Description

Although sand will experience its consolidation (and settlement) almost instantly after a load is applied, clayey soils approach their eventual consolidations gradually. Equation 18.38 is used to calculate the settlement at a particular moment in time after the soil is loaded. U_{AV} is the average *degree of consolidation*.

S_{ULT} is the settlement calculated from Eq. 18.37. Usually, the degree of consolidation is calculated from the *time factor*, which in turn, depends on the time, layer thickness, and the *coefficient of consolidation*.[33]

Equation 18.39: Degree of Consolidation Time Factor

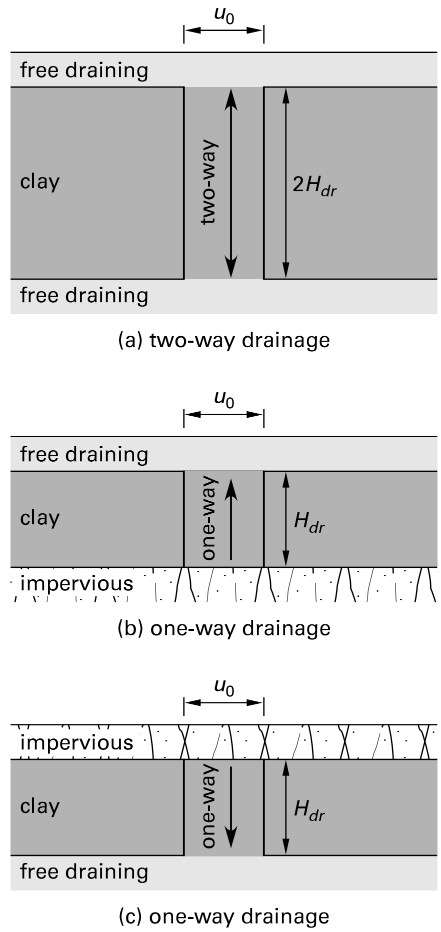
$$T_v = \frac{c_v t}{H_{dr}^2} \qquad 18.39$$

Description

The degree of consolidation, U, is the percentage of the total settlement of a clay layer achieved at a time, t. The degree of consolidation can be determined by dividing the change in excess pore pressure at time t by the initial excess pore pressure, u_0. The initial excess pore pressure is constant with the depth of the soil layer.

The time factor, T_v, given by Eq. 18.39, is a function of the average degree of consolidation, U (%), of a saturated clay layer at time t. Table 18.6 shows the variation of the time factor, T_v, with the degree of consolidation. The coefficient of consolidation, c_v, has units of square distance per time. The length of the average maximum drainage path, H_{dr}, is dependent on the soil type above and below the clay layer. Figure 18.12 shows the three types of drainage path conditions with a constant pore pressure u_0. Figure 18.12(a) depicts two-way drainage, with free-draining soil above and below the clay layer; in this case, the height of drainage, H_{dr}, is one-half the full height of the clay layer, with half the excess pore pressure both above and below the soil. Figure 18.12(b) and Fig. 18.12(c) depict one-way drainage, where either the soil layer above or below the clay layer are impervious; in these cases, the height of drainage is the full height of the clay layer.

Figure 18.12 Different types of Drainage with u_0 constant



Example

A 10 ft thick clay layer has a permeable sand layer above and below it. The coefficient of consolidation is 0.25 ft^2/day. Most nearly, what is the rate of consolidation?

(A) 125 days

(B) 153 days

(C) 187 days

(D) 191 days

Solution

Sand above and below the clay layer indicates two-way drainage, so the height of drainage, H_{dr}, is cut in half. From Table 18.6, for a degree of consolidation, U, of

[33] t_c is not related to the preconsolidation pressure, p_c, although they share the same subscript. t_c is the time since the load was applied. T is used to designate the time factor, although the traditional symbol is T_v.

