Analysis of Water Inflow in Yuejialiang Tunnel Based on Modflow

Wenhan Cao, Zhang Qiang, Hongye Li, Shi Xiao, Wu Hong

Chengdu University of Technology, State Key Laboratory of Geological disaster Prevention and environment Protection, Chengdu 610059, China

Abstract

Aiming at the engineering practice of the Yuejialiang tunnel in the Bazhong area, a groundwater numerical simulation model of the tunnel was established in the Visual Modflow, and fitting makes the model more accurate. Based on this, a segmented forecast of the amount of water inflow from the tunnel is expected to provide guidance for future construction.

Keywords

Water in tunnel; karst area; modflow; analytical method.

1. Introduction

For a long time, the sudden, unpredictable and extremely destructive ability of tunnel water inrush often brings huge safety hazards and property losses to the construction process and later engineering operations [1-3]. The prediction of tunnel water inflow have become an important part of tunnel design and construction. Therefore, in combination with local hydrogeological conditions, accurate analysis of tunnel water inflow is a problem that must be faced and solved during tunnel construction.

Visual Modflow is the most widely used 3D groundwater flow simulation software developed by Waterloo, Canada. The core module for groundwater flow simulation is MODFLOW [4-6] developed by the US Geological Survey. Visual Modflow has the advantages of wide applicability, high visibility, and quick solution. Based on the hydrogeological survey data of the Yuejialiang tunnel site, this paper uses Visual Modflow to establish a groundwater numerical simulation model. On this basis, the simulation compares the change of groundwater flow field with time after tunnel construction, and predicts the water inflow of the tunnel.

2. Geological Conditions

The Yuejialiang Tunnel is located in Nanjiang County, Bazhong City,the tunnel entrance is located in Huangniubaliang, Huitan Township, Nanjiang County, Bazhong City and the tunnel exit is located in the village of Youchang Township, Nanjiang County, Bazhong City. The tunneling area belongs to the deep-cut erosion-tectonic erosion landform, which is a massive mountain topography with an elevation of about 990~1600m and a relative height difference of about 500m. It belongs to the middle and low mountain topography. The annual average rainfall is 1194mm, the highest is 1828mm, the monthly maximum rainfall is 279.8mm, and the precipitation is concentrated from June to September. According to the borehole data in the study area, the tunnel through the rock formation is the intrusive rock, which is dominated by meso-basic and medium-acid diorite (δ), granite and granite porphyry (γ). The body is relatively fragmented, and the joint fissures are natural water storage and runoff channels; the intrusive rock overlying strata are the Sinian system of the Upper Sinian Dengying Formation (Zbd), which is about 380-670 meters thick, and is not intrusive with the underlying elemental intrusive rocks. Integrate contacts.

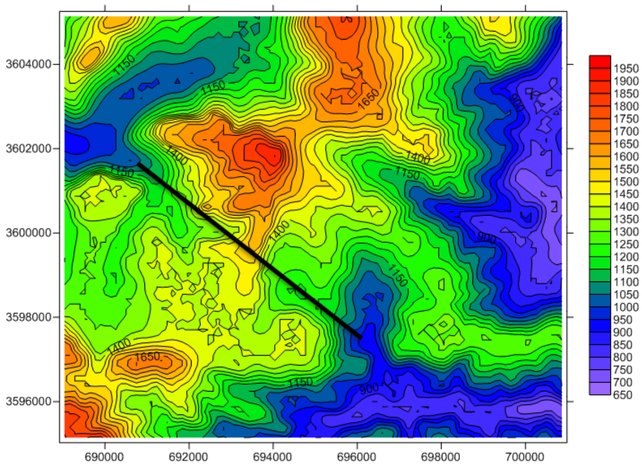

Fig.1 Contour Map of the Regional Model

3. Hydrogeological Model Generalization and Modeling

3.1 Groundwater Numerical Simulation Mode

The model area is 122.68km2, and the horizontal and vertical sections are divided into 120×120 grids. Considering the permeability coefficient of different rock layers and tunnel construction, the model aquifer is generalized into 5 layers. The first layer is a strong weathering layer, ranging from 10m to 64m; the second layer is the overlying soluble rock thickness, which is 380-670 meters; the third layer is the elevation of the tunnel, which is 960m; the fourth layer is bedrock and the strong weathering layer has a thickness of about 30 m; the fifth layer is a bedrock as a relatively water-repellent layer of the model.

