Consolidation principles in foundation design

Omid Giyasi Tabrizi[1], Naser Alizade Agdam[2]

[1.] BS student of Civil Engineering, Tabriz Branch, Islamic Azad University, Tabriz, Iran
[2.] BS student of Civil Engineering, Tabriz Branch, Islamic Azad University, Tabriz, Iran
Corresponding Author's: Omid Giyasi Tabrizi.
ghiasi_omid1367@yahoo.com

Abstract: The primary and secondary consolidation settlements, of saturated cohesive soils are generally estimated using consolidation theory. 'A consolidation test is performed to obtain a compression parameter for the amount of settlement and a consolidation parameter for the settlement rate estimate. The over consolidation ratio OCR can also be determined from this test. The test is performed on an "undisturbed" sample which is placed in a consolidation ring available in diameters ranging from 45 to 115 mm (1.8 to 4.5 in). The sample height is between Z(1 and 30 mm (0.75 and 1.5 in); 20 mm is the most commonly used thickness to reduce test time. The larger-diameter samples give better parameters, since about the same amount of disturbance is developed for any size sample, with the relative effects less for the larger samples. The most common test diameter is 64 mm (2.5 in), since this best balances the costs of sample recovery and disturbance effects. Tube diameters larger than 76 mm may result in a premium charge for the sample-particularly if a larger borehole must be made.

[Omid Giyasi Tabrizi, Naser Alizade Agdam. **Consolidation principles in foundation design**. *Life Sci J* 2013; 10(6s):775-778] (ISSN: 1097-8135). http://www.lifesciencesite.com. 123

Key words: consolidation- soil pressure- premium change- undisturbed stress.

Introduction:

The consolidation test proceeds by applying a series of load increments to the sample and recording sample deformation at selected time intervals. Sufficient laboratory data should be obtained to allow computation of the water content w_N and the specific gravity so that the void ratio at any time interval can be computed.

The load-deformation data are plotted on either a semi logarithmic plot or $\sqrt{t}$ as illustrated in Fig. 2-10. The purpose of these plots is to obtain the time at some percent consolidation. The t5o value (time at 50 percent) is most commonly used, and the procedure for obtaining it is to obtain the dial reading at 100 percent consolidation D_{100} and the dial reading at the start of the test D_o.

The procedure for finding D_o is to either-use the actual initial dial reading at the start of the test or, if the initial curve is parabolic, find the apparent value. This may be necessary, since one cannot plot log time at t = 0. The corrected value of D_o is found as follows:

1. Select a time t_1 in the parabolic portion.
2. Select a second time $t_2 = 4t_1$ in the parabolic part.
3. Obtain the offset between t_1 and t_2.
4. Plot this offset distance above t_1 to obtain D_o.

The D_{100} value is obtained as the intersection of tangents drawn to the midcurve area and the end portion as shown on Fig. 2-10a. Considerable interpretation is necessary if the curve does not exhibit a pair of identifiable tangent zones. Sometimes an increase in vertical scale will improve the tangent locations.

The D_{5o} (or other percent consolidation value) is obtained from D_o and D_{100}. This value projected to the settlement curve allows one to obtain t_{50} from the time axis.

The $\sqrt{t}$ method is also used to obtain t5,. This method involves plotting the dial reading versus $\sqrt{time}$ with a straight line estimated for the first-several points. This line is extended to the abcissa, and a point 15 percent larger is located (see Fig. 2-10b). Through this point and the intercept of the ordinate axis a second straight line is drawn. When the dial reading versus time curve intersects this second line, the D_{90} value is obtained. The apparent initial dial reading Do is obtained where the initial straight-line part of the settlement curve intersects the ordinate axis. With D_{90} and D_o values it is easy to obtain D_{50} and r_{50} which is most commonly used. Values of t_{50} should compare by the two methods, but in real soils large differences are sometimes obtained. The $\sqrt{time}$ method is more rapid, since the test for that load increment can be terminated when D9o is found; however,[1] if secondary compression is to be estimated, the semilog plot should be used).

