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EFFECT OF DISSOLVED AIR IN WATER ON CONSOLIDATION TEST RESULTS

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Abstract

Although the total settlement of saturated clay specimens under the action of vertical pressure increment includes the immediate settlement, primary consolidation settlement, and secondary compression settlement, the traditional consolidation test results only show the primary consolidation settlement and secondary compression settlement. Therefore, in the case where the primary consolidation settlement contains immediate settlement, the line type of the fitting curve of consolidation test deviates from the theoretical one. In view of this, the authors of this paper redefine saturation and immediate settlement for the first time and provide a trial-and-error procedure to separate the immediate settlement and primary consolidation settlement. Further, through two case studies, the following are determined: (1) When the pore space of the clay specimen is filled with water containing highly compressible dissolved air, and the dissolved air in water is compressed instantaneously after the vertical pressure increment is applied, the sum of the settlements that occur directly or indirectly after the dissolved air in water is compressed is defined as immediate settlement. (2) The proposed trial-and-error procedure can clearly distinguish the immediate settlement of the seemingly saturated clay specimen from the primary consolidation settlement. (3) The immediate settlement of the seemingly saturated clay specimen is a highly complex nonlinear problem, and its magnitude may exceed half of that of the primary consolidation settlement; therefore, it cannot be calculated by the elastic theory formula, because such kind of calculation will give an incorrect result that the immediate settlement is only a small part of the total settlement. (4) When the primary consolidation settlement does not contain the immediate settlement, the line type of the fitting curve of consolidation test will be consistent with that of the theoretical one; therefore, the difference between the coefficients of consolidation obtained by the square root of time fitting method and the logarithm of time fitting method will be greatly reduced. Based on the above four conclusions, the authors suggest to incorporate the definition of immediate settlement and the trial-and-error procedure proposed in this paper into traditional soil mechanics. This would ensure that the consolidation test results including the immediate settlement, primary consolidation settlement, and coefficient of consolidation meet practical needs.

Keywords: dissolved air in water, seemingly saturated clay, consolidation test, immediate settlement, primary consolidation settlement.

Introduction

Figure 1 shows that in the traditional consolidation test, the soil specimen is tested under the K_0 condition, where the lateral displacement is constrained.

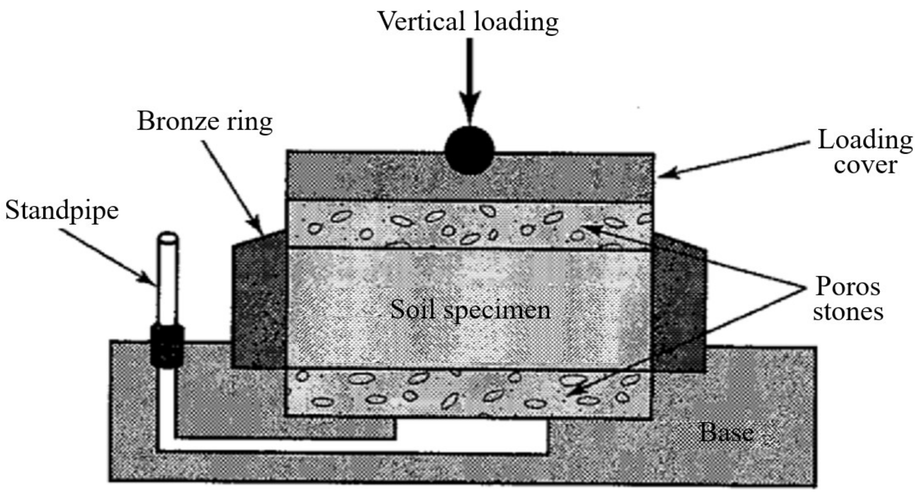
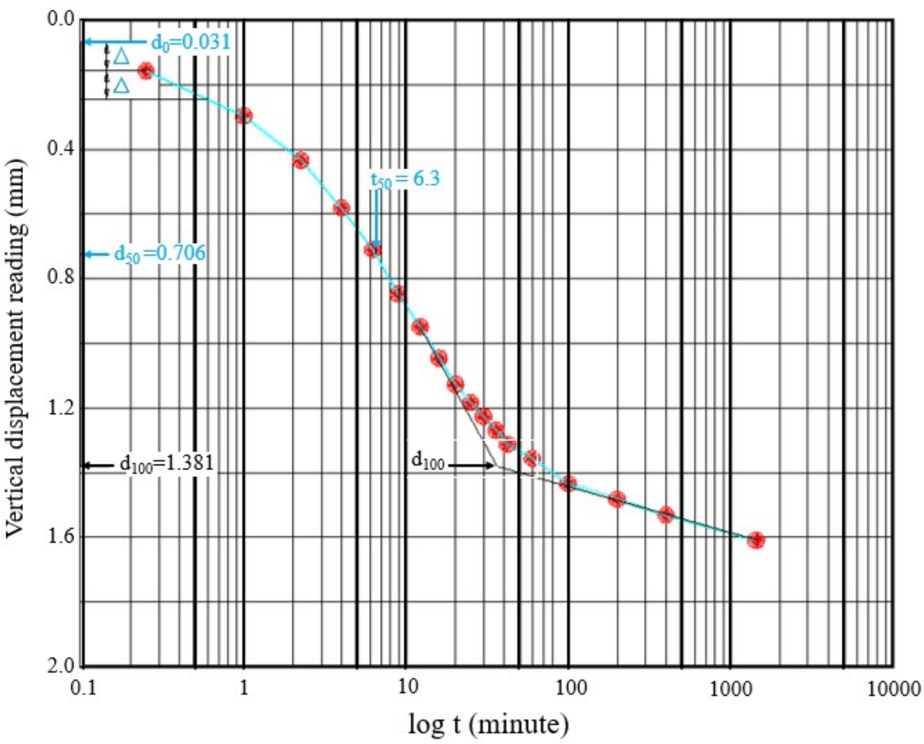
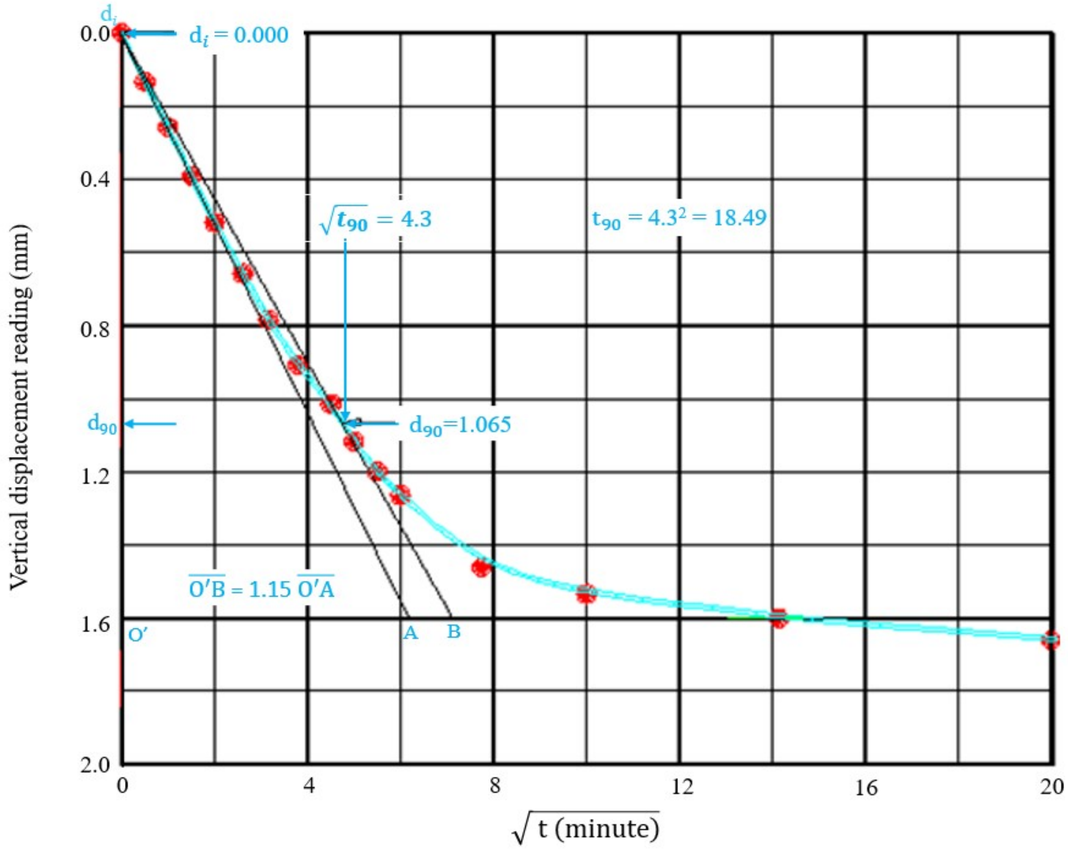


