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SIMULATION OF LONG-TERM CONSOLIDATION BEHAVIOUR OF SOFT SENSITIVE CLAY

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ABSTRACT

Rational prediction for long-term consolidation response of soft clay has been an active research since long. Depending on soil conditions, excess pore water pressures are sometimes increased or become stagnant over a period of time following the ceasing of applied load. This unusual phenomenon is mainly due to the degradation of soil-structure that is more pronounced in soft sensitive clay. This type of unstable soil behaviour and its long-term effects have not been possible to simulate successfully till date. For example, pore water pressure profiles beneath the test embankments over highly sensitive Champlain clay at Saint Alban show that pore water pressures continue to increase for some times even after the completion of the construction [1, 2]. In the present paper, an attempt has been carried out to simulate this kind of anomalous soil behaviour during the long-term consolidation process.

For the realistic representation of soft soil conditions, the elasto-viscoplastic constitutive model [3] with consideration for structural degradation of soil skeleton [4, 5] is used. Present simulation method is based on a two-dimensional updated Lagrangian finite element framework under plane strain condition. Based on Euler's backward implicit time integration scheme, the final system of equation is solved using a two-dimensional computer code through the implementation of an automatic time increment selection scheme [5].

The layered and overconsolidated Champlain clay beneath the test embankments at St. Alban is considered [2]. Construction history of the test embankment D is shown in Fig. 1. Automatically computed time increments [5] for the total computation time of 1000 days are shown in Fig. 2.

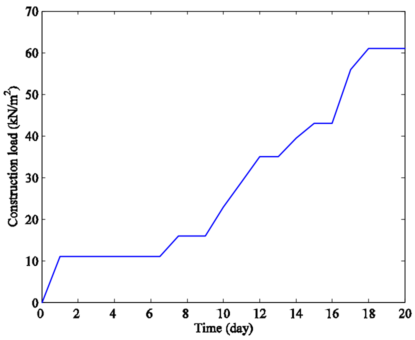

Fig. 1: Construction history

Fig. 3 shows the time history of vertical settlements at the centreline of the embankment (on the surface). The overall agreement between the FEM and experimental results for vertical settlements is quite good. However, the predicted values by the FEM model are slightly smaller than the field responses during the initial period of time, although it predicts slightly larger settlements after around 500 days. Lateral displacements at the toe of the embankment are shown in Fig. 4. Up to the end of the computation time, i.e., up to 1000 days, the predicted values by the current simulation procedure are almost similar, although they become larger just before and after the end of the construction but rapidly converge towards the field values. Pore water pressures at 2.25m depth below the centreline of the embankment also agree well with the field data as presented in Fig. 5. The time history of pore water pressures shows that pore water pressures increase with time, even sometime after ceasing the construction load. This anomalous pore water pressure generation is analogous to that observed in the field tests. Thus the elasto-viscoplastic constitutive model considering structural degradation effect is capable of reproducing the long-term consolidation response of soft sensitive clay, including the atypical pore water pressure generation after the end of the construction of the embankment.

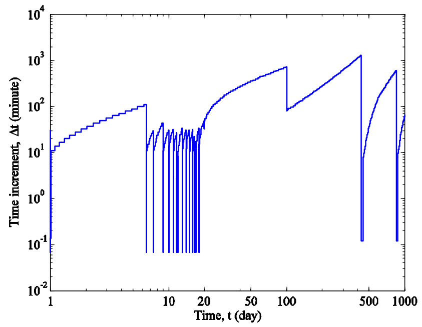

Fig. 2: Time Increments

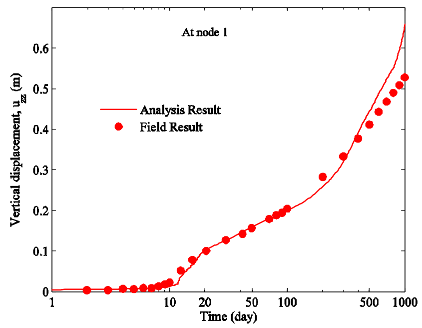

Fig. 3: Settlement at the centre

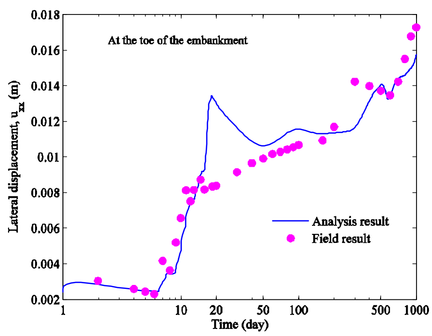

Fig. 4: Lateral displacements at toe

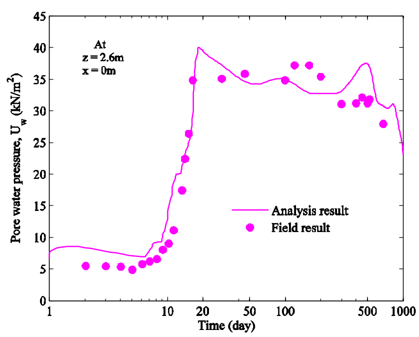

Fig. 5: Pore water pressures

REFERENCES

[1] M. Kabbaj, F. Tavenas and S. Leroueil, "In situ and laboratory stress-strain relationships", *Geotechnique*, Vol. **38**(1), pp. 83-100, 1988.

[2] F. Oka, F. Tavenas and S. Leroueil, "An elasto-viscoplastic FEM analysis of sensitive clay foundation beneath embankment", *Proc. 7th Int. Conf. Comput. Methods Adv. Geomech.*, Vol. **2**, pp. 1023-1028, 1991.

[3] T. Adachi and F. Oka, "Constitutive equations for normally consolidated clay based on elasto-viscoplasticity", *Soils Found.*, Vol. **22**(4), pp. 57-70, 1982.

[4] S. Kimoto, F. Oka and Y. Higo, "Strain localization analysis of elasto-viscoplastic soil considering structural degradation", *Comput. Methods Appl. Mech. Engrg.*, Vol. **193**, 2845-2866, 2004.

[5] M. R. Karim, *Simulation of long-term consolidation behaviour of soft sensitive clay using an elasto-viscoplastic constitutive model*, Doctoral Thesis, Kyoto University, Japan, 2006.