PRECOMPRESSION : (PRELOADING)

* Compressible clay (Normally Consolidated)
* Lie at a limited depth
* Large consolidation settlements are expected

Precompression → to reduce post. construction settlements.

CHAPTER TWELVE Soil Improvement and Ground Modification

GENERAL PRINCIPLES

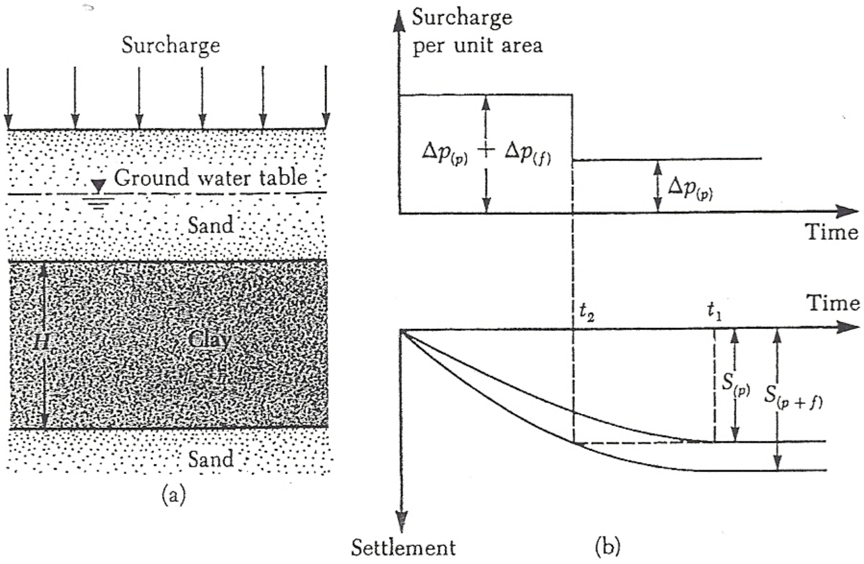


FIGURE 12.22 Principles of precompression

ΔP_p : structural load per unit area (permenant load)

H_c : Compressible clay layer thickness

S_p : max. primary settlement due to ΔP_p

$$S_p = \frac{C_c H_c}{1+e_o} \log \frac{P_o + \Delta P_p}{P_o}$$

If a surcharge of $\Delta P_p + \Delta P_f$ is placed on the ground

Primary Cons settlement :

$$S_{p+f} = \frac{C_c H_c}{1+e_o} \log \frac{P_o + (\Delta P_p + \Delta P_f)}{P_o}$$

Note: S_p would occur at t_2 with ΔP_f which much smaller than t_1 where ΔP_f is not applied.

Then
- apply a temporary surcharge $\Delta P_p + \Delta P_f$ (earth fill)
- keep it for a period of t_2 and remove.
- built your structure with ΔP_p
- no appreciable settlement shall occur.

" GROUND IS IMPROVED "

Determination of ΔP_f and t_2:

if you apply $\Delta P_p + \Delta P_f$ the degree of consolidation at t_2:

$$U = \frac{S_p}{S_{p+f}} = \frac{\log\left[\frac{P_o + \Delta P_p}{P_o}\right]}{\log\left[\frac{P_o + \Delta P_p + \Delta P_f}{P_o}\right]} = \frac{\log\left\{1 + \frac{\Delta P_p}{P_o}\right\}}{\log\left\{1 + \frac{\Delta P_p}{P_o}\left[1 + \frac{\Delta P_f}{\Delta P_p}\right]\right\}}$$