Figure 1. Traditional K_0 consolidation test for saturated clay (McCarthy, 2007).

As shown in Figure 2, Taylor (1948) obtained the consolidation test results of vertical displacement readings with respect to logarithm of time and square root of time in the case when a vertical pressure increment was applied.



(a) Changes in vertical displacement with logarithm of time.



(b) Changes in vertical displacement with square root of time.

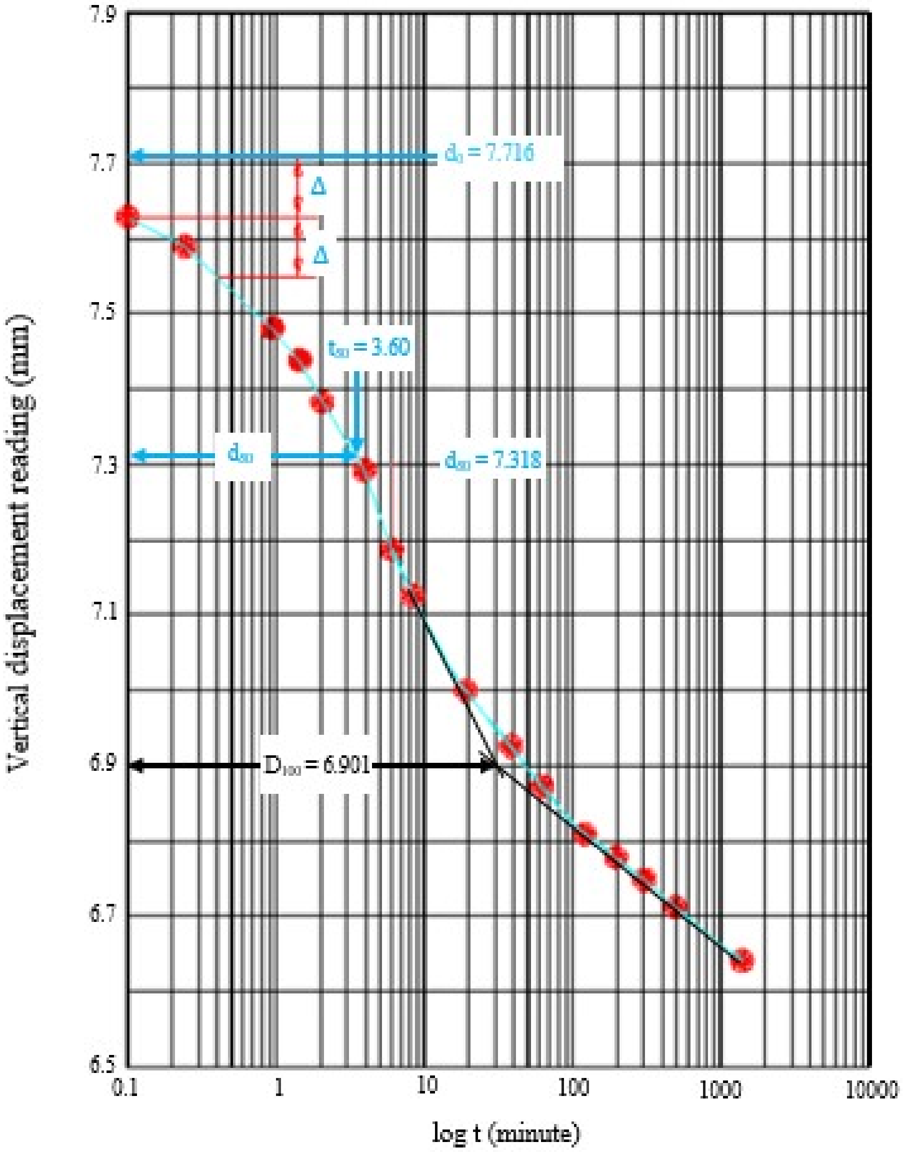
Figure 2. Consolidation test results of Taylor (1948).

Figure 2a shows that the vertical displacement for a 0% consolidation ratio is d_0 = 0.031 mm and that for a 100% consolidation ratio is d_{100} = 1.381 mm. Then, by the linear relationship, the vertical displacement for a 90% consolidation ratio is calculated as d_{90} = 1.246 mm.