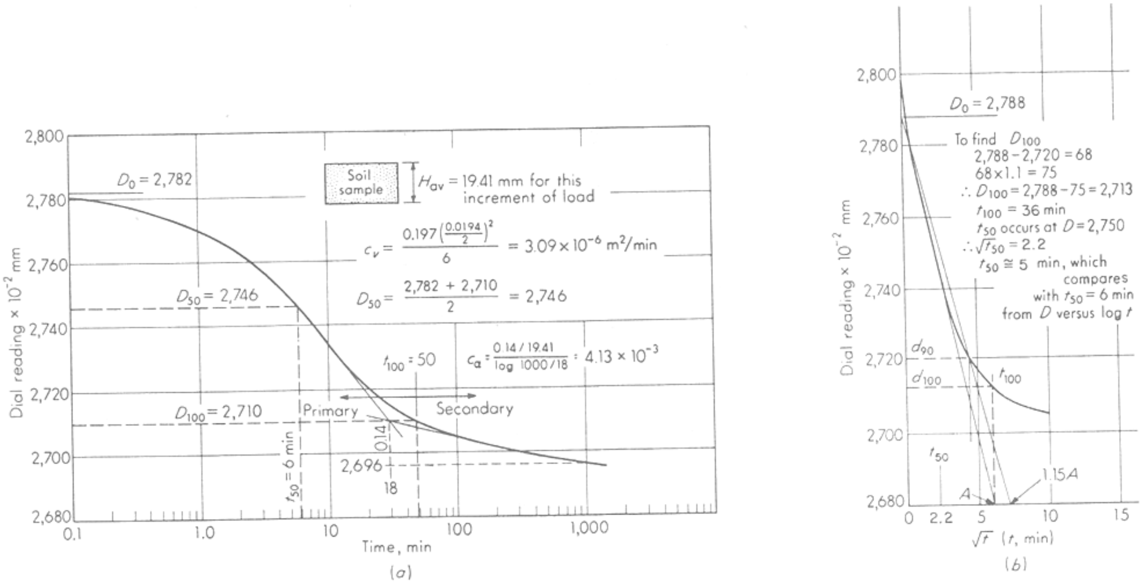


Figure 2-10

The Coefficient of Consolidation cv

The t_{50} data are used to compute the coefficient of consolidation c_v as

$$c_v = \frac{T_i H^2}{t_i}$$

where T_i = time factor

H = length of longest drainage path for a particle of water; in the laboratory it is the half sample thickness when drainage is from both faces

T_i = time for i percent consolidation to take place- t_{50} is usually used

Case I is usually assumed in the conventional laboratory test. For 50 percent consolidation Eq. becomes

$$c_v = \frac{0.19H^2}{t_{50}}$$

The several load increments give separate values of c_v which can be plotted on the void ratio or strain versus log p curve shown in Fig. 2-ll. The plot is usually very erratic because of changes in void ratio, temperature, and S.

The curve can be smoothed somewhat by using a small vertical scale-beyond this it is an exercise in engineering judgment to determine the value of c, to use for estimating field settlements. The time for a given settlement to take place in the field is obtained as a rearrangement of Eq. to obtain

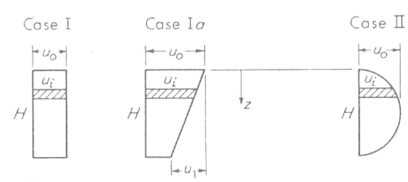
$$T_i = \frac{T_i H_f^2}{c_v}$$

Primeny consolidation settlements

Primary consolidation settlements occur during the time of an excess porepressure gradient caused by a stress change in the stratum of interest. At the end of primary consolidation the excess pore pressure is very nearly zero and the stress change has gone from a total to an effective state. Additional settlements termed secondary compression (or consolidation) continue for some additional time. ThAse will be considered in a later section.

Table 2-4 Time factors for indicated pressure distribution

U, %	Case I	Case II
0	0.000	0.000
10	0.008	0.048
20	0.031	0.090
30	0.071	0.115
40	0.126	0.207
50	0.197	0.281
60	0.287	0.371
70	0.403	0.488
80	0.567	0.652
90	0.848	0.933
100	∞	∞



The sharp break in the e versus log p or ε versus log p curve is used to estimate whether the soil is preconsolidated. Casagrande (1936) proposed the method shown in Fig. 2-11 a to determine a value of p_c. Steps in the method are:

1. Determine by eye the sharpest curvature and draw a tangent.
2. Draw a horizontal line through the tangent point and bisect the angle a thus produced [2].