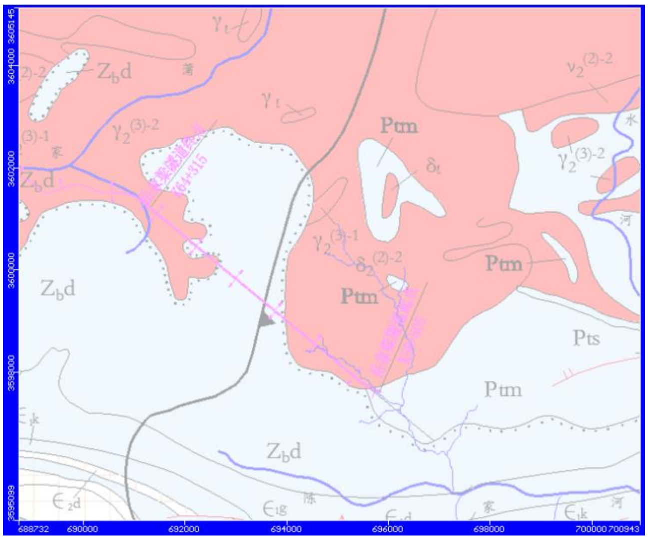

Fig.2 Plan of the Study Area

3.2 Processing During the Simulation Period

In this study, the seepage field in December 2017 was used as the initial seepage field, and the flow field in March 2018 was used as the fitting flow field for the calculation and evaluation of groundwater resources. The simulation period is five hydrological years from March 2018 to March 2023. One month is used as a time step, and the time step is automatically controlled by the model.

3.3 Processing of Source and Sink Items

Source and sink items in the tunnel area include replenishment items and excretion items. The source of recharge in the study area is atmospheric rainfall. The northwest side of the model is the excavation boundary and flow boundary of the Pujia River on the west side of the model watershed. The groundwater on the east side of the watershed is mainly discharged to the Chenjiahe River.

3.4 Model Verification

The model utilizes the groundwater observation data of the simulated area borehole in March 2018 for debugging verification. After the parameter adjustment, the simulated groundwater in the study area is basically consistent with the borehole observation value. As can be seen from Fig. 3, the observation point simulates the calculation of the groundwater level well. The difference between the value and the observed value is small and within 95% confidence interval, the model has higher accuracy.