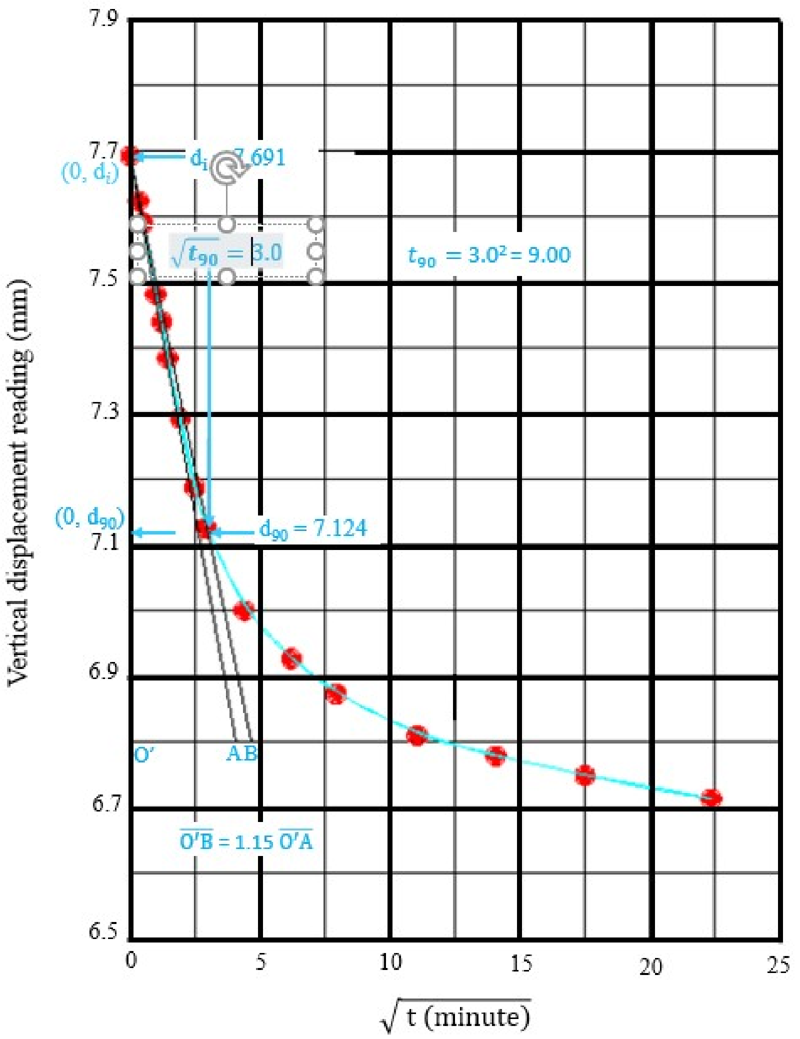
Figure 2b shows the intersection of the line connecting (0, d_i) and point B and the square root of time fitting curve of consolidation test. Theoretically, the consolidation ratio corresponding to the intersection should be 90%, and its corresponding vertical displacement d_{90} should be 1.246 mm. However, the actual vertical displacement for the intersection is 1.065 mm, and its corresponding consolidation ratio is only 78.9%.

Figure 3 shows the result of the consolidation test conducted by Lambe

(1951). By comparison, the problem of excessive error in the consolidation test result is consistent in Figures 2 and 3.



(a) Vertical displacement changes with logarithm of time.



(b) Vertical displacement changes with square root of time.

Figure 3. Traditional consolidation test results of Lambe (1951).

Figure 3a shows that by the logarithm of time fitting method (Taylor 1948), d_0 is 7.716 mm and d_{100} is 6.901 mm. Then, by linear relationship, d_{90} is calculated as 6.983 mm.

Figure 3b shows the intersection point of the line connecting (0, d_i) and point B and the square root of time fitting curve of consolidation test. Theoretically, the consolidation ratio corresponding to the intersection should be 90%, and the corresponding vertical displacement d_{90} should be 6.983 mm. However, the actual vertical displacement is 7.124 mm, with the corresponding consolidation ratio being only 72.6%. The above facts clearly show that the traditional consolidation test results have been difficult to apply due to excessive errors. To improve the above-mentioned problem, the fitting curves of consolidation tests obtained by using the square root of time fitting method (Taylor, 1948) and the logarithm of time fitting method need to be corrected.

Redefinition of the Immediate Settlement

In traditional soil mechanics, the water in the pore space is assumed to be incompressible, so saturation is defined as the pore space of the soil being filled with water. Based on the above assumption and definition, immediate settlement (or volume distortion settlement) is defined as the settlement caused by instantaneous volume distortion under the action of vertical pressure and the conditions of undrained and no volume change (McCarthy, 2007).

However, in the K_0 consolidation test, under the condition that the lateral displacement is constrained for the saturated clay specimen, the settlement can only occur in the vertical direction. Therefore, under the condition of no volume change (i.e., the volumetric strain ε_v is equal to zero), the traditionally defined immediate settlement cannot exist, although the immediate settlement does exist in the consolidation test result.

Fredlund (1976) showed that at 20 °C and 1 atmospheric pressure, 1000 cm^3 of water contains 18 cm^3 of dissolved air. The coefficients of compressibility of air (c_a) and pure water without dissolved air (c_w) are 6.96 x 10^{-3} m^2/kN and 4.67 x 10^{-7} m^2/kN (Richard *et al*., 1970), respectively. According to You (1977), the coefficient of compressibility of soil solid (c_s) is approximately 10^{-8} m^2/kN and that of the saturated clay layer (a_v) is approximately10^{-3} to 10^{-5} m^2/kN. Then, the coefficient of compressibility for water containing dissolved air (c_{aw}) can be calculated as 1.26 x 10^{-4} m^2/kN. Since c_{aw} is approximately 270 times c_w, the water containing dissolved air cannot be assumed to be incompressible. The state where the pore space is filled with water containing dissolved air should therefore be called the seemingly saturation state.

For the seemingly saturated clay layer, the authors redefine immediate settlement as follows: When the seemingly saturated clay specimen is under vertical pressure, the immediate settlement is the sum of the direct and indirect settlements caused by the instantaneous compression of dissolved air in the water. The direct immediate settlement comes from the compression of the dissolved air in the water, while the indirect immediate settlement comes from the change in the structure of the plate-like clay particles caused by the volume change of the dissolved air in the water.

Proposed Evaluation Method of the Newly Defined Immediate Settlement

For the consolidation test of the seemingly saturated clay specimen, the initial thickness of the specimen before the application of the vertical pressure increment is H_i, the initial vertical displacement is d_i, and the final thickness of the specimen after the test is completed under the action of the vertical pressure increment is H_f. If the consolidation test result is plotted with the vertical displacement reading and the logarithm of time as the coordinate axes, the logarithm of time fitting method (refer to Figures 2a and 3a) can be used to obtain the following:

1) The vertical displacement d_0 for the consolidation ratio equal to 0%.
2) The vertical displacement d_{100} for the consolidation ratio equal to 100%.
3) The vertical displacement d_{90} for the consolidation ratio equal to 90% calculated by linear relationship.

On the vertical axis of the coordinate of vertical displacement reading and square root time shown in Figure 4, the coordinate points (0, d_i) and (0, d_{90}) are first marked; then, the trial-and-error procedure shown in Table 1 is used to inversely locate the coordinate point (0, d_0) with the aid of the mapping method. Thus, the distance $\overline{d_i d_0}$ between the positions of (0, d_i) and (0, d_0) shown in Figure 4 is defined as the immediate settlement for the seemingly saturated clay specimen.