Table 18.6 *Variation of Time Factor with Degree of Consolidation**

U (%)	T_v	U (%)	T_v	U (%)	T_v
0	0	34	0.0907	68	0.377
1	0.00008	35	0.0962	69	0.390
2	0.0003	36	0.102	70	0.403
3	0.00071	37	0.107	71	0.417
4	0.00126	38	0.113	72	0.431
5	0.00196	39	0.119	73	0.446
6	0.00283	40	0.126	74	0.461
7	0.00385	41	0.132	75	0.477
8	0.00502	42	0.138	76	0.493
9	0.00636	43	0.145	77	0.511
10	0.00785	44	0.152	78	0.529
11	0.0095	45	0.159	78	0.547
12	0.0113	46	0.166	80	0.567
13	0.0133	47	0.173	81	0.588
14	0.0154	48	0.181	82	0.610
15	0.0177	49	0.188	83	0.633
16	0.0201	50	0.197	84	0.658
17	0.0227	51	0.204	85	0.684
18	0.0254	52	0.212	86	0.712
19	0.0283	53	0.221	87	0.742
20	0.0314	54	0.230	88	0.774
21	0.0346	55	0.239	89	0.809
22	0.0380	56	0.248	90	0.848
23	0.0415	57	0.257	91	0.891
24	0.0452	58	0.267	92	0.938
25	0.0491	59	0.276	93	0.993
26	0.0531	60	0.286	94	1.055
27	0.0572	61	0.297	95	1.129
28	0.0615	62	0.307	96	1.219
29	0.0660	63	0.318	97	1.336
30	0.0707	64	0.329	98	1.500
31	0.0754	65	0.340	99	1.781
32	0.0803	66	0.352	100	∞
33	0.0855	67	0.364		

*u_0 constant with depth

90%, the time factor, T_v, is 0.848. The rate of consolidation is

$$T_v = \frac{c_v t}{H_{dr}^2}$$

$$t = \frac{H_{dr}^2 T_v}{c_v}$$

7.5

$$= \frac{(0.75\ \text{ft})^2(0.848)}{0.25\ \frac{\text{ft}^2}{\text{day}}}$$

$$= 190.8\ \text{days} \quad (191\ \text{days})$$

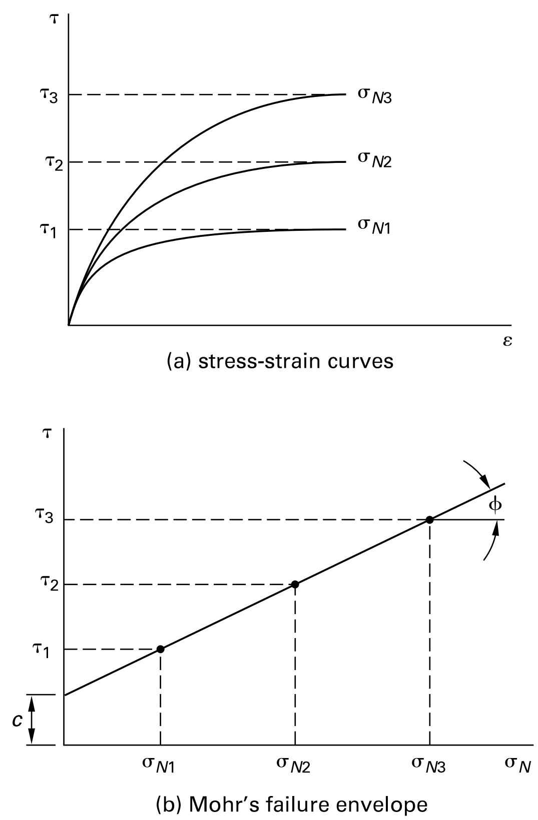
The answer is (D).

20. DIRECT SHEAR TEST

The *direct shear test* is a relatively simple test used to determine the relationship of shear strength to consolidation stress. In this test, a disc of soil is inserted into the direct shear box. The box has a top half and a bottom half that can slide laterally with respect to each other. A normal stress, σ_N, is applied vertically, and then one half of the box is moved laterally relative to the other at a constant rate. Measurements of vertical and horizontal displacement, δ, and horizontal shear load, T, are taken. The test is usually repeated at three different vertical normal stresses. (See Fig. 18.13.)

Because of the box configuration, failure is forced to occur on a horizontal plane. Results from each test are plotted as horizontal displacement versus horizontal *shear stress*, τ (horizontal force divided by the nominal area). *Failure* is determined as the maximum value of horizontal stress achieved. The vertical normal stress and failure stress from each test are then plotted in Mohr's circle space of normal stress versus shear stress.

Figure 18.13 *Graphing Direct-Shear Test Results*



(a) stress-strain curves

(b) Mohr's failure envelope

A line drawn through all of the test values is called the *failure envelope* (*failure line* or *rupture line*).

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