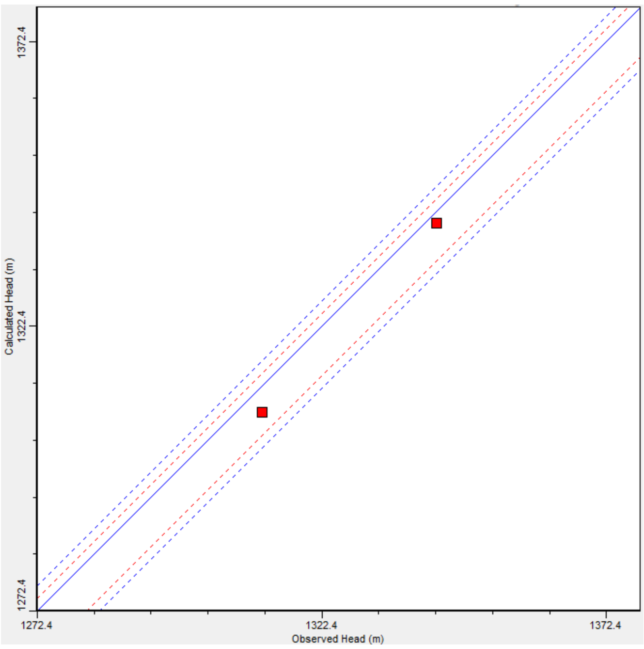

Fig. 3 Fitting Curve of Simulated and Observed Hydraulic Head

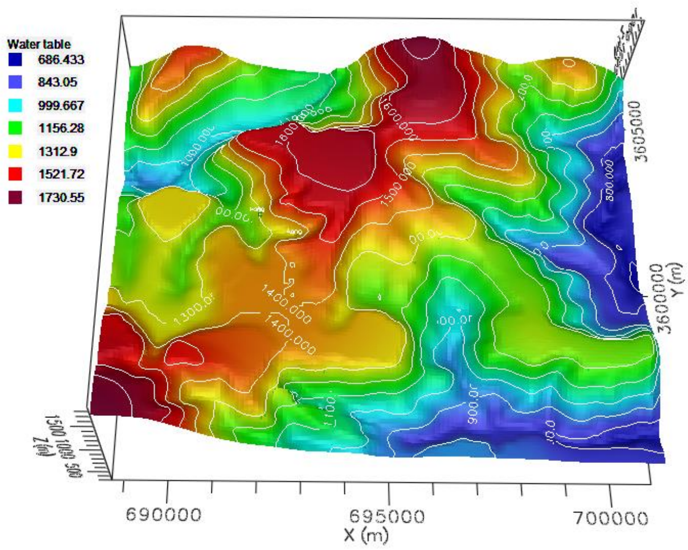

Fig. 4 Contour Map of Initial Groundwater Table (in m)

4. Results and Discussion

The initial water level, boundary flow (determined according to multi-year average precipitation, evaporation and groundwater level), hydrogeological parameters, etc. are substituted into the model, and the tunnel is divided into three sections according to whether the magmatic rock is covered with soluble rock. Soluble rock (replaced with #1 segment in this paper), intermediate soluble rock segment

(#2 segment) and non-soluble rock segment at the tunnel exit (#3 segment). The Drain simulation module is used in Modflow, and the calculation results are shown in Figure 5 to Figure 7.

