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ESTIMATION OF SOIL PARAMETERS BY INVERSE ANALYSIS IN COUPLED CONSOLIDATION PROBLEM

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1. INTRODUCTION

Inverse analysis is becoming more and more popular to estimate model parameters in the field of geotechnical engineering. With an approximate set of initial parameters based on geologic information, constitutive model computes deformation using FEM. Objective information is computed from the difference of FEM results and the observed data. Prior information, about model parameters and zonation, with a certain ratio is added to the objective information to yield the total objective function. Optimized parameters for a particular ratio are obtained by perturbing the parameters to get minimum gradient of the total objective function. Best model regarding the prior information is selected based on minimum ABIC value. The case study shows reasonable agreement with the theory.

2. METHODOLOGY

Figure 1 shows soil profile of the site obtained from soil investigations. At the test site, almost 25m thick soft clayey soil with N values varying between 0 and 1 is deposited, on which new large land has just been dredged and reclaimed by residual soil excavated from some construction sites. The third layer is the alluvial clayey soil of Yuraku-cho layer (Ac_1) (25m thick silty and clayey soil deposit). From soil investigation results, Ac_1 layer is found to be very weak with N values between 0 and 1. Vertical sand drain of 42 m long are installed to have soil improved. Embankment and foundation is divided into 10 material zone(fig.2). The total area of embankment and foundation is descretized into 322 rectangular elements with 359 nodes. Sand drains are modeled as 1-dimensional seepage pipe element as proposed by Sakajo(1987). As because ground just under the embankment is improved using sand drain, properties of material zone 2, 4 and 7 are considered as most sensitive for optimization. Elastic consolidation analysis is performed and hence, sand drain permeability (Kv), soil permeability (Kx, Ky) and Young's modulus of Elasticity (E) are optimized sequentially. Surface settlement at the center of embankment, lateral displacement at 4.0m, 9.0m, 13.9m and 21.0m depth below the embankment toe and pore pressures at 21.0m and 29.5m depth at the center of embankment are considered as observed data.

3. RESULT AND DISCUSSION

Pipe element permeability changes sufficiently to accommodate the sand drain behavior. Installation of sand drain also improves the overall stiffness, specially in material zone 2, 4, and 7. So, improved Young's modulus of elasticity reduces the error criterion (J_u) drastically (Table.1) to adjust the displacement behavior. Observed small lateral displacement around material zone 4, gives the impression of having stiffer material in that zone. Considering this information as a prior information from geologic measurement, Young's modulus of elasticity is optimized. Series of figures under Fig.3 show very good improvement towards the matching of observed and calculated deformations and pore pressure compare to the non-inverse case. Optimized parameters have been selected based on objective to subjective ratio, λ=1.0, which yields the minimum J_u. It is to be noted that surface settlement is not uniform around the vertical axis like pure embankment model test. This also may influence to have the difference between observed and calculated surface settlement. Fig.3 (a) and (b) show lower surface settlement and slower pore pressure dissipation respectively than those of the observed. Having too much lateral deformation in Ac_1 layer may cause the flow disruption along the vertical sand drains subsequently reducing the pore pressure dissipation. It is obvious that observed data has an important effect on optimization. Measuring the deformation, specially lateral deformation, in the field consists of considerable uncertainty. Type, location, quantity and quality of observed data are also very important for a successful optimization.

4. CONCLUSION

Optimization for different type of parameter is working very well. Obtained result has a very good agreement with the expected result. The desired optimization program is expected to work by searching the gradient direction, so that different type of parameter can be optimized simultaneously. Further study is required in algorithm development to consider simultaneous optimization of different type of parameter. Solution of multi- collinearity problem among the parameters is one of the most important research directions in this field.

