Ⅲ - A172

Self-weight consolidation in a clay layer at a constant rate of increasing thickness

Goro Imai　○ Bipul Chandra Hawlader　*Yokohama National University, Japan.*

ABSTRACT: One dimensional self-weight consolidation of a fresh sedimented soil during continuous sedimentation is analyzed with a consolidation model with creep and the obtained result is compared with one of the non-viscous model.

INTRODUCTION

A variety of soil deposition is possible in nature and practice. Intermittent deposition of dredged slurry onto a closed reclaimed area is the major one in engineering practices, in which pump-dredged soil slurry is discharged continuously. Soil particles of the dredged slurry undergo sedimentation as well as simultaneous consolidation. Therefore, it is required to develop a theoretical base to estimate the progress of consolidation of a soil layer which increases in thickness with time. This type of land formation by dredging is normally done over a large area compared to its thickness with applied surface loading being almost zero, and it is time consuming. Therefore, one dimensional compression of the layer occurs while effective stress reaches equilibrium with the self-weight of soil as well as the effect of viscosity. This consolidation process occurs under very low effective stress level, i. e. large void ratio and very high compressibility with largely changing permeability. These special conditions are taken into account in this study.

CONSOLIDATION MECHANISM

To make a theoretical model of self-weight consolidation process for a sedimented fresh soil, consolidation theory developed by Imai (1995) is used with some restriction.

PARAMETER SELECTION

Compression index $C_c = -(1+e)A/0.434$ is here obtained from a linear relationship $\log(1+e) = A \log\sigma' + D$ which has been proposed by Yano *et. al.* (1988) and means the linearity between natural strain and logarithm of effective stress. Permeability k is obtained from another relationship, $\log c_v = B \log\sigma' + \log c_{v0}$ proposed by Yano (1988) and Yamauchi (1991), using the definitions $k = \gamma_w m_v c_v$ and $m_v = (1/\sigma').[-A(1+e)/(1+e_0)]$, that is the next equation is used here.

$$\log k = (A+B-1)\log \sigma' + \log(-A\gamma_w c_{v0})$$

NUMERICAL TREATMENT

At first, the authors considered that a very thin layer of fresh soil (3 mm) initially lies on an impermeable bed with uniform void ratio and effective stress. Then the further sedimentation continuously increases the thickness of the soil layer. But, for the purpose of numerical analysis, this process is considered here to be step by step accumulation of a fresh sediment of 1 mm. It instantly covers the top surface of the previously sedimented soil and starts to consolidate due to its self weight just after this formation being accompanied with the consolidation of the underlying soil.

The whole consolidation process has been solved by a computer program coded in FORTRAN 90. The way to solve the non linear differential equation by a finite difference technique is described in detail by Hawlader and Imai (1997). The computational parameters used in this analysis are A=-0.127, B=0.465, c_{v0} = 6.17 cm^2/d, σ'_0 =0.1gf/cm^2, e_0 = 7.25, C_s =0.16 and a =0.05.

COMPUTATION RESULTS

Consolidation state of the total soil layer is described by the average degree of consolidation ($\bar{U}$)defined as $\bar{U} = 1 - \frac{\Sigma u \Delta\xi}{\Sigma \gamma' h \Delta\xi}$. Where, h is the depth of a soil layer from its top and u is the remaining pore pressure at the depth h and is $\gamma' h - \sigma'$. The average degree of consolidation ($\bar{U}$)is close to 1 in the early stage of deposition, i.e. the deposit is in a highly consolidated state. As the deposition proceeds with time, the degree of consolidation reduces because of the retardation of water squeeze, and the soil layer goes into a lower degree of consolidation state.

The effect of deposition rate for same soil is shown in Fig. 1. From this figure it is clear that, slower the deposition rate, higher the degree of consolidation.

Figure 2 shows the progress of consolidation during deposition and also subsequent consolidation for three different ending time of deposition. In this figure arrows indicate the end of deposition which is in different thickness and in different consolidation states. In the same figure, dotted lines show the solution obtained from the non-linear and non-viscous model proposed by Yamauchi *et. al.* (1991). They demonstrate that the progress of consolidation retards by the effect of viscosity. Therefore, the solution from this viscous model (solid line) lies above the one from non-viscous

Key words: Continuous sedimentation, Self-weight consolidation, Viscosity.
Corresponding Address: Dept. of Civil Engineering, Yokohama National University, Tokiwadai 79-5, Yokohama 240.
Tel. 045-339-4038　Fax. 045-331-1707

model (dotted line). At the same time required time of consolidation is also longer when viscosity is considered.

