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Applicability of simplified analytical models to single-well permeability tests

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Accurate estimation of hydraulic properties of geological media by field investigation methods, such as permeability tests, are fundamentally necessary for the design and safety assessment of facilities related to geological disposal of hazardous wastes, including radioactive nuclear waste. Preliminary analyses of *in-situ* permeability tests often utilize simplified analytical models assuming steady-state axisymmetric flow or unsteady-state radial flow for the groundwater flow around a borehole. However, the estimated values of permeability may be dependent on the analytical models being used. In addition, the permeability would be estimated at different values from different test methods when several test methods are practiced at the same test interval. If this is the case, a proper judgment is required for determining which value can be the best and what are the reasons for the differences.

To reduce the uncertainty in determining the permeability, this study revisited the simplified analytical models for the pressure pulse, constant head and constant flow rate tests and refined the analytical models considering vertical hydraulic boundary conditions. Using a set of dimensionless parameters, the analytical models are compared and their differences are examined by a numerical approach. The results showed that the applicabilities of individual analytical models are different. Especially in the pressure pulse test, the steady-state axisymmetric flow model may overestimate the permeability and the possible error increases as the ratio of wellbore storage to formation storage capacity reduces. The unsteady-state radial flow model would be appropriate for the analyses of measurement data at the early part of the unsteady state; however, the applicability is also dependent on the storage capacities of both the wellbore and formation. The steady-state axisymmetric flow model may not introduce significant errors in the permeability; however, the accuracy is dependent on the ratio of the formation thickness to the length of test interval and the anisotropy of permeability itself. Therefore the estimation by the steady-state axisymmetric flow model can only be used as a reference value for subsequent analyses using more refined models.