Evaluating influence of underground construction on groundwater flow interruption

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1. Introduction

Land transportation system like railway and highway are sometimes constructed underground because of the issues such as noise, vibration and unsuitable landscape. However, long underground structures may pose environmental problems. If such an underground structure is constructed using cut and fill method, then long and deep cut-off walls are normally built, which are left as they are even after the completion of the construction work in many cases. The long and deep walls and the tunnel itself may interrupt flow in aquifers in the area resulting to rise and drawdown of groundwater levels on upstream and downstream sides, respectively. These change in groundwater levels lead to many environmental problems, for example, groundwater leakage to basements, plants' death on upstream side, land subsidence, water level decrease in wells on downstream side and so forth.

2. Concept of Flow Interruption Evaluation

If the above-mentioned problems are predicted for a particular site, then the degree of possible negative impacts and appropriate countermeasures have to be evaluated, which is done in the following steps:

(1) Evaluating possible impacts on natural groundwater flow

(2) Evaluating linkage between the impacts and natural groundwater flow

(3) Setting criteria to evaluate negative environmental impacts

Direct influences of underground construction on groundwater flow such as rise and drawdown of groundwater level, decreased flow rate and change in groundwater flow path, are known as primary phenomena. The consequences of the primary phenomena, for example: decrease in well performance, land subsidence, leakage to basements and so forth, are secondary phenomena. Evaluation of environmental impacts due to underground construction is quantitative evaluation of the primary phenomena, their influence on secondary phenomena based on the co-relationships between them and possible negative impacts on the secondary phenomena.

3. Evaluation Criteria

The following two evaluation criteria are set to examine the necessity of countermeasures:

(1) Limit criterion: The limits of the chosen indicators, for example: groundwater level, are specified in this technique. The changes in groundwater level more than the specified values are not permitted.

(2) Permission criterion: Values of chosen parameters for an area are specified in permission criterion. This criterion is set by limit criterion considering allowance for uncertainty in site investigation. Permission criterion can be set almost equal to limit criterion if the precision in investigation is high. Otherwise, a large difference is permitted between the two criteria.

4. Evaluation Method

Influence prediction is executed with the primary phenomena having distinct correlation with the secondary phenomena. The predictions are usually done by calculating variations in groundwater levels using numerical techniques such as FEM and other simplified calculation methods. Numerical analysis methods are most common since groundwater flow interruption and its consequences in underground constructions are usually of large scale. However, high accuracy of the numerical results can not be expected if the provided data on ground and groundwater are not sufficient. Simplified calculation methods, for example: 2-D plane flow, 2-D section flow and 3-D flow, are more effective in influence prediction in early stage. These simplified methods have enough precision under simple ground and boundary conditions. The results indicated that hydraulic gradient of natural groundwater flow, length of the constructed underground structure and intersection angle between flow direction and the structure greatly affect the predictions.