% U : average degree of consolidation at t_2

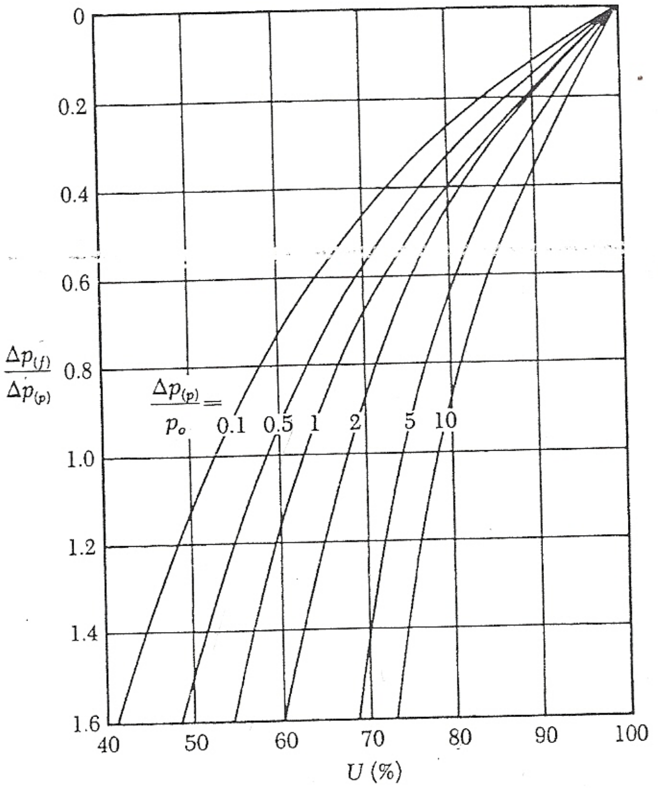


FIGURE 12.23 Plot of $\Delta p_{(f)}/\Delta p_{(p)}$ against U for various values of $\Delta p_{(p)}/p_o$ — Eq. (12.11)

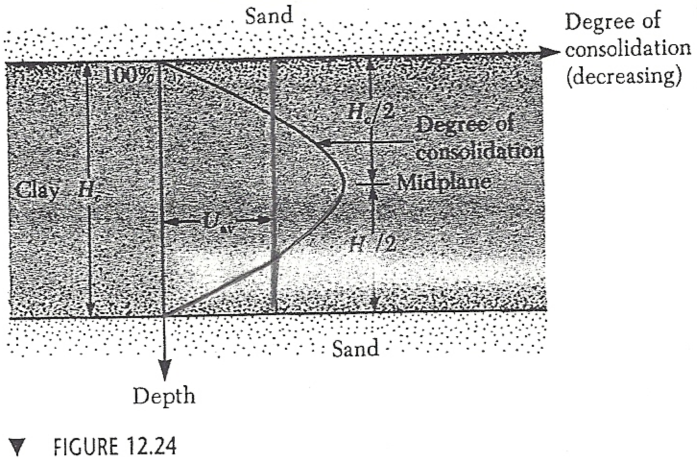
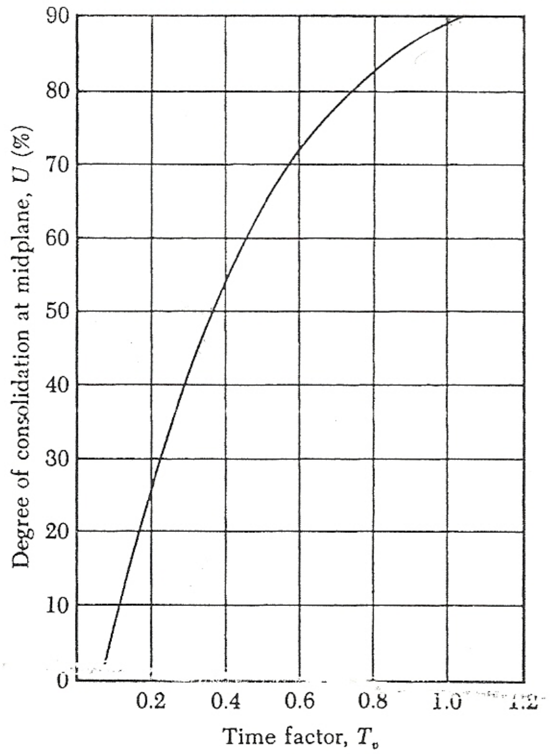


FIGURE 12.24

* if U_{av} from Fig. 12.23 is used:
after removal of surcharge and application of permanent load: the portion of clay close to drainage surface will continue to swell, and the soil close to the midplane will continue to settle.
A conservative approach: assume $U\%$ is the mid-plane degree of consolidation:
$U\% = f(T_v)$ $\quad$ T_v: time factor $= \frac{C_v t_2}{H^2}$
H: max drainage path ($H_c/2$ if two way drainage)
$U\%$ (mid plane) vs. T_v is given below:



▼ FIGURE 12.25 Plot of midplane degree of consolidation against T_v

Engineering applications:

i. ΔP_f is known t_2 must be determined

ΔP_f, P_o and ΔP_p is known → find U% from 12.23

then obtain T_v from Fig. 12.25. $t_2 = \frac{T_v H^2}{C_v}$

ii. t_2 is specified → ΔP_f must be obtained.

