{n} \alpha_i Z(x_i)
\]  

(1)

In formula (1), \( k \) represents the number of samples, and \( \alpha \) represents the weight of the sample point. Unbiasedness and minimum estimated variance are the selection criteria for weight \( \alpha_k \), then:

\[
E\left[Z(x_0) - Z^*(x_0)\right] = 0
\]

\[
Var\left[Z(x_0) - Z^*(x_0)\right] = \text{min}
\]

(2)

In formula (2), \( E[] \) represents the mean and \( Var[] \) represents the variance. According to the above conditions combined with the LaGrange multiplier method to find the conditional extremum, \( \alpha_k \) can be obtained.
3. Experimental Design

3.1. BIM implementation process
The area of foundation treatment is huge and there are many divisions. Comprehensive consideration of the foundation treatment plan of each district, according to the construction technology and BIM application requirements, the plan model is divided into five parts: geological model, drainage slab and mixing pile model, stacking model, excavation replacement model and completion surface model, combined with foundation The processed zoning plan is uniformly modelled.

3.2. Geological model
In the Civil3D software in the Autodesk platform, the drilling data processed into a unified format can be imported into the geological and geotechnical module, and a three-dimensional drilling histogram with geographic location information and stratigraphic information can be gradually generated (Figure 2) → Same soil Three-dimensional geological surface → three-dimensional solid model of soil layer (Figure 3). The three-dimensional geological model contains information such as the stratum name, elevation and borehole required for the design, and can quickly cut to generate the required section, assist in the design, and improve the quality [4]. Surfaces and solids in the model can also be used for accurate modelling and calculation of foundation treatment schemes.

Figure 2. Three-dimensional drilling model.

Figure 3. Three-dimensional geological model.

3.3. Heap loading model
According to the geological changes and settlement calculation results of the site, the soil surface area and taxiway area are divided into 33 and 9 treatment areas respectively, and the stacking height of each area is determined according to calculations, which are different. Many partitions and different stacking heights bring great difficulties to the calculation of stacking, especially when dealing with the
common boundary of multiple adjacent partitions, it is impossible to show this complex back pressure situation in detail in a two-dimensional plane. It is very error prone and difficult to check [5]. When the unloading condition is reached after the stacking load is completed, the calculation of the unloading amount is also faced with the same complicated problem: the settlement is uneven in the large-area stacking area, and the top surface of the piled load after settlement is no longer a flat surface. It is impossible to complete the unloading amount if it depends on manual hands. In the actual calculation, the calculation difficulty can only be reduced by simplifying the conditions, and it is barely completed. However, this is also the main reason for the large difference between the actual construction amount.

We use Civil3D's curved surface and grading tools to simulate the process of stacking and unloading by considering the calculated settlement of the main boreholes, and obtain more accurate stacking and unloading projects in each area based on the data such as curved surfaces and entities established in the process. Volume (Figure 4). The comparison between the stacking and unloading engineering quantities calculated by the model and the results of hand calculations is shown in Table 1.

![Figure 4. Preloaded surface.](image)

| Table 1. Comparison of calculation results of stacking and unloading engineering. |
| --- | --- | --- |
| **Area** | **Taxiway** | **Soil area** |
| **Types** | **Heap load** | **Unloaded amount** | **Heap load** | **Unloaded amount** |
| **Description** | **Over 2.5m stacking capacity** | **Medium coarse sand cushion** | **Total unloading** | **Unloaded outbound volume** | **Site dumping volume** |
| **Engineering quantity/10,000 m³** | **Model calculation** | **Manual calculation** | **Model calculation** | **Manual calculation** |
| **Taxiway** | 300.65 | 20.94 | 241.73 | 44.14 | 10.85 |
| **Manual calculation** | 344.34 | 253.99 |
| **Difference/ten thousand m³** | -22.75 | -12.26 |
| **Difference of earthwork net value/%** | -4.1 |
| **Soil area** | 285.06 | 79.79 | 44.14 | 10.85 |
| **Model calculation** | 378.61 | 59.17 |
| **Manual calculation** | -13.76 | -4.18 |
| **Difference/ten thousand m³** | -2.9 |
When it is confirmed that there is no obvious error in the manual calculation result, the difference between the net earthwork calculated by the model and the manual calculation result is 4.1% and 2.9%, respectively. The corresponding model calculation results are significantly lower, which is easier under the simplified conditions of the manual calculation [6]. The characteristics of multi-calculation of engineering quantities can cross-verify the accuracy of engineering quantities in the project. On the premise of ensuring that the model is created without errors, the results of the model calculation are reliable.

3.4. Verification results of foundation seismic experiments

In order to verify the effectiveness of the BIM-based seismic performance evaluation method for building masonry structures, simulation experiments are carried out. The collapse rate, the degree of fit between the evaluation results of different methods and the actual evaluation results are selected as the experimental indicators, and the traditional method and the proposed method are compared and analysed. The simulation experiment was carried out in the hardware environment of Intel quad-core 2.8GHz CPU, 8GB memory, and Windows8 as the operating system. The extraction and analysis of experimental data was realized through the Quast Mobile platform [7]. The experiment takes a building project in the virtual BIM model as an example. It is assumed that the number of floors in the model is 20, the building area is about 36,000m², and the building height is 86.5m. The collapse probability of the masonry structure of the building is set through the virtual Quast Mobile platform, and the seismic performance is tested by comparing the data obtained by the test with the real data set. The result of setting is 37%, the test result is shown as in Fig. 5.

![Figure 5. The effect of seismic fortification intensity method on the seismic performance of building masonry structures.](image)

Analysing Figure 5, we can see that in the 12 iterations, the fit between the seismic performance evaluation results obtained and the actual evaluation results is between 70% and 90%, and the highest fit of the evaluation results is 90%. In the 12 iterations, the fit between the evaluation results of the seismic performance of the building masonry structure and the actual evaluation results is between 0% and 70%. The highest fit of the evaluation results is above 60%, and the lowest fit is below 50%. The comparison shows that the seismic performance evaluation results of the building masonry structure proposed in this paper have a high degree of fit with the actual evaluation results, and the evaluation results of seismic performance can be accurately obtained, which verifies the accuracy of the proposed method in this paper.

4. Conclusion
The process model of preloading Analysing created by Civil3D can consider the uneven settlement during the stacking period in a large-scale site, to obtain accurate stacking and unloading engineering quantities. After studying the traditional three-dimensional geological body construction method, based on the idea of triangular prism model, and comprehensively using BIM technology, this paper proposes an algorithm for constructing a geological body BIM model. The BIM model of the geological body obtained by this algorithm can directly express the distribution and direction of the geological layer, and at the same time provide a data basis for the subsequent engineering design and construction plan selection.

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