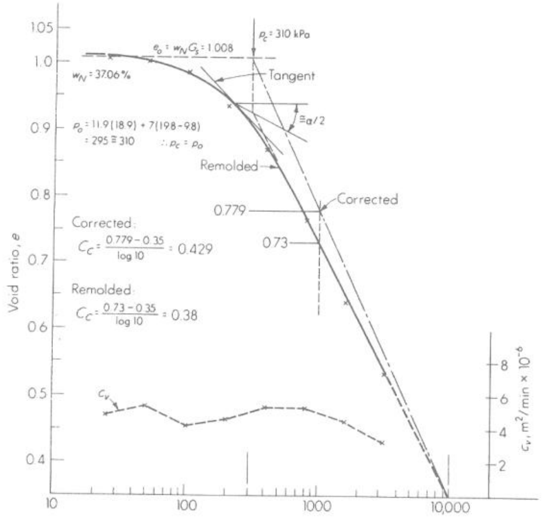


Figure 2-11. Methods of presenting settlement data to obtain settlement parameters C_c and C_c'.

Method of correcting normally consolidated clay [after Schmertmann (I9SS)] is shown on (a). Data used to plot both curves are shown on (6). Slight discrepancy between C_c', values due to plotting.

Substituting Δe from Eq. (a), we obtain

$$\Delta n = \frac{a_v \Delta p}{1+e_o} = m_v \Delta p$$

where m_v = coefficient of volume compressibility:

$$m_v = \frac{a_v}{1+e_o} = \frac{\varepsilon}{\Delta p} = \frac{1}{E_s}$$

From Fig. 2-12the settlement ΔH is by proportion

$$\frac{\Delta H}{H} = \frac{\Delta e}{1+e_o} \qquad \text{(f)}$$

or $$\Delta H = m_v \Delta p H = \varepsilon H \qquad \text{(g)}$$

where H = total thickness of stratum and ε = average unit strain in H.

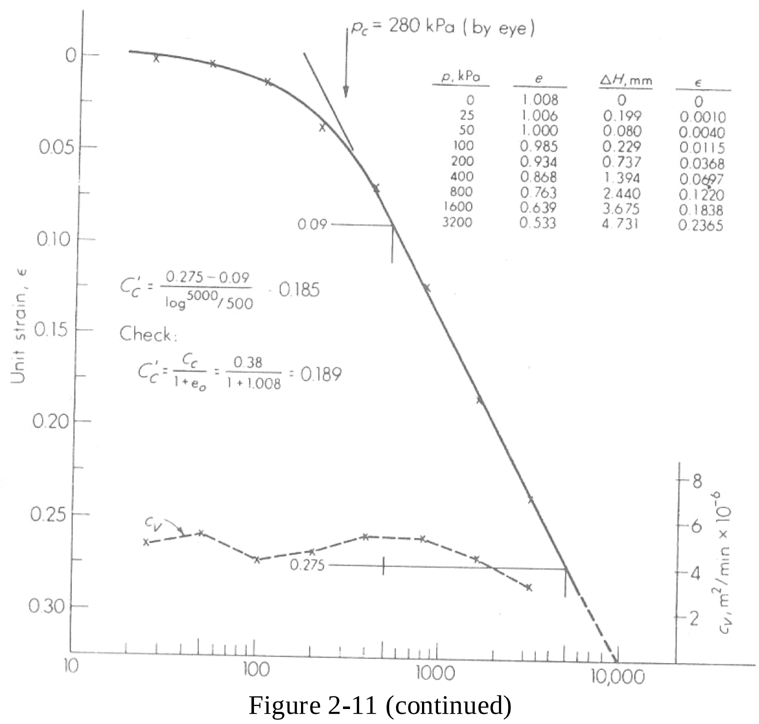


Figure 2-11 (continued)

From the definition of C_s and Eq. (f),

$$\Delta H = \frac{C_c H}{1+e_o} \log \frac{p_2}{p_1}$$

For a normally consolidated soil with increase in effective pressure of Δp we have