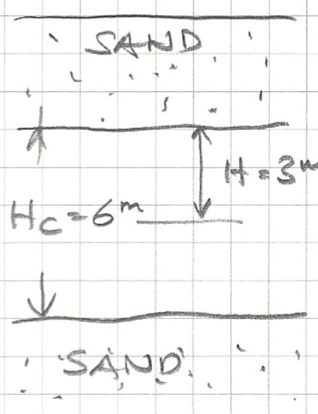
Calculate $T_v = \frac{t_2 C_v}{H^2}$ → U% from Fig 12.25.

then go ~~to~~ Fig. 12.23 → $\frac{\Delta P_f}{\Delta P_p}$ → ΔP_f is found.

~~EXAMPLE~~:

a. The total primary consolidation settlement of the bridge without precompression

b. The surcharge, $\Delta p_{(f)}$, needed to eliminate by precompression the entire primary consolidation settlement in 9 mo.



Clay:

$P_o = 210$ kPa

$\Delta P_p = 115$ kPa

$C_c = 0.28$

$e_o = 0.9$

$C_v = 0.36$ m²/mo

Solution

Part a

The total primary consolidation settlement may be calculated from Eq. (12.8):

$$S_{(p)} = \frac{C_c H_c}{1+e_o} \log\left[\frac{p_o + \Delta p_{(p)}}{p_o}\right] = \frac{(0.28)(6)}{1+0.9} \log\left[\frac{210+115}{210}\right]$$

$$= 0.1677 \text{ m} = \mathbf{167.7\ mm}$$

Part b

$$T_v = \frac{C_v t_2}{H^2}$$

$C_v = 0.36$ m²/mo.

$H = 3$ m (two-way drainage)

$t_2 = 9$ mo.