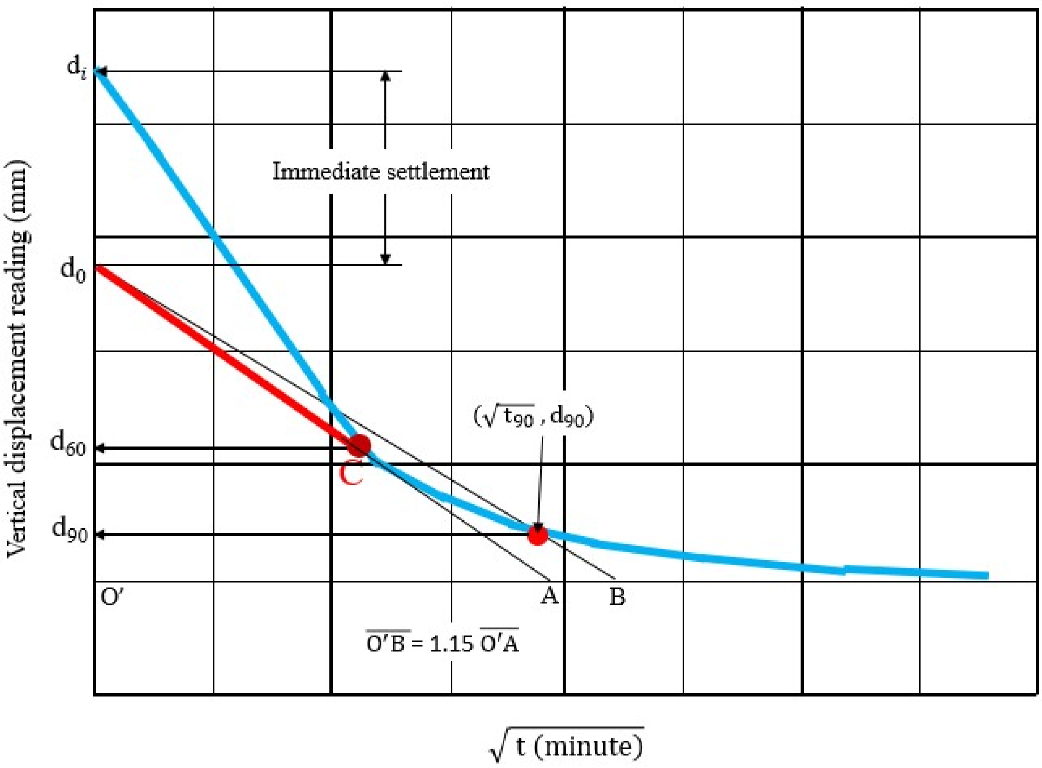


Figure 4. Schematic diagram of using consolidation test results to determine immediate settlement (Hsu, 2006).

Table 1. Trial-and-error procedure for determining immediate settlement.

Step 1: Assume the dissolved air in water will not affect the logarithm of time fitting curves of consolidation tests shown in Figures 2a and 3a.
Step 2: In Figures 2a and 3a, when d_o and d_{100} are obtained by the logarithm of time fitting method, d_{90} is calculated according to the linear relationship
Step 3: In Figures 4, a point (0, d_o) is assumed on the ordinate.
Step 4: Draw a horizontal line through (0, d_{90}) to cross the fitting curve of consolidation test at a point ($\sqrt{t_{90}}$, d_{90}).
Step 5: Connect the two points (0, d_0) and ($\sqrt{t_{90}}$, d_{90}) into a straight line, then the extension line of the straight line and the horizontal line passing through point O′ intersect at point B.
Step 6: Take a point A on the horizontal line $\overline{O'B}$ such that the length $\overline{O'A} = \overline{O'B}/1.15$.
Step 7: Connect the two points (0, d_o) and A to form a straight line $\overline{d_oA}$.

Step 8: When the line $\overline{d_0A}$ is tangent to the square root of time fitting curve of consolidation test at point C and its consolidation ratio is equal to 60%, go to step 9; otherwise, assume another point (0, d_o) again on the ordinate axis, and continue to perform step 4 to step 8.

Step 9: Use the red solid line $\overline{d_0C}$ shown in Figure 4 to correct the logarithm of time fitting curves of consolidation tests as those shown in Figures 2a and 3a.

In the process of locating the vertical displacement d_o, the following two formulas presented by Casagrande (1938) and Taylor (1948) must be met: For consolidation ratio $U \leqq 60\%$,

$$T = \frac{\pi}{4}U^2 \quad \text{(Equation 1)}$$

For consolidation ratio $U > 60\%$,

$$T = 1.781 - 0.933\log(100 - U\%) \quad \text{(Equation 2)}$$

Equations 1 and 2 indicate that the following:

1) When the consolidation ratio is less than or equal to 60%, the relationship curve between vertical displacement reading and square root time obtained from the consolidation test is a straight line.

2) When the consolidation ratio is greater than 60%, the relationship curve between the vertical displacement reading and the square root time obtained from the consolidation test is a curve.

Case Studies

Case 1: Evaluation of immediate settlement of Taylor consolidation test results

1) Correction of the square root of time fitting curve

Figure 2b shows the vertical displacement changes with square root time for the traditional consolidation test results given by Taylor (1948). To correct the consolidation ratio for the intersection of the connection line between point (0, d_0) and point B and the fitting curve of consolidation test equal to 90%, first, with d_{90} = 1.246 mm, a horizontal line passing through the point (0, d_{90}) is drawn, and the horizontal line intersects the square root of time fitting curve of consolidation test at point ($\sqrt{t_{90}}$, d_{90}) as shown in Figure 5. By using the trial-and-error procedure listed in Table 1, the vertical displacement d_0 is obtained as 0.293 mm, and the immediate settlement $\overline{d_i d_0}$ is obtained as 0.293 mm from Figure 5.

