Geotechnical Engineering, Vol. 23, 1992

A NOTE ON THE PREDICTION OF SECONDARY COMPRESSION

by

N.S. Pandian[1], A. Sridharan[2] and K.S. Kumar[3]

ABSTRACT : Based on Parkin's velocity method for the evaluation of C_v, a new approach is suggested for the determination of secondary compression and ultimate settlement. The needed input parameters are simple to determine.

KEY WORDS Secondary Compression, Consolidation, Time factor, Primary compression, Ultimate settlement.

NOMENCLATURE

C	: Constant of integration
C_v	: Coefficient of consolidation
e	: Void ratio
e_{100}	: e at the end of primary compression
H	: Average thickness of consolidating layer
H_{field}	: H in field
H_{lab}	: H in laboratory
K	: Ratio of secondary compression to thickness of consolidating layer
K_{lt}	: Limiting value for K
S	: Slope of secondary compression line
T	: Time factor
t	: time
t_{100}	: t corresponding to end of primary compression
$t_{100\ field}$	: t_{100} in field
$t_{100\ lab}$	: t_{100} in laboratory
U	: degree of consolidation

[1] Assistant Professor

[2] Professor and Chairman, Division of Mechanical Sciences
Department of Civil Engg., Indian Institute of Science Bangalore 560 012, INDIA.

[3] Scientific Officer
Indira Gandhi Centre for Atomic Research, Kalpakkam 603 102, INDIA.

$\frac{dU}{dT}$	: Theoretical consolidation rate
Δ ult	: Ultimate settlement
Δ e	: Change in void ratio
Δe_{100}	: Δ e due to primary compression
Δe_s	: Δ e due to secondary compression
δ	: Compression
δ_{100}	: δ due to primary compression
δ_s	: δ due to secondary compression
$\delta_{s\ field}$	: δ_s in field
$\delta_{s\ lab}$	: δ_s in laboratory
$\frac{d\delta}{dt}$	: time rate of compression
$(\frac{d\delta}{dt})_{100}$	: $\frac{d\delta}{dt}$ corresponding to end of primary compression

INTRODUCTION

In general, secondary compression forms only a minor part of the total compression and hence, is usually neglected. But, in the case of soft clays, micacious soils and highly organic soils, it can be comparable to that of primary compression. Hence, it cannot be neglected in such situations. The relation between time and secondary compression continues to be investigated. Many researchers have stated that secondary compression proceeds linearly with logarithm of time (Buisman, 1936, Zeevart, 1957, Aboshi, 1973 and Yashuhara, 1982). Some have concluded that secondary compression can be nonlinearly varying with logt (Leonards and Altschaeffl, 1964, and Choi and Lepeda-Diaz, 1981). It has been also reported that secondary compression varied linearly with both logt and t (Terzaghi, 1953). Different definitions have been given to secondary compression by different authors and methods suggested for the evaluation (Wahls, 1962, Mesri and Godlewski, 1977, Sridharan and Sreepada Rao, 1981, Tan, 1971 and Kee, 1971).

VELOCITY METHOD

Parkin's (Parkin, 1978) velocity method is for the evaluation of coefficient of consolidation C_v. Parkin compared the characteristic features of theoretical consolidation rate dU/dT versus time factor T on a log-log plot with those of experimental settlement rate dδ/dt versus time t on a log-log plot. The theoretical plot obtained using Terzaghi's theory is given in Fig. 1. It is evident that the slope of the curve increases during the later stages of T, tending to infinity. However, the experimental plots of log (dδ/dt) vs. logt do not show increase in slope beyond a certain