Hence

$$T_v = \frac{(0.36)(9)}{3^2} = 0.36$$

According to Figure 12.25, for $T_v = 0.36$ the value of U is 47%. Now

$\Delta p_{(p)} = 115$ kN/m²

$p_o = 210$ kN/m²

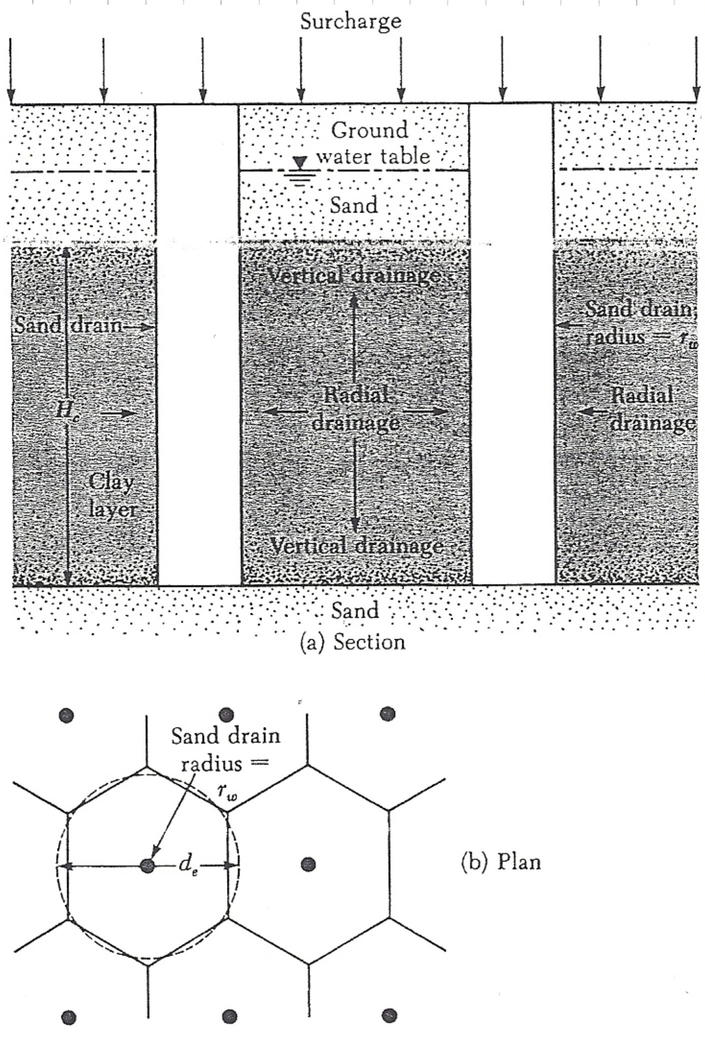
So

$$\frac{\Delta p_{(p)}}{p_o} = \frac{115}{210} = 0.548$$

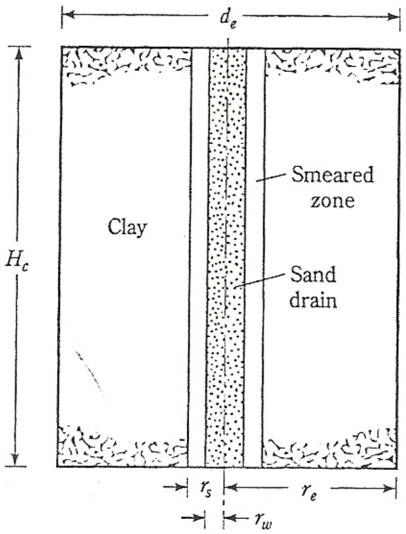
According to Figure 12.23, for $U = 47\%$ and $\Delta p_{(p)}/p_o = 0.548$, $\Delta p_{(f)}/\Delta p_{(p)} \approx 1.8$, so

$$\Delta p_{(f)} = (1.8)(115) = \mathbf{207\ kN/m^2}$$ ▲

SAND DRAINS to accelerate consolidation settlement



▼ FIGURE 12.28 Sand drains



▼ FIGURE 12.29 Schematic diagram of a sand drain

$$U_{v,r} = \frac{\log\left[1+\frac{\Delta p_f}{p_0}\right]}{\log\left\{1+\frac{\Delta p_p}{p_0}\left[1+\frac{\Delta p_f}{\Delta p_p}\right]\right\}}$$

$U_{v,r}$: average degree of consolidation due to both radial and vertical drainage.

For a given surcharge and t_2:

$$U_{v,r} = 1-(1-U_r)(1-U_v)$$

U_r : average degree of cons. due to radial drainage only

U_v : ave. degree of cons. due to vertical drainage only

r_w : radius of the sand drain

$r_e = \frac{d_e}{2}$: radius of effective zone of drainage

r_s : radial distance from center of sand drain to farthest point of smeared zone.

$$U_r = 1 - \exp\left(\frac{-8T_r}{m}\right) \qquad (12.15)$$

where

$$m = \frac{n^2}{n^2 - S^2}\ln\left(\frac{n}{S}\right) - \frac{3}{4} + \frac{S^2}{4n^2} + \frac{k_h}{k_s}\left(\frac{n^2 - S^2}{n^2}\right)\ln S \qquad (12.16)$$

$$n = \frac{d_e}{2r_w} = \frac{r_e}{r_w} \qquad (12.17)$$

$$S = \frac{r_s}{r_w} \qquad (12.18)$$

k_h = hydraulic conductivity of clay in the horizontal direction in the unsmeared zone

k_s = horizontal hydraulic conductivity in the smeared zone

T_r = nondimensional time factor for radial drainage only $= \frac{C_{vr}t_2}{d_e^2}$ (12.19)

C_{vr} = coefficient of consolidation for radial drainage

$$= \frac{k_h}{\left[\frac{\Delta e}{\Delta p(1 + e_{av})}\right]\gamma_w} \qquad (12.20)$$

