VIRTUAL REALITY VISUALIZATION OF GROUNDWATER FLOW SIMULATED OVER A FRACTURE PLANE

Chandani Pathirana Saitama University
Kunio Watanabe Saitama University
Yuko Kawarai Shimizu Corporation

1. INTRODUCTION

Groundwater analysis is widely used in the field of environmental engineering for clarifying the effect of groundwater flow on the migration of hazardous substances. However, there are two problems remaining to be addressed before the successful use of this technique to solve practical engineering problems.

The first is construction of proper hydrogeological model. Usually observation data are not enough for construct a proper hydrogeological model. It is difficult to resolve the hydrogeological situation of underground on the basis of limited amount of information. Therefore, trial and error process is needed to construct a proper model. In this process, the distribution of piezometric head is calculated by an assumed hydrogeological model (i.e. underground structure and hydrological parameters) and is compared with the observations. If difference is occured, change model and parameters and calculation is executed. This process needs to be repeated a large number of times with different hydrogeological conditions in order to obtain hydrological model that closely agree with the observations. The technique how to get the best model should be constructed.

The second is how to share the common image of underground structure with specialists in other fields such as chemist, biologist, governors etc, in a way that is easy to understand as well as accurate. The best approach should be based on visuals, in a 3-dimensional environment. The non-specialist can use the intuition related to 3-dimensional vision to effectively comprehend the situation. The virtual reality visualization techniques seems to be well used in the trial and error process and image sharing. In this paper some preliminary results of the technique are presented.

2. VISUALIZATION TECHNIQUE AND PROCESS

In this study, the CAVE (CAVE Automatic Virtual Environment) system (Cruz-Neira et al. 1993)[1] was selected for the virtual reality visualization of the analyzed piezometric head distribution. The audience, who were specialists of many different academic fields enter in a room equipped with visualization hardware so that they can share the image of underground structures.

As an example, groundwater flow patterns on a fracture plane were visualized. Figure 1 gives an idealized illustration of the problem. It was assumed that a tunnel is passing through a fracture plane. The changes in groundwater flow induced by the tunnel excavation was investigated and visualized.

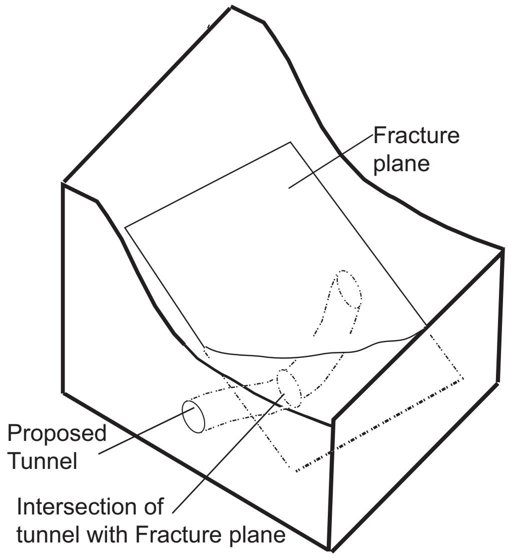

Fig. 1 A model of tunnel meeting a fracture plane.

Finite Element Method (FEM) based on the Galerkin technique as explained by Pinder and Gray[2] was used for the analysis of piezometric head over the fracture plane. Figure 2 illustrates the mesh division of the fracture plane used for the analysis. A traiangular 2-dimensional element was used. The hole in the center of the domain indicates the tunnel. Boundary conditions given in the analysis are also described in the figure.

Figure 3(a), (b) and (c) display the three examples of different hydrogeological models considered in trial and error process. Hydraulic conductivity in the shaded areas was 1.0E+3 times larger than the other areas.

Figure 4 schematically shows the procedure of the overall proposal.

Many hydrogeological models are assumed for the fracture plane and groundwater flow around the tunnel was computed. Each results of calculation, such as piezometric head distribution, pollutant concentrations etc. are visualized in CAVE system. And those results are compared with measured values. This process is repeated until a model which produces good agreement with all the observation data. Discussion and exchange of ideas of geologist, hydrologist etc. are conducted in the CAVE system. The best hydrogeological model is used for communicating with other specialists of different academic

Keywords: **groundwater, hydrogeology, 3-d visualization, finite-element**
Address: Geosphere Research Institute, 255 Shimo Okubo Sakura ku, Saitama shi 338-8570 JAPAN
E-mail: chandanipathirana@yahoo.com

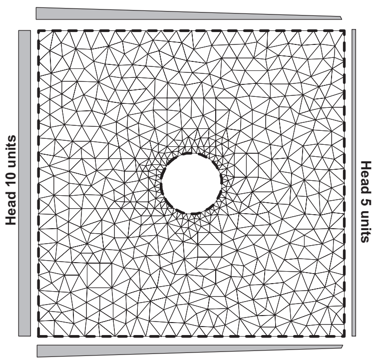

Fig. 2 Finite-element mesh

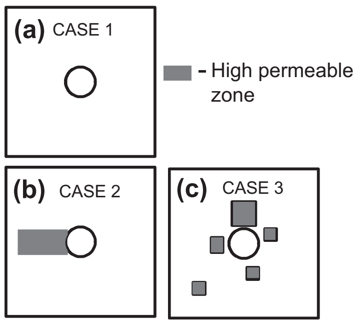

Fig. 3 Hydrogeological models assumed.

