STUDY ON INFILTRATION BEHAVIORS OF UNSATURATED SLOPES BY USING LABORATORY AND NUMERICAL MODELS

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1. INTRODUCTION

Knowledge of infiltration behaviors which is a function of time, provides very useful information for the Finite Element Method(FEM)- Stability analysis of slopes; such as variation of seepage forces and increase of self-weight of the slope.

This paper presents some results of the preliminary stages of a research program carried out to explicate the mechanism of rapid failure of HAIDO slopes due to heavy rainfall.

In this stage the study is focused on infiltration by sprinkling at a specified angle;and a two-dimensional saturated-unsaturated flow prediction model is used.

2. SAMPLE TO BE INVESTIGATED

2.1 PHYSICAL PROPERTIES OF THE SOIL

The soil was collected from Hokubu town in Kumamoto Prefecture.
The physical properties are as listed in Table 1 below.

TABLE 1 : Physical properties of the soil

Wn (%)	41.5	GRAVEL (%)	0.3
Gs	2.497	SAND (%)	14.3
S_{ra} (%)	67.2	SILT (%)	70.9
k_{sat} (cm/s)	1.98×10^{-4}	CLAY (%)	14.5
CONSISTENCY	Non plastic	U_c=8.0, U_c'=0.78	
Larg. Part. size: 4.76 mm		Soil type: VH_1	

2.2 WATER RETENTION AND PERMEABILITY

The soil-water retention curve was measured by using the Column Suction Method , and fitted by using the VAN GENUCHTEN'S EQUATION (Fig. 1).

The relative permeability was predicted by using VAN GENUCHTEN'S EQUATION in MUALEM'S predictive conductivity model(Van Genuchten[2],1980).

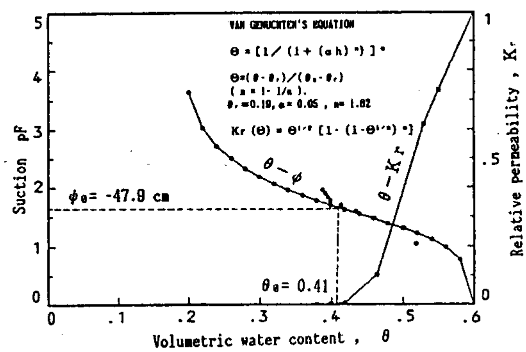

Fig.1 Water retention curve

3. LABORATORY AND NUMERICAL MODELS

3.1 LABORATORY INFILTRATION MODEL

Test apparatus and test procedure

Infiltration was carried by Sprinkling method at a rate of 25 mm/h on a 10 cm thick HAIDO soil layer hand compacted in 4 layers to a wet density ρ_t of 1.390 g/cm^3. Before compaction three pore pressure gauges were fixed at the base to monitor the variation of the pore pressure at the bottom of the soil layer during sprinkling.

Horton's infiltration curve

During the test the net inflow into the soil was measured and

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Horton's infiltration curve was derived.

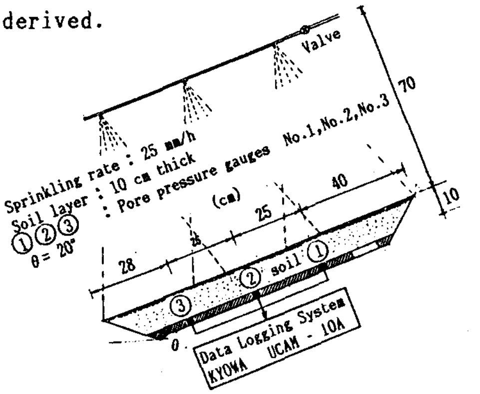

Fig.2 Schematic diagram of Lab. model

3.2 SATURATED-UNSATURATED FLOW MODEL

From the equation of continuity and Darcy's law it is possible to derive a quasilinear partial differential equation for two-dimensional flow of water in an unsaturated porous medium Eq.(1)(Akai[1] et al,1979).

$$\mathrm{div}\, K(\psi)\ (\psi + x_3) = (C(\psi) + \alpha S_s)\ \delta\psi / \delta t \qquad (1)$$

where $K(\psi)$ is a permeability tensor of second order, $C(\psi)$ is the specific moisture capacity, ψ is the capillary potential, x_3 is the gravitational potential, S_s is specific storage.

Eq.(1) is subjected to the following initial condition, Eq.(2) and boundary conditions, Eqs.(3) and (4).

$$\psi(x_i, 0) = \psi_0(x_i) \qquad (2)$$

$$\psi(x_i, t) = \psi_b(x_i, t) \qquad (3)$$

$$(K_{ij}(\psi)\,\delta\psi/\delta x_j + K_{i3})\, n_i = -V(x_i, t) \qquad (4)$$

where ψ_a, ψ_b and V are prescribed functions, n_i is a unit outer normal vector on the boundary Γ.

The relationships $K(\theta)$ and $\psi(\theta)$ can be obtained experimentally Fig.1) assuming a single-valued function.

Eq.(1) with Eqs.(2),(3) and (4) can be solved by the finite element method (FEM). The finite element formulation of this equation may be done most easily with the Galerkin method (Akai[1],1979).

4. COMPARISON OF RESULTS

The results are compared as shown in Fig.3 and Fig.4. The agreement between computed and measured values are considered encouraging. With improvement of laboratory simulation procedures good agreement is expected.

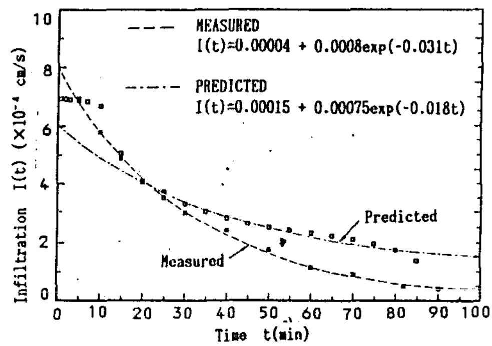

Fig.3 Horton's infiltration curve

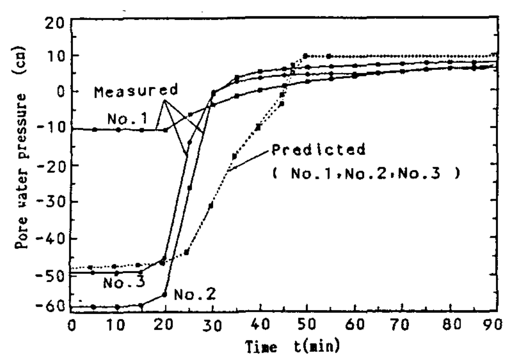

Fig.4 Variation of Pore water pressure

CONCLUSIONS

The above Numerical model can be adapted to solve more complicated practical problems involving soil stratification and variations in hydraulic conductivity

REFERENCES

1)Akai et al: Finite element analysis of 3-D flow in sat.-unsat.soils, ICNMG,1979
2)Van Genuchten: A closed form equation for predicting the hydraulic conductivity of unsaturated soil,S.Sc.Am.J,Vol.144