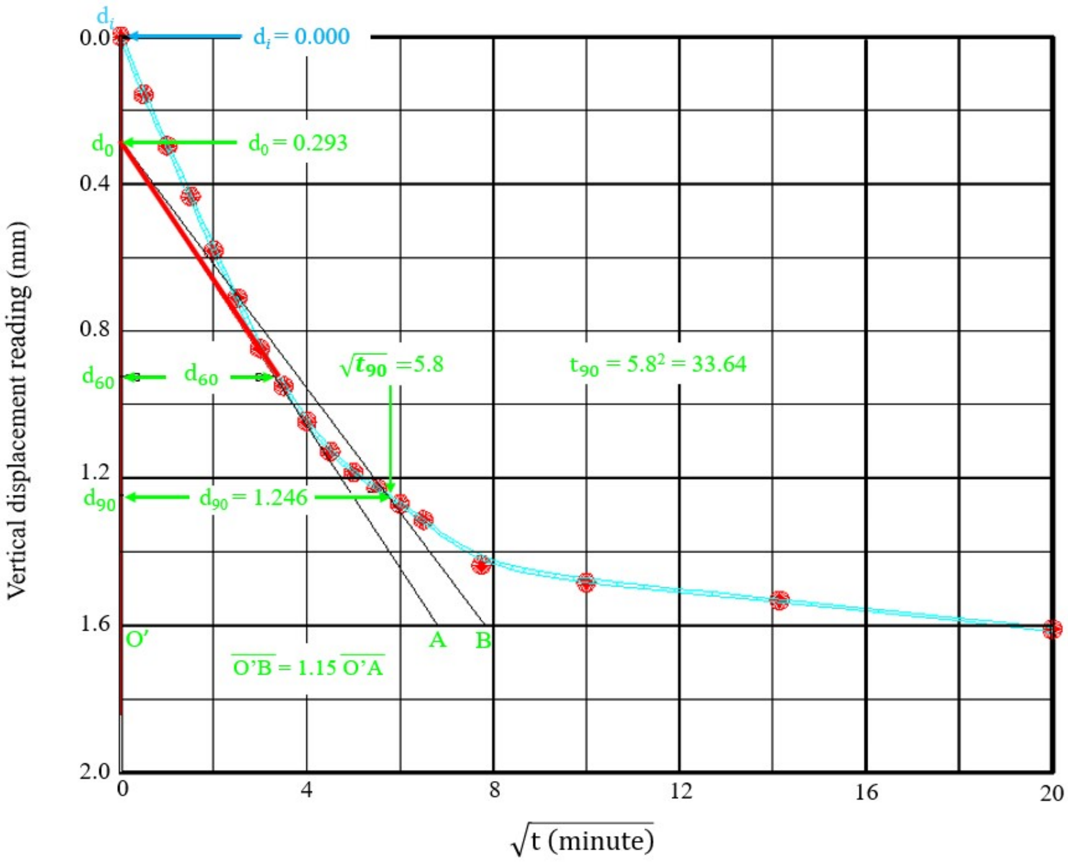
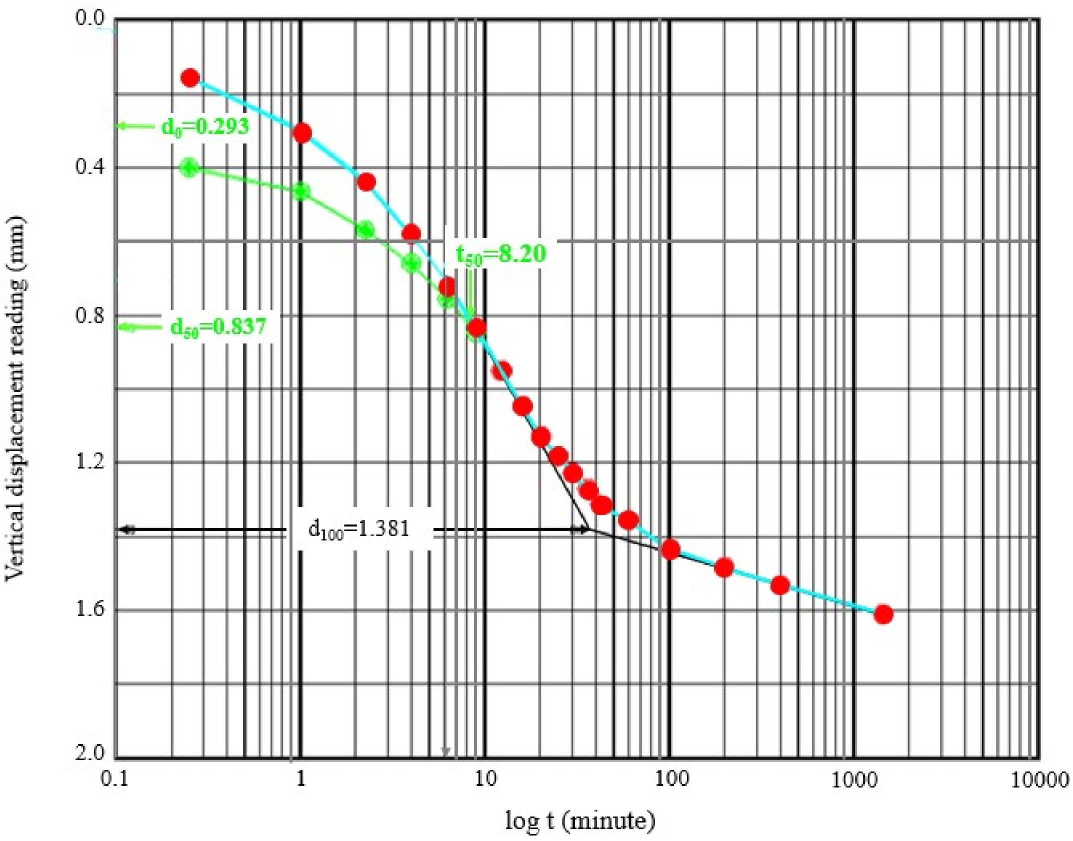


Figure 5. The newly defined immediate settlement obtained through the trial-and-error procedure in case 1.

2) Correction of the logarithm of time fitting curve

Since the immediate settlement and the primary consolidation settlement are separated, the red solid line with the consolidation ratio equal to 0% to 60% for the square root of time fitting curve of consolidation tests shown in Figure 5 can be used to correct the logarithm of time fitting curve of consolidation test shown in Figure 2a. In Figure 6, the green solid line represents the corrected logarithm of time fitting curve of consolidation test; then, the primary consolidation settlement $\overline{d_0 d_{100}}$ shown in Figure 6 is obtained as 1.088 mm. Thus, the ratio of the immediate settlement $\overline{d_i d_0}$ and the primary consolidation settlement $\overline{d_0 d_{100}}$ is 0.269.



Note: The blue solid line and the green solid line represent the consolidation test results before and after correction, respectively

Figure 6. Logarithm of time fitting curves of consolidation tests before and after correction for the immediate settlement (Data before correction are from Taylor, 1948).

3) Calculation of the coefficient of consolidation

In this consolidation test, the vertical pressure applied is 784.56–1569.12 kPa, the thicknesses of the specimen before (H_0) and after (H_f) the test are 2.4468 and 2.2858 cm, respectively. During the test, the top and bottom surfaces of the test specimen are drained, so the maximum drainage path H_{drain} is 1.1832 cm. Figure 6 shows that when the fitting curve of consolidation test does not include immediate settlement, t_{50} is corrected from 6.3 min to 8.2 min, and t_{90} is corrected from 18.49 min to 33.64 min. Thus, based on the above data, Table 2 shows the calculated coefficient of consolidation c_v before and after the correction of immediate settlement using the logarithm of time fitting method and the square root of time fitting method (Taylor, 1948), respectively.

Table 2. Comparison of the calculated coefficients of consolidation c_v obtained by using logarithm of time fitting method and square root of time fitting method before and after the correction of immediate settlement for the consolidation test performed by Taylor (1948).

Before correction:

$$c_v = \frac{T_{50} H_{drain}^2}{t_{50}} = \frac{0.197 \times 1.1832^2}{6.30 \times 60} = 7.30 \times 10^{-4} cm^2/sec.$$

$$c_v = \frac{T_{90} H_{drain}^2}{t_{90}} = \frac{0.848 \times 1.1832^2}{18.49 \times 60} = 1.07 \times 10^{-3} cm^2/sec.$$

After correction:

$$c_v = \frac{T_{50} H_{drain}^2}{t_{50}} = \frac{0.197 \times 1.1832^2}{8.20 \times 60} = 5.61 \times 10^{-4} cm^2/sec.$$

$$c_v = \frac{T_{90} H_{drain}^2}{t_{90}} = \frac{0.848 \times 1.1832^2}{33.64 \times 60} = 5.88 \times 10^{-4} cm^2/sec.$$

For the results of the consolidation test, Table 2 shows that before correcting the immediate settlement, the coefficient of consolidation c_v obtained by the square root of time fitting method is 1.466 times that obtained by the logarithm of time fitting method. In other words, the effect of immediate settlement on the consolidation test results obtained by both methods is not the same. After correcting the immediate settlement, the coefficient of consolidation c_v obtained by the square root of time fitting method is 1.048 times that obtained by the logarithm of time fitting method; in other words, when the fitting curve of consolidation test does not contain immediate settlement, the coefficients of consolidation obtained by both methods tend to be consistent.

Case 2: Evaluation of immediate settlement of Lambe consolidation test results

1) Correction of the square root of time fitting curve

Figure 2b shows the vertical displacement changes with square root time for the traditional consolidation test results given by Lambe (1951). To make the consolidation ratio corresponding to the intersection point of line $\overline{d_0 B}$ and the fitting curve of consolidation test in Figure 2b equal to 90%, by using d_{90} = 6.964 mm, a horizontal line passing through point (0, d_{90}) is drawn; the horizontal line intersects the square root of time fitting curve of consolidation test at point ($\sqrt{t_{90}}$, d_{90}) as shown in Figure 7. Then, by using the trial-and-error procedure listed in Table 1, the vertical displacement d_0 can be obtained as 7.413 mm, and the immediate settlement $\overline{d_i d_0}$ is obtained as 0.278 mm from Figure 7.

