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Evaluation of complex aquifers with different configurations

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Abstract Three design methods are usually used in the analysis and design of ground water control systems. These methods are: the analysis using equilibrium formulas, the analysis using flow net and the analysis through numerical modeling. Numerical ground water models have proven to be essential when dealing with complex aquifer situations. One of the most known numerical models is "Modflow" which is a three dimensional finite difference model oriented for ground water modeling. The dewatering activities that take place at the Banha power station was utilized in calibrating the performance of the numerical modeling process. A parametric study was carried out with different configurations and boundary conditions. The study covers the performance of sand drains with different depths and spacing. These readings had been compared to "Modflow" results and good agreement between the field data and the analysis results had been observed.

For complex ground water control problems where the assumptions of the conventional equilibrium formulas are not valid, the use of these formulas may lead to serious errors in design. In this condition, the use of 3-D finite difference analysis is essential to obtain reliable results and design for a groundwater control system.

Introduction

Equilibrium formulas have been used for decades in the design of dewatering systems. These formulas were basically developed by Thiem [1] and have been supplemented by many other investigators [2]. The groundwater modeler has to deal with different types of uncertainties, in particular with parameters such as uncertainties [3,4] and conceptualization uncertainties [5], in order to handle conceptualization uncertainty.

The aim of the calculations of a dewatering system using the equilibrium formulas is to determine the required pumping rate and the number of wells needed in order to lower the water level to a desired level. These equilibrium formulas assume an ideal aquifer and in turn, the design using these formulas has several limitations and can only be applied for dewatering problems which are very simplified in their nature [2]. For complex aquifer situations, numerical groundwater models have proven to be a useful and essential tool. These models can deal successfully with the complicities and

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limitations of the design method using the equilibrium formulas [6,7].

The complex aquifer situation includes cases of non-equal constant head boundary, partially penetrating wells, different discharge capacities, soil anisotropy, barrier boundaries, recharge boundaries and multiple aquifer configurations.

This paper, focuses on the use of three dimensional finite difference analysis for the design of deep wells dewatering system and how to model and how to solve by Mod Flow to demonstrate the capability of the three dimensional modeling for dealing with complex aquifer situations. Four case studies have been chosen to compare the result of the mod flow with actual field data. These measurements showed the efficiency and the accuracy of the numerical model.

Problematic problem

Case study (1): Banha power station

Description of the case study

The problem under study is located at the Banha power station. The structure understudy is a deep pump house structure of dimensions (69.45 m × 35.60 m). The ground level is about 0.00, while the foundation level of the structure is at level of −10.00. Figs. 1 and 2 show a section plan of the pump house structure at the foundation level as well as a cross section elevation showing the concrete structure levels.

Soil formation and groundwater level

Detailed site investigation showed that the soil formation along the site is almost constant and includes two main layers. The top layer is impervious clay with a thickness of 11.00 m followed by deep sand aquifer with interlayers of fine gravel to a depth of more than 30 m boreholes.

The groundwater is located at a level of −4.00. Fig. 3 shows the soil formation at the structure location.

Need of dewatering system

Although the excavation level is located at a level of −10.00 inside the top clay layer, a relief system is required to satisfy the safety of the clay layer against piping. Back analysis showed that a drawdown of 6.00 m is required to achieve a safety factor of 1.15.

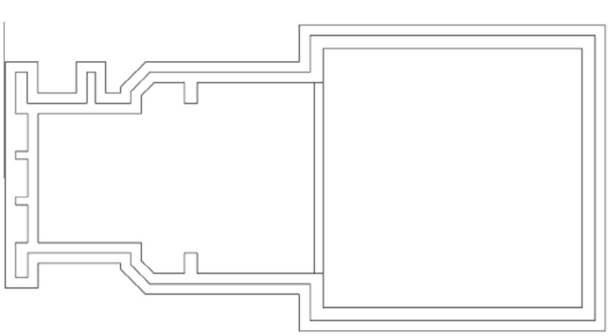

Fig. 1 Section plan for the pump house structure.

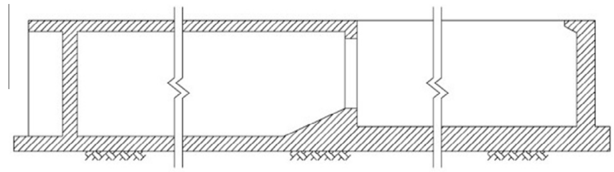

Fig. 2 Section elevation.

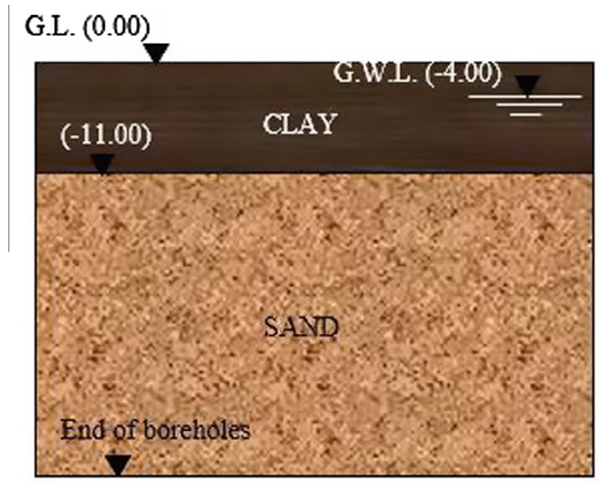

Fig. 3 Soil formation at the structure location.

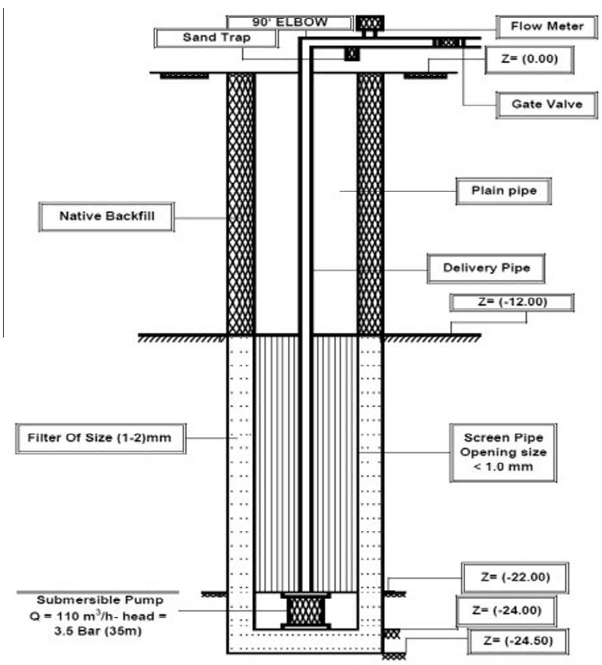

Fig. 4 Typical configuration of dewatering wells.

Wells configuration, distribution and piezometers location

The preliminary design assumed a constant rate of discharge of 110 m^3/h/well. The typical configuration of wells is shown in Fig. 4. The results of preliminary design indicated that the required number of wells was about 16 wells with the