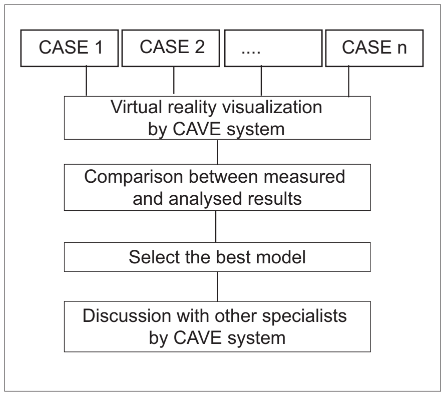

Fig. 4 Overall plan

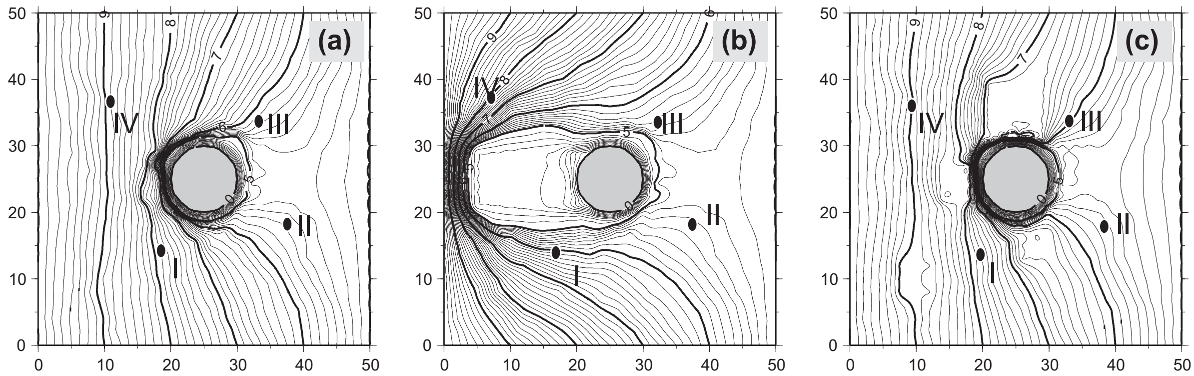

Fig. 5 Constant-head lines for three cases.

fields to evaluate the effect of the fracture on the pollutant migration, etc..

Figure 5 shows the piezometric head distribution calculated for each case. Solid circle in these figures shows the points at which calculated piezometric head are compared with the observed values. In this example four points are illustrated. Figure 6 shows the piezometric head at each point considered. Those points are compared with the measured value at above points as schematically shown in this figure. This procedure is practical for making proper hydrogeological model of a major fracture.

3. CONCLUSIONS

CAVE system was applied to the trial and error process for evaluating hydrogeological conditions on a fracture. It was found that the system can be used as an effective tool for the evaluation of hydrogeological models. Further, the CAVE system could also be used for the effective communication of hydrogeological conditions between hydrogeologists and other experts involved in mitigation of groundwater contamination problems. It is concluded that the virtual reality visualization can be well applied to the problems in the groundwater technology.

4. REFERENCES

1. Cruz-Neira, C., D.J. Sandin, and T.A. Defanti (1993,August). Surround-screen projection-based virtual reality: The design and implementation of the cave. In *Proceedings of SIGGRAPH'93 Computer Graphics Conference*, pp. 135-142. ACM SIGGRAPH.
2. Pinder, G.F. and W.G. Gray (1977). *Finite Element simulation in surface and subsurface hydrology.* Academic press, inc.

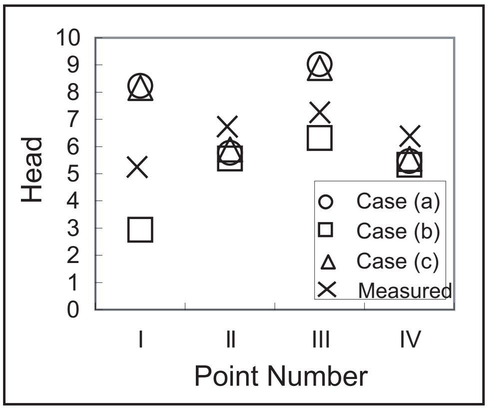

Fig. 6 Pressure head values at sampling points (see fig 2). A hyphothetical set of 'mesured' data is also shown.