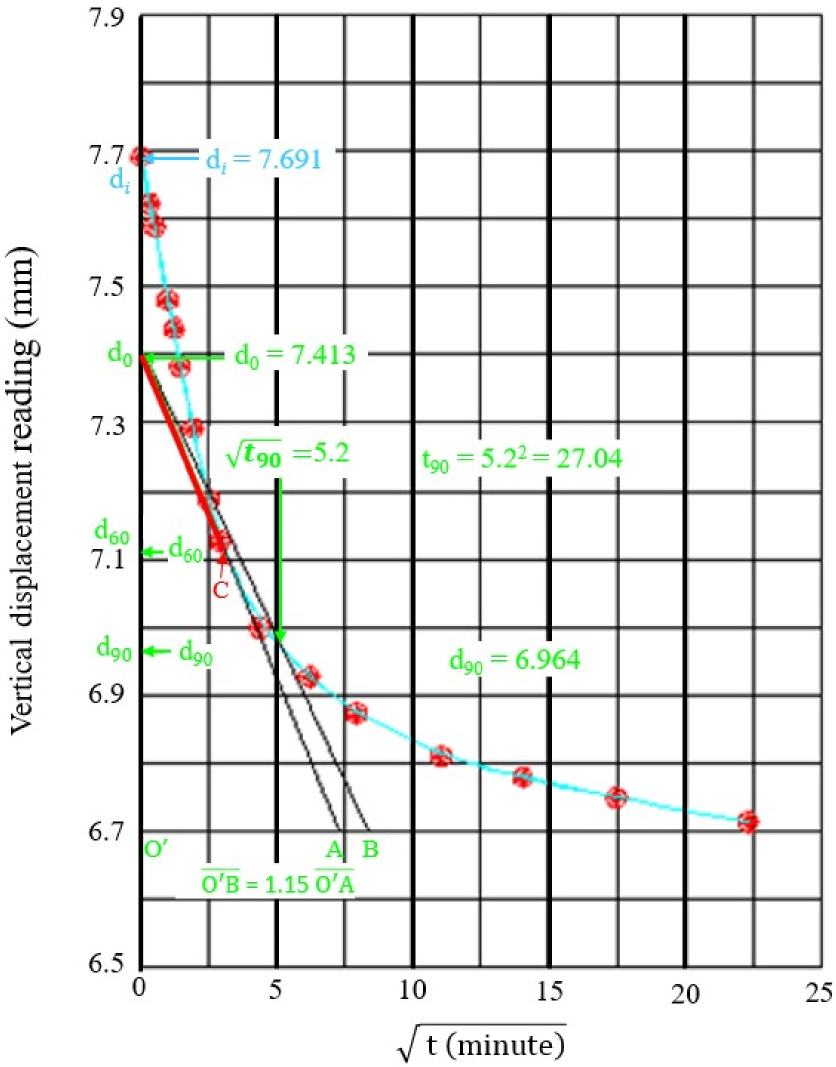
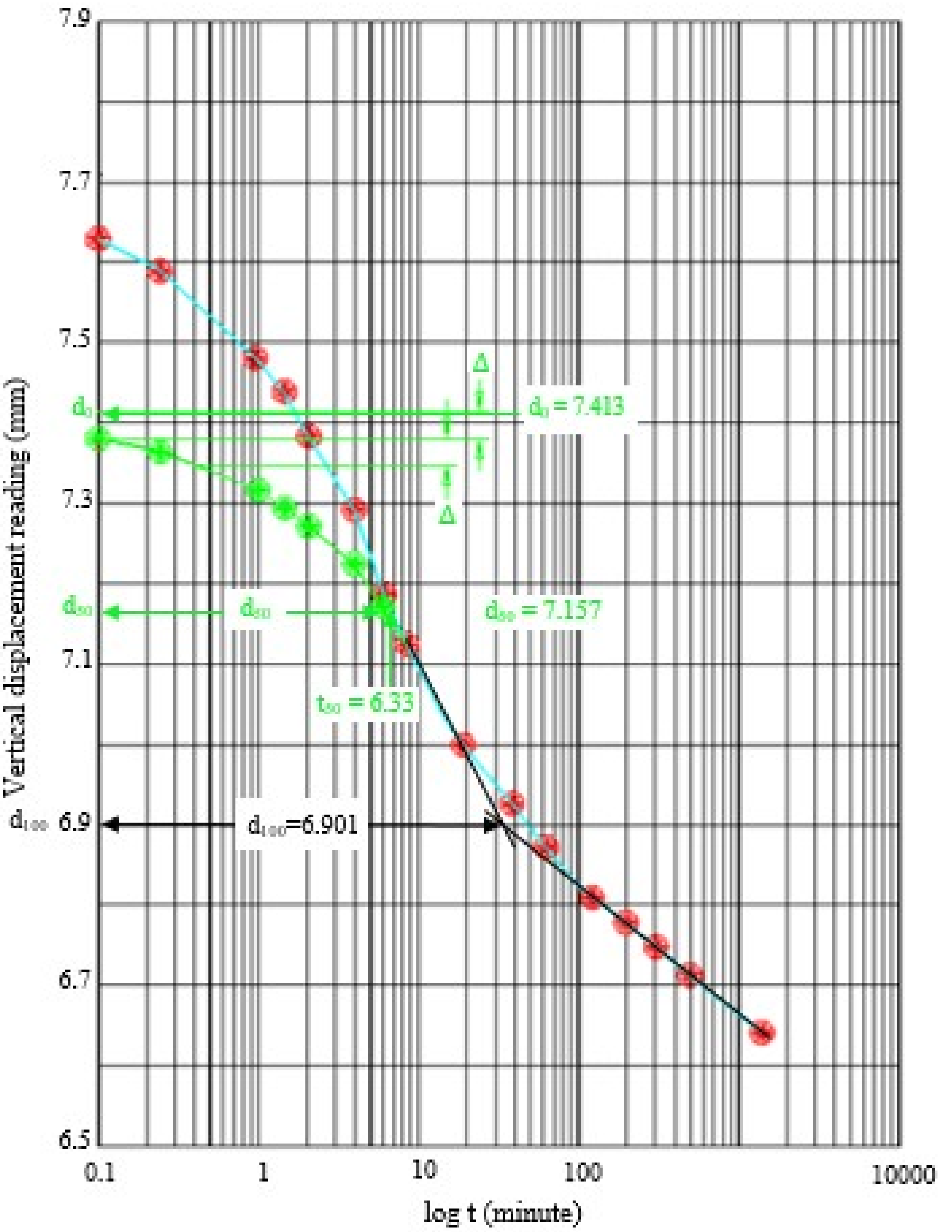


Figure 7. The newly defined immediate settlement obtained through the trial-and-error procedure in case 2.