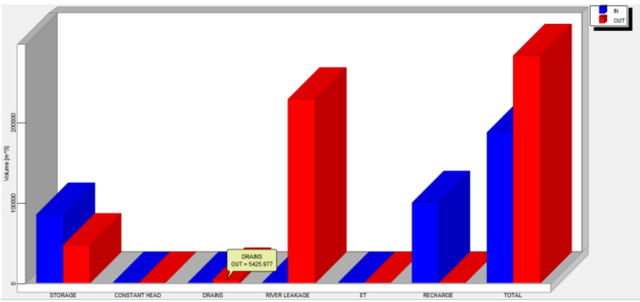

Fig.5 Tunnel Groundwater Inflow

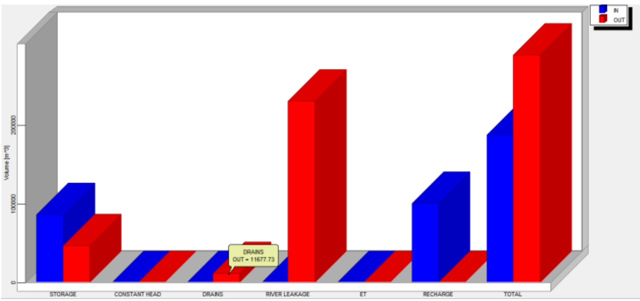

Fig.6 Tunnel Groundwater Inflow

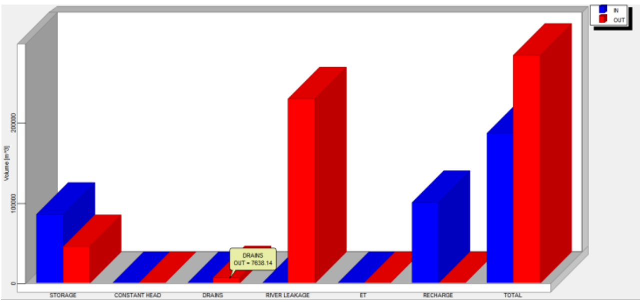

Fig.7 Tunnel Groundwater Inflow

It can be seen from the figure that the water inflow in the non-soluble rock section of the #1 and #3 sections is 5425m3/d and 7638m3/d, and the water inflow in the middle #2 section of the soluble rock section is 11677m3/d because of the overlying soluble rock section. The permeability coefficient of the overlying soluble rock section is large, and the rainfall infiltration coefficient is also large, which results in the tunnel water inflow in section #2 is higher than that in the non-soluble rock section. However, since the soluble rock in section #2 is only the overlying stratum, the tunnel is essentially a non-soluble rock that traverses. There is a bead-like cave at the junction of the soluble rock and the non-soluble rock above the tunnel, and some atmospheric rainfall will pass through the underground dark river. The discharge of the beaded caves reduces the amount of water in the #2 section to some extent.

5. Conclusion

There are many methods for predicting the amount of water inflow from tunnels. Numerical methods have greater advantages due to their ability to deal with unsteady flows and complex hydrogeological conditions[7-8]. In this paper, the three-dimensional groundwater model of the study area is established by using Visual MODFLOW software. The basic parameters, source and sink items and well group processing of the model are analyzed. The model parameters are determined by adjustment. The model verification is good, indicating that the model can carry out complex boundary conditions. Underwater tunnel water volume forecast. According to the difference of stratum lithology, the tunnel is divided into three sections, and the water inflow of the three sections of the tunnel is simulated respectively. It is found that the water inflow of the three sections is small, and the water inflow of the #2 section of the tunnel covered with soluble rock stratum is small. Larger. The simulation results are in line with the actual project and can guide the construction of the project.

References

[1] Zi Yi, Ma Shiwei. The Mechanism and Engineering Prevention of Water Inrush Disaster in Karst Tunnel[J]. Journal of Railway Engineering Society,2011,28(02):84-89.

[2] Li Shucai, Li Shuzheng, Zhang Qingsong, et al. Advance prediction of karst fissure water and unfavorable geological conditions[J]. Chinese Journal of Rock Mechanics and Engineering,2007(02):217-225.

[3] LIU Zhao-wei, HE Man-chao, WANG Shu-ren. Study on mechanism of karst water inrush in Yuanliangshan tunnel and its prevention and control measures[J]. Rock and Soil Mechanics,2006(02):228-232+246.

[4] TIAN Jie, JIN Xin, HE Tengsheng. Numerical simulation of groundwater runoff in mountainous areas based on MODFLOW[J]. Journal of Lanzhou University (Natural Science), 2014, 50(03): 324-332+337.

[5] Yang Wei, Luo Zhouquan, Wang Yiwei, Xie Chengyu. Analysis and prediction of mine groundwater flow field based on Visual Modflow[J]. Mining and Metallurgical Engineering, 2013, 33(04): 11-15+21.

[6] LIU Qun-qun, HAN Man, SONG Tao, CHEN Hao.Numerical Analysis of Seepage Field in Groundwater Sealed Oil Cave Reservoir[J]. Journal of Ocean University of China (Natural Science Edition),2007(05):819-824.

[7] Yao Lili, Hu Litang. A Case Study of Predicting Tunnel Water Inflow Using FEFLOW[J]. Engineering Investigation, 2015, 43(11): 39-43.

[8] LI Caimei, YANG Yonggang, QIN Zuodong, ZOU Songbing, LI Jinchang. Dynamic simulation and prediction of groundwater in mining area based on FEFLOW and GIS technology[J]. Arid Land Geography,2015,38(02):359-367.