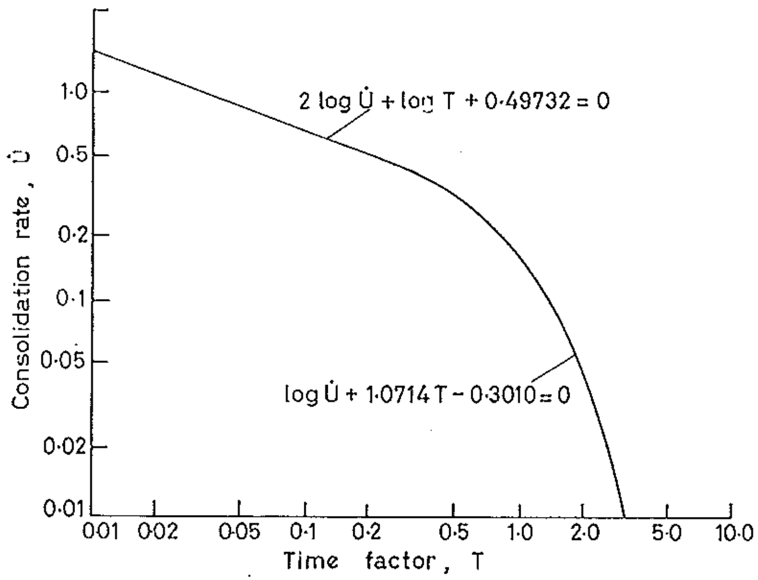

Fig. 1

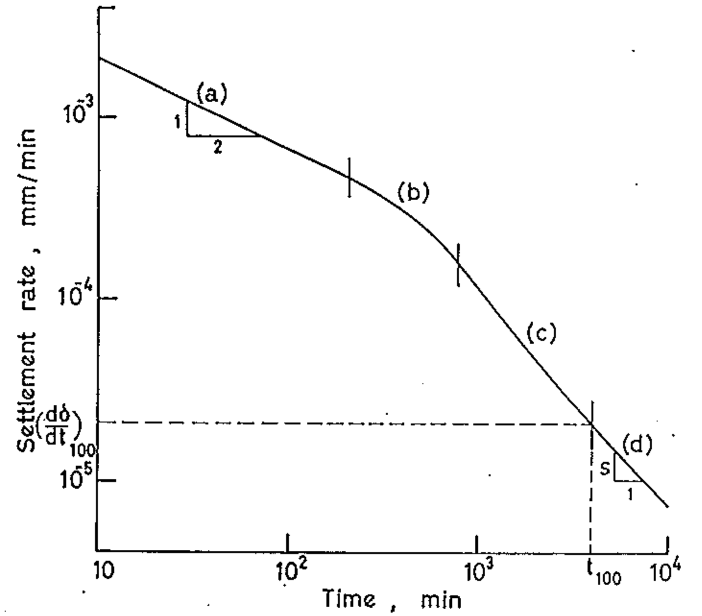

Fig. 2

value. This can be attributed to the presence of secondary compression in real soils.

PROPOSED METHOD

Figure 2 shows a typical log $(d\delta/dt)$ vs. logt plot based on experimental results (Patrick and Parkin, 1985). It shows a linear portion of slope 1 : 2 (a) which is present in the theoretical plot followed by a curved portion (b) commencing at $U \approx 50\%$ also following Terzaghi's theory, but leading to a linear section which does not conform to the theoretical relation (c) (that is, the slope tending to infinity). This is followed by another straight line (d) the slope of which depends on the magnitude of secondary compression. Thus, comparing with the theoretical plot, it can be stated that the first straight line (a) corresponds to less than 50% consolidation, the second straight line (c) is just before the end of primary compression and the last one (d) after the dominance of secondary compression begins. So, the second straight line can be considered as a tangent at 100% primary compression. The intersection point of lines (c) and (d) gives $(d\ \ /dt)_{100}$ and t_{100} which can be taken as constants. If S is the slope of the secondary compression line (d),

$$S = \frac{\log \frac{d\delta}{dt} - \log\left(\frac{d\delta}{dt}\right)_{100}}{\log t - \log (t)_{100}}$$

$$\log \frac{d\delta/dt}{(d\delta/dt)_{100}} = S \log \frac{t}{(t)_{100}} = \log \left(\frac{t}{t_{100}}\right)^S$$

$$\frac{d\delta}{dt} = \left(\frac{d\delta}{dt}\right)_{100} \left(\frac{t}{t_{100}}\right)^S$$

$$d\delta = \left(\frac{d\delta}{dt}\right)_{100} \left(\frac{t}{t_{100}}\right)^S dt$$

Integrating

$$\delta = \frac{\left(\frac{d\delta}{dt}\right)_{100} \left(\frac{1}{t_{100}}\right)^S t^{S+1}}{S+1} + C$$

The constant of integration C can be evaluated using the condition that at $t = t_{100}$, $\delta = \delta_{100}$.

$$C = \delta_{100} - \frac{\left(\frac{d\delta}{dt}\right)_{100} \left(\frac{1}{t_{100}}\right)^S t_{100}^{S+1}}{S+1}$$

$$\delta = \left(\frac{d\delta}{dt}\right)_{100} \left(\frac{1}{t_{100}}\right)^S \left[\frac{t^{S+1} - t_{100}^{S+1}}{S+1}\right] + \delta_{100}$$

The amount of secondary compression in the lab. specimen is found from

$$\delta_{s\ lab} = \delta - \delta_{100} = \left(\frac{d\delta}{dt}\right)_{100} \left(\frac{1}{t_{100}}\right)^S \left[\frac{t^{S+1} - t_{100}^{S+1}}{S+1}\right]$$

$$t_{100\ field} = t_{100\ lab} \left[\frac{H_{field}}{H_{lab}}\right]^2$$

The secondary compression in the field is given by

$$\delta_{s\ field} = \frac{\delta_{s\ lab}}{H_{lab}} H_{field} = K\, H_{field}$$

The limiting void ratio has been reported to be 0.25 (Schofield and Wroth, 1968) and this limit enables the determination of the ultimate settlement.

$$e_o - (\Delta e_{100} + \Delta e_s) = 0.25$$

$$\Delta e_s = e_o - \Delta e_{100} - 0.25$$

$$K_{lt} = \frac{\delta_{s\ lab}}{H_{lab}} = \frac{\Delta e_s}{1+e_o}$$

$$= \frac{e_o - \Delta e_{100} - 0.25}{1+e_o}$$

In order to limit the final void ratio to 0.25, the value of K is restricted to K_{lt}

i.e., $K \leq K_{lt}$

The amount of ultimate settlement is estimated as

$$\Delta_{ult} = K_{lt}\, H + \delta_{100}$$

CONCLUSION

A method is suggested for the estimation of secondary compression and total compression based on simple input parameters. This approach needs to be verified based on laboratory/field data.

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