2) Correction of the logarithm of time fitting curve

Since the immediate settlement and the primary consolidation settlement are separated, the red solid line with the consolidation ratio equal to 0% to 60% for the square root of time fitting curve of consolidation tests shown in Figure 7 can be used to correct the logarithm of time fitting curve of consolidation test shown in Figure 3a. In Figure 8, the green solid line represents the corrected logarithm of time fitting curve of consolidation test; then, the primary consolidation settlement

$\overline{d_0 d_{100}}$ shown in Figure 6 is obtained as 0.512 mm. Thus, the ratio of the immediate settlement $\overline{d_i d_0}$ and the primary consolidation settlement $\overline{d_0 d_{100}}$ is obtained as 0.543.



Note: The blue solid line and the green solid line represent the consolidation test results before and after correction, respectively

Figure 8. Correction of the logarithm of time fitting curve of consolidation test (Data before correction is from Lambe, 1951).

3) Calculation of the coefficient of consolidation

In this consolidation test, the vertical pressure applied is 196.14–392.28 kPa, the thicknesses of the specimen before (H_0) and after (H_f) the test are 3.1115 and 3.0074 cm, respectively. During the test, the top and bottom surfaces of the test specimen are drained, so the maximum drainage path H_{drain} is 1.5297 cm. Figure 8 shows that when the fitting curve of consolidation test does not include immediate settlement, t_{50} is corrected from 3.60 min to 6.33 min, and t_{90} is corrected from 9.00 min to 27.04 min. Thus, based on the above data, Table 3 shows the calculated coefficient of consolidation c_v before and after the correction of the immediate settlement using the logarithm of time fitting method and the square root of time fitting method, respectively.

Table 3. Comparison of the calculated coefficients of consolidation c_v obtained by using logarithm of time fitting method and square root of time fitting method before and after the correction of immediate settlement for the consolidation test performed by Lambe (1951).

Before correction:

$$c_v = \frac{T_{50} H_{drain}^2}{t_{50}} = \frac{0.197 \times 1.5297^2}{3.60 \times 60} = 2.14 \times 10^{-3}\ cm^2/sec.$$

$$c_v = \frac{T_{90} H_{drain}^2}{t_{90}} = \frac{0.848 \times 1.5297^2}{9.00 \times 60} = 3.67 \times 10^{-3}\ cm^2/sec.$$

After correction:

$$c_v = \frac{T_{50} H_{drain}^2}{t_{50}} = \frac{0.197 \times 1.5297^2}{6.33 \times 60} = 1.21 \times 10^{-3}\ cm^2/sec.$$

$$c_v = \frac{T_{90} H_{drain}^2}{t_{90}} = \frac{0.848 \times 1.5297^2}{27.04 \times 60} = 1.22 \times 10^{-3}\ cm^2/sec.$$

For the results of the consolidation test, as shown in Table 3, before correcting immediate settlement, since the primary consolidation settlement contains immediate settlement, the coefficient of consolidation c_v obtained by the square root of time fitting method is 1.715 times that obtained by the logarithm of time fitting method. This result indicates that the effect of immediate settlement on the fitting curves of consolidation tests obtained by the two different methods is not the same.

After correcting immediate settlement, since the primary consolidation settlement does not contain immediate settlement, the coefficient of consolidation c_v obtained by the square root of time fitting method is 1.008 times that obtained by the logarithm of time fitting method. Such a result indicates that without the effect of immediate settlement, the coefficients of consolidation obtained by the two methods tend to be the same.

Comparison and Discussion of Results

1) Before correcting the immediate settlement, after applying the vertical pressure increment, as shown in Figures 2a and 3a, the initial fitting curves of consolidation tests are too steep. As a result, the two t_{50} in the logarithm of time fitting curves of consolidation tests appear low, which in turn cause the calculated coefficients of consolidation c_v to appear high.

2) These problems are present in Figures 2b and 3b also. As a result, the two t_{90} in the square root of time fitting curves of consolidation tests appear low, which in turn cause the calculated coefficients of consolidation c_v to appear high.

3) The corrected square root of time fitting curves of consolidation tests shown in Figures 5 and 7 only contain the primary consolidation settlement; therefore, their line type tends to be consistent with the line type of the square root of time factor fitting curve of consolidation theory shown in Figure 9. As a result, the two t_{90} in the corrected square root of time fitting curve of consolidation tests allow the calculated coefficients of consolidation c_v to meet actual needs.

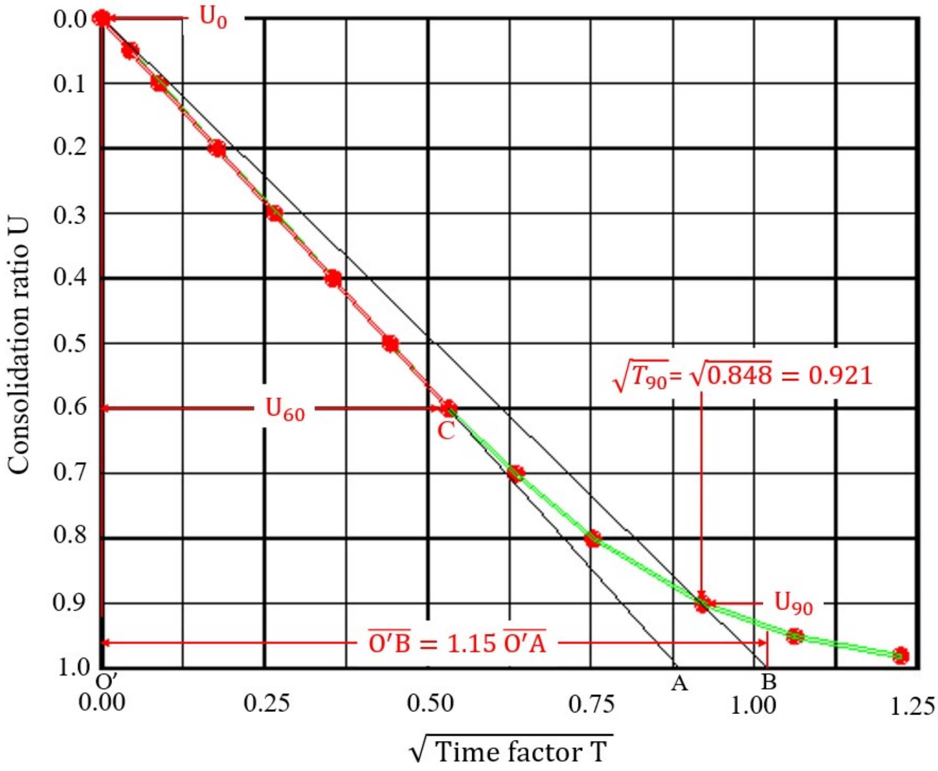


Figure 9. Theoretical consolidation curve of the square root of time fitting method (Reproduced from Taylor, 1948).

4) The corrected logarithm of time fitting curves of consolidation tests shown in Figures 6 and 8 only contain the primary consolidation settlement; therefore, their line type tends to be consistent with the line type of the logarithm of time factor consolidation theory curve shown in Figure 10. As a result, the two t_{50} in the corrected logarithm of time fitting curves of consolidation tests allow the calculated coefficients of consolidation c_v to meet actual needs.