Pore pressure isochorones in Fig. 3 shows the local change in consolidation state during the formation of the soil layer. In this figure excess pore pressure (u) is normalized by $\gamma' H$ and depth of soil layer is normalized by H, where H is the total thickness of the soil layer at any time. Excess pore pressure is initially zero at any position of the layer and then increases with deposition, and at infinite time it becomes to 1 at the bottom of the deposit. The excess pore pressure dissipation after the end of deposition at 3000 min is shown in Fig. 4.

CONCLUDING REMARKS

A realistic model to simulate a consolidation process during continuous sedimentation followed by self-weight consolidation is proposed with a finite difference solution method considering the effect of viscosity. In order to asses its applicability accurate field measurements in soft soil will be needed.

REFERENCES

Imai, G. 1995. Analytical examination of the foundation to formulate consolidation phenomena with inherent time dependence. *Key Note Lecture, com.and cons. of clayey soil, , IS-Hiroshima, Japan,* vol.2, 891-935.

Imai, G. *et. al.* 1992 A constitutive equation of one-dimensional consolidation derived from inter-connected tests. *Soils and Found.*, 32(2): 83-96.

Hawlader, B. C. and Imai, G. 1997. Effect of viscosity during self-weight consolidation of fresh sedimented soil. *Proc. of 32nd annual meeting of JSSMFE.* (submitted).

Yamauchi, H. *et. al.* 1991. Sedimentation-consolidation analysis of pump-dredged cohesive soils. *Geo-coast'91,* Yokohama, 129-134.

Yano , K. *et. al.* 1988. On multi-stage sedimentation test of cylindrical clay sample for pump dredging. *Proc. of 23rd annual meeting of JSSMFE.* 223-226. (in Japanese).

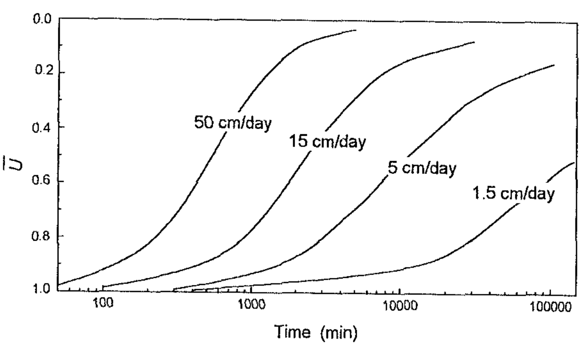

Fig. 1 Effect of deposition rate

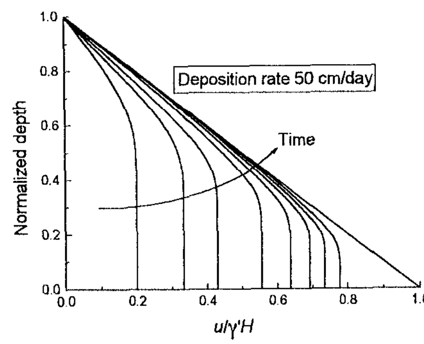

Fig. 3 Pore pressure isochrone during deposition

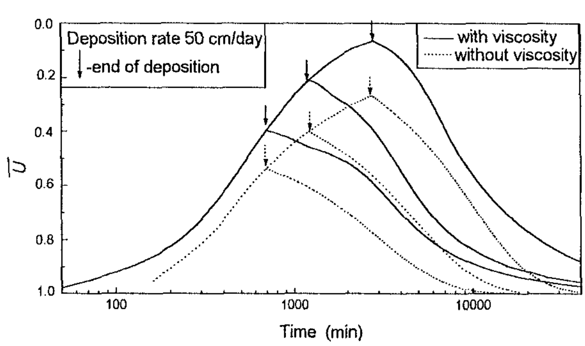

Fig. 2 Average degree of consolidation during and after formation of clay layer

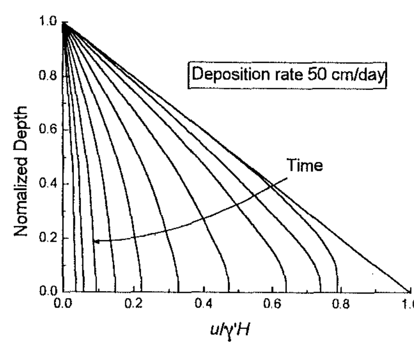

Fig. 4 Pore pressure isochrone after end of deposition