5. ACKNOWLEDGEMENT

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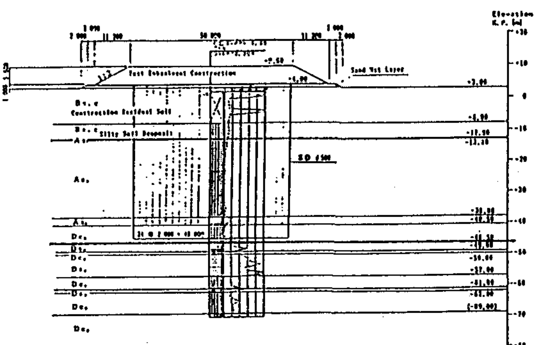

Fig.1 Soil Foundation Profile

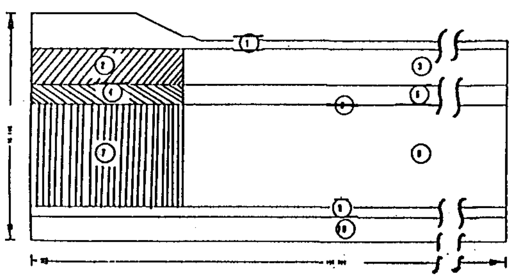

Fig.2 Model Zonation

Table.1 Parameter optimization

PARM	INITIAL	FINAL	J_o (I/F)	J_p (I/F)	ABIC	MEAN
K_{p1} K_{p2}	.625E-8 .625E-8	.120E-5 .450E-7	27645./ 18456.	311.8/ 255.5	519.2	.625E-6 .625E-6
K2 K4 K7	4.7E-8 3.2E-8 2.1E-8	N.S.	--	--	--	4.7E-5 3.2E-5 2.1E-5
E2 E4 L_1 E7	1.30E3 4.10E2 1.27E2	4.60E2 9.31E2 4.33E2	18463./ 8310.	9126.3/ 231.1	501.5	6.0E2 1.0E3 4.0E2
E2 E4 L_2 E7	4.60E2 9.31E2 4.33E2	5.82E2 9.56E2 3.97E2	8310./ 8536.	232.7/ 22.6	500.2	6.0E2 1.0E3 4.0E2
E2 E4 L_3 E7	4.60E2 9.31E2 4.33E2	4.06E2 9.32E2 4.31E2	8310./ 8347.	232.7/ 184.0	501.1	6.0E2 1.0E3 4.0E2

(*) K_p : Sand drain permeability (m/sec)
K : Soil permeability (m/sec)
E : Soil Young's modulus (t/m^2)
J_o : Objective information
J_p : Subjective information

N.S. : Not Sensitive
I/F : Initial / Final
L_1 : λ = 1.0
L_2 : λ = 2.0
L_3 : λ = 0.5

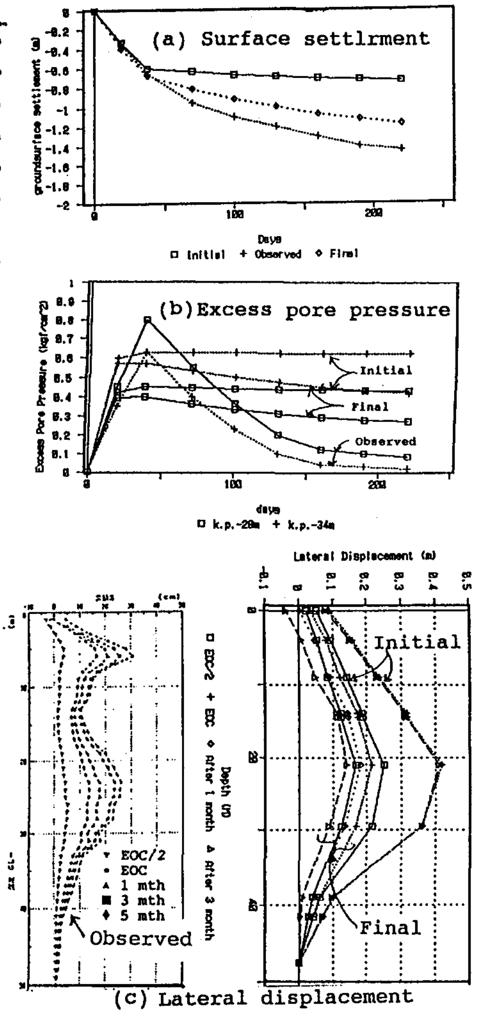

Fig.3 Deformations and excess pore pressure distribution before and after optimization