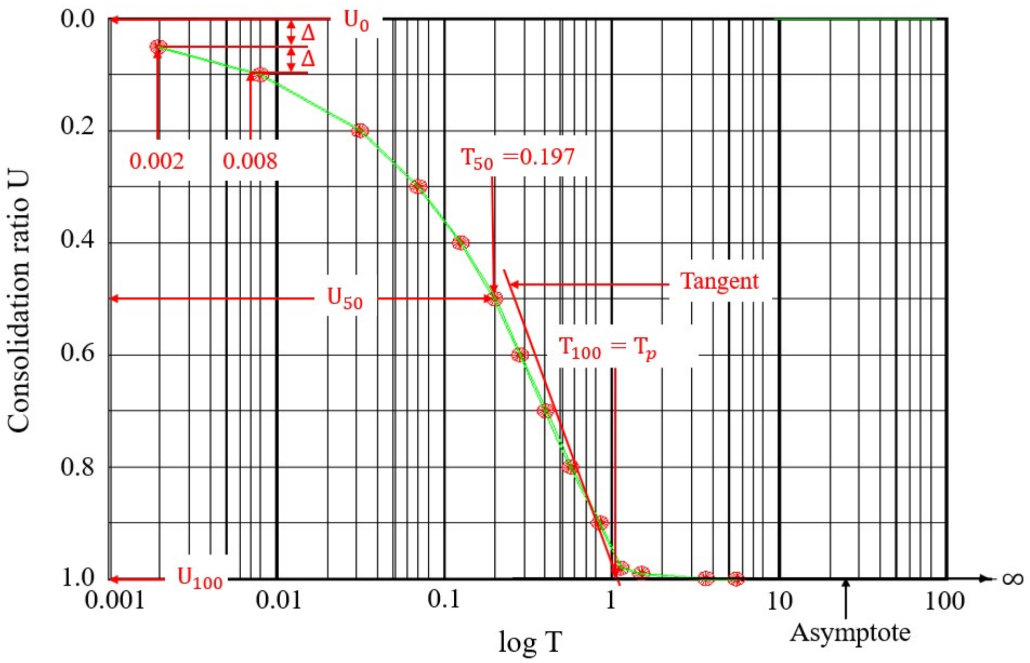


Figure 10. Theoretical consolidation curve of the logarithm of time fitting method (Reproduced from Taylor, 1948).

5) In the square root of time fitting curve of consolidation test, because the primary consolidation settlement includes immediate settlement, the position of the vertical displacement reading d_{90} corresponding to the consolidation ratio equal to 90% falls on the consolidation ratios 78.9% and 72.6% as shown in Figures 2b and 3b, respectively.

6) When the primary consolidation settlement includes immediate settlement, the t_{50} and t_{90} obtained from the test will be lower, resulting in the higher calculated coefficient of consolidation c_v.

7) Since the pore water of the soil contains highly compressible dissolved air, the following assumptions or definitions of traditional soil mechanics are inconsistent with the facts:

   (1) Water containing highly compressible dissolved air is assumed to be incompressible.

   (2) Saturation is defined as the pore space being filled with water containing highly compressible dissolved air.

   (3) When the water containing dissolved air is not drained, it is traditionally assumed that there is no volume change during the test.

   (4) Immediate settlement is defined as the settlement caused by instantaneous volume distortion under no volume change condition after applying the vertical pressure increment.

8) When the seemingly saturated clay is under vertical pressure increment, although the test can be controlled under instantaneous undrained conditions, the compressed air dissolved in the water will still cause volume change. The compression of dissolved air in water will not only directly cause immediate settlement but also induce changes in the arrangement of clay particles, leading to another more significant immediate settlement.

9) The content of dissolved air in water changes with temperature, pressure, and pore space distribution, making the immediate settlement of the seemingly saturated clay layer a highly complex inelastic problem. Therefore, it is difficult to apply elastic theory formulas for accurate evaluation.

10) The results of the two cases in this paper show that the immediate settlement of the seemingly saturated clay specimen is considerable, and the ratios of the immedi-

ate settlement to the primary consolidation settlement are 0.269 and 0.543, respectively. However, in traditional soil mechanics, the seemingly saturated clay specimen is regarded as the saturated specimen, following which the elastic theory formula is used to calculate the immediate settlement. Because the modulus of elasticity E_u adopted is the slope of the stress–strain curve instantaneously after the vertical pressure increment is applied under the undrained condition, and a theoretical value of 0.5 is used as the Poisson's ratio υ for the condition of no volume change. Because the adopted modulus of elasticity E_u and Poisson's ratio υ are both high, the calculated immediate settlement is low. Therefore, most of the total settlement of saturated clay specimens is mistaken as the primary consolidation settlement, and the immediate settlement is only a small part (McCarthy, 2007).

Conclusions and Suggestions

When pore water contains highly compressible dissolved air, the assumption of incompressible pore water, the definition of saturation, and the definition of immediate settlement of the saturated clay specimens adopted in traditional consolidation tests are all inconsistent with the facts. In view of this, in this study, first, saturation was redefined as seemingly saturation, and then immediate settlement for seemingly saturated clay layers was redefined. Further, based on the results of two case studies, the following five conclusions are obtained:

1) In the K_0 consolidation test, because the lateral displacement of the saturated clay specimen is constrained, the settlement only exists in the vertical direction. However, after the vertical pressure increment is applied, perhaps the specimen will produce microscopic instantaneous volume distortion, but the immediate settlement in the vertical direction will not occur under no volume change condition. Considering this reason, the evaluation of the immediate settlement of saturated clay layers in traditional soil mechanics is the indirect use of the elastic theory formula instead of the direct use of the definition of immediate settlement.

2) In traditional soil mechanics, the effect of dissolved air in water is ignored, which leads to a seemingly saturated clay specimen being regarded as a saturated clay specimen. In this case, the immedi-

ate settlement calculated by the elastic theory formula is mistaken for only a small part of the total settlement (McCarthy, 2007). However, when the effect of dissolved air in the water is considered, the immediate settlement of the seemingly saturated clay specimen may be greater than the primary consolidation settlement.

3) For the seemingly saturated clay specimen containing highly compressible dissolved air in pore water, in the K_0 consolidation test, even if it is controlled under undrained conditions, the air dissolved in water will be compressed by the vertical pressure increment, and the instantaneous volume change of the specimen makes the fitting curve of consolidation test include immediate settlement.

4) When the fitting curve of consolidation test includes immediate settlement, the consolidation ratio for the intersection of the straight line $\overline{U_0 B}$ and the square root of time factor fitting curve of consolidation theory shown in Figure 9 should be equal to 90%. However, the actual consolidation ratio of the two intersections shown in Figures 2b and 3b is much lower than 90%. In this case, there will be a problem that the coefficients of consolidation obtained by the square root of time fitting method and the logarithm of time fitting method are not the same.

5) Using the corrected square root of time fitting curve of consolidation test for the consolidation ratio of 0% to 60%, the original logarithm of time fitting curve of consolidation test can be corrected. The line type of the corrected fitting curve of consolidation test is close to that of the theoretical one; therefore, the coefficient of consolidation c_v obtained by the square root of time fitting method and the logarithm of time fitting method will tend to be the same.

Based on the above conclusions, the authors suggest that the traditionally defined immediate settlement for the saturated clay specimen should be replaced by the newly defined immediate settlement for the seemingly saturated clay specimen in the future. Moreover, the traditional elastic theory formula calculation method should be replaced by the trial-and-error procedure proposed in this paper for assessing immediate settlement. This way, we can clearly distinguish the K_0 consolidation test results between the immediate settlement and the primary consolidation settlement, thereby rendering the test results related to both settlements consistent with actual needs.

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