Table 3. C_f value for a few clay deposits

Deposit	C_f value	Method for evaluation field of hydraulic conductivity	Remarks
Bangkok clay at Asian Institute of Technology campus	25	Back-analysis	Chai et al. (1995)
Bangkok clay at Nong Hao (close to sea)	4	Back-analysis	Chai et al. (1996)
Malaysia Muar clay deposit	2	Back-analysis	Chai and Bergado (1993)
Ariake clay (close to sea area)	4	Back-analysis	Chai and Miura (1999)
Clayey deposit in Eastern China	6	Back-analysis	Shen et al. (2000)
Louiseville (Canada)	About 1[a]	Self-boring permeameter	Tavenas et al. (1986)
St-Alban (Canada)	About 3[a]	Self-boring permeameter	Tavenas et al. (1986)

[a]Laboratory value was determined by direct measurement. For other cases, laboratory values were deduced from C_v value (C_v is coefficient of consolidation).

for the coefficients of consolidation. It is guessed that for the two cases reported by the writers, Yokohama site may have a smaller C_f value and Banjarmasin site may have a larger C_f value. This can be confirmed if the field test data of embankments on the natural deposits are available. If this is the case, the c_h values adopted in the analyses by the writers can be explained in a more rational way.

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TWO CASE STUDIES OF CONSOLIDATION SETTLEMENT ANALYSIS USING CONSTANT RATE OF STRAIN CONSOLIDATION TEST[i)]

Closure by Koji Suzuki[ii)] and Kazuya Yasuhara[iii)]

The writers treated consolidation settlement started from overconsolided state. Therefore, consolidation in the two case studies presented in Figs. 15 and 19 can be divided into three phases.

Phase I (before PVD installation): the deposit is in overconsolidated state and consolidation is one dimensional.

Phase II (after PVD installation): the deposit is in overconsolidated state and consolidation includes radius drainage. From PVD installation to 450 days for Isogo case and 280 days for Banjarmasin case.

Phase III (after PVD installation): the deposit is in normally consolidated state and consolidation includes radius drainage. After 450 days for Isogo case and 280 days for Banjarmasin case.

The discussers pointed out two important aspects in prediction of consolidation with vertical drains. The first one is the effect of smeared zone and the second is the difference of permeability between laboratory specimens and actual deposits. These two aspects are studied in succeeding paragraphs for each phase by comparing the results of analysis and actual settlement behavior shown

i) Vol. 44, No. 6, December 2004, pp. 69–81. (Previous discussion by J.-C. Chai, N. Miura and S. Hayashi, Vol. 46, No. 2, April 2006, pp. 267–268).
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in Figs. 15 and 19.

In the Isogo case, the ground settled 80 cm during Phase I, where the settlements were one dimensional and there was no smear effect. These settlement can be explained by the analysis using $c_{v(OC)}$ values deduced from laboratory consolidation tests as indicated in Fig. 15. This fact suggests that there is no difference in permeability in vertical direction between laboratory and field. In the Banjarmasin case, the ground settled about 10 cm before the installation of PVD. Although the settlement is not so large, the comparison between the actual settlement and the result of analysis shown in Fig. 19 also implies no difference in permeability in the field and laboratory.

The settlement in Phase III gives useful information of stratification such as thin sand layers and sand seams, because its effect grows after vertical drains are installed (Tanaka et al., 1991). The analysis was performed for Phase III settlement with assuming that apparent value of c_h is equal to $c_{v(NC)}$ determined by laboratory consolidation test. This assumption has widely been employed in routine and conventional design of vertical drain method, according to the experiences in the past. The results of analyses well agree with the actual settlements during Phase III observed in the two cases as presented in Figs. 15 and 19. If the past experiences, on which $c_h = c_{v(NC)}$ is based, are obtained from soft clay deposits without stratification, it could be said that there is no effect of stratification in the consolidation settlement of the two cases. There are some papers that pointed out that laboratory tests generally underestimate permeability of clay deposits in the field. However, the two cases reported by the writers did not show such difference in permeability.

The agreement between the actual settlement and analysis with $c_h = c_{v(NC)}$, observed in Phase III in both cases, also suggests that there is no difference in smear effect on how to determine apparent value of c_h in the two cases after the ground went into normally consolidated state.

When the consolidation was in Phase II, the writers used apparent value of $c_{h(OC)}$ equal to $c_{v(NC)}$ ($=170\ cm^2/d$) for Isogo case, while that for Banjarmasin case is $c_{v(OC)}$ ($=800\ cm^2/d$), which is 40 times as large as $c_{v(NC)}$ ($=20\ cm^2/d$). This mean that smear effect in Phase II settlement is larger in Isogo case with higher $c_{v(NC)}$ than in Banjarmasin case with lower $c_{v(NC)}$, as the discussers pointed out. This also means that smear effect in Phase II (overconsolidated state) is different from that in Phase III (normally consolidated state).

In order to discuss this matter, smear effect for overconsolidated state should be investigated for clays with various values of c_v. However, it is very difficult to determine consolidation parameters in overconsolidation state. Due to this reason, the writers tried to use more reliable parameter ($c_{v(NC)}$) to explain the difference in determining apparent values of $c_{h(OC)}$, even though fundamental base is lacking. Therefore, as of this moment, accumulation of case histories seems the most effective option to discuss this matter.

Vertical drain method has become very popular technique to improve soft clay deposits. However, test embankment is highly recommendable to determine appropriate parameters for analysis, in particular, for the area there is no past experience.

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