$P_2 = P_o + AP$ and $p_1 = P_o$ and

$$\Delta H = \frac{C_c H}{1+e_o} \log \frac{p_o + \Delta p}{p_o}$$

From inspection of Fig. 2-13

And $$\Delta H = \Delta e = C_c \log \frac{p_2}{p_1}$$

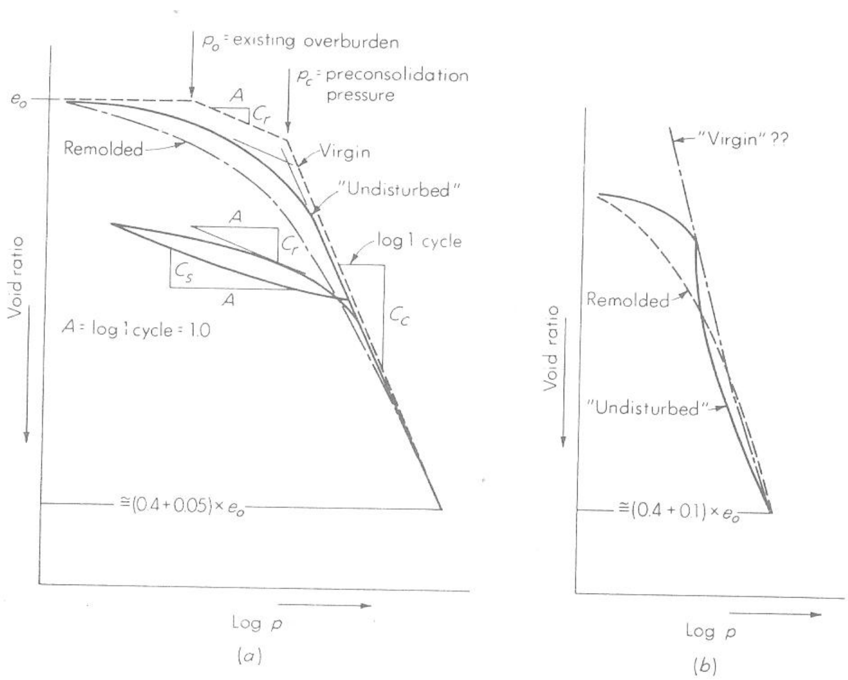


Figure 2-12

Void ratio versus log p curves. (a) General plot for a reconsolidated soil with method shown to correct-for sample disturbance using C,. (6) C, is not clearly identified when the soil structure collapses to produce a sharp break in curve.

Also

$$\varepsilon = \frac{\Delta H}{H_t} = \frac{\Delta H}{1+e_o} = C_c' \log\frac{p_2}{p_1}$$

Equating ΔH,

$$C_c'(1+e_o)\log\frac{p_2}{p_1} = C_c \log\frac{p_2}{p_1}$$

$$C_c' = \frac{C_c}{1+e_o}$$

The settlement using C_c' is

$$\Delta H = C_c' H \log\frac{P_2}{P_1}$$

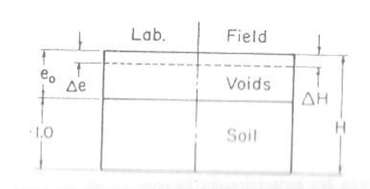


Figure 2-13

Soil relationships for settlement equations. Left side is laboratory, right side field relationships. And for normally consolidated clay[3].

$$\Delta H = C_c' H \,\mathrm{Log}\frac{p_o + \Delta p}{p_o}$$

Conclusion

1- Settlement computations for preconsolidated soils are similar except that the slope of the e versus log p or ε versus log p curve between p_o and p_c.

2- The total JH is the sum of the computed settlements along the two branches and should be significantly less than for a normally consolidated soil.

Reference

1- Bjerrum, L., et al. (1969), Reduction of Negative Skin Friction on Steel Piles to Rock, 7th IC5MFE, vol. 2, pp. 27-34.
2- Blaine, E. S. (1967), Practical Lessons in Caisson Sinking from the Baton Rouge Bridge, ENR, Feb. 6, pp. 213-21 S.
3- Blanchet, R., et al. (1980), Behavior of Friction Piles in Soft Sensitive Clays, CGJ, vol. 17, no. 2, May, pp. 203-224.

1/2/2013