For a *no-smear case*, $r_s = r_w$ and $k_h = k_s$, so $S = 1$ and Eq. (12.16) becomes

$$m = \left(\frac{n^2}{n^2 - 1}\right)\ln(n) - \frac{3n^2 - 1}{4n^2} \qquad (12.21)$$

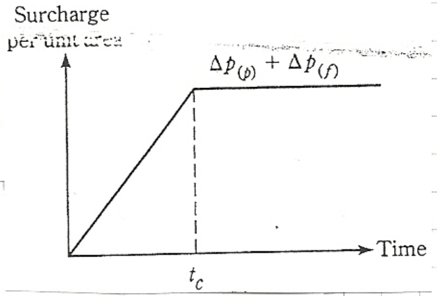
Table 12.7 gives the values of U_r for various values of T_r and n.

If the surcharge is applied in the form of a *ramp* and *there is no smear*, then (Olson, 1977)

$$U_r = \frac{T_r - \frac{1}{A}[1 - \exp(-AT_r)]}{T_{rc}} \quad (\text{for } T_r \le T_{rc}) \qquad (12.22)$$

and

$$U_r = 1 - \frac{1}{AT_{rc}}[\exp(AT_{rc}) - 1]\exp(-AT_{rc}) \quad (\text{for } T_r \ge T_{rc})$$



where

$$T_{rc} = \frac{C_{vr}t_c}{d_e^2} \quad (\text{see Figure 12.30b for definition of } t_c) \qquad (12.24)$$

$$A = \frac{2}{m} \qquad (12.25)$$

▼ TABLE 12.7 Variation of U_r for Various Values of T_r and n — No-Smear Case [Eqs. (12.15) and (12.21)]

Degree of consolidation U_r (%)	Time factor T_r for value of $n(= r_e/r_w)$				
	5	10	15	20	25
0	0	0	0	0	0
1	0.0012	0.0020	0.0025	0.0028	0.0031
2	0.0024	0.0040	0.0050	0.0057	0.0063
3	0.0036	0.0060	0.0075	0.0086	0.0094
4	0.0048	0.0081	0.0101	0.0115	0.0126
5	0.0060	0.0101	0.0126	0.0145	0.0159
6	0.0072	0.0122	0.0153	0.0174	0.0191
7	0.0085	0.0143	0.0179	0.0205	0.0225
8	0.0098	0.0165	0.0206	0.0235	0.0258
9	0.0110	0.0186	0.0232	0.0266	0.0292
10	0.0123	0.0208	0.0260	0.0297	0.0326
11	0.0136	0.0230	0.0287	0.0328	0.0360
12	0.0150	0.0252	0.0315	0.0360	0.0395
13	0.0163	0.0275	0.0343	0.0392	0.0431
14	0.0177	0.0298	0.0372	0.0425	0.0467
15	0.0190	0.0321	0.0401	0.0458	0.0503
16	0.0204	0.0344	0.0430	0.0491	0.0539
17	0.0218	0.0368	0.0459	0.0525	0.0576
18	0.0232	0.0392	0.0489	0.0559	0.0614
19	0.0247	0.0416	0.0519	0.0594	0.0652
20	0.0261	0.0440	0.0550	0.0629	0.0690
21	0.0276	0.0465	0.0581	0.0664	0.0729
22	0.0291	0.0490	0.0612	0.0700	0.0769
23	0.0306	0.0516	0.0644	0.0736	0.0808
24	0.0321	0.0541	0.0676	0.0773	0.0849
25	0.0337	0.0568	0.0709	0.0811	0.0890
26	0.0353	0.0594	0.0742	0.0848	0.0931
27	0.0368	0.0621	0.0776	0.0887	0.0973
28	0.0385	0.0648	0.0810	0.0926	0.1016
29	0.0401	0.0676	0.0844	0.0965	0.1059
30	0.0418	0.0704	0.0879	0.1005	0.1103
31	0.0434	0.0732	0.0914	0.1045	0.1148
32	0.0452	0.0761	0.0950	0.1087	0.1193
33	0.0469	0.0790	0.0987	0.1128	0.1239
34	0.0486	0.0820	0.1024	0.1171	0.1285
35	0.0504	0.0850	0.1062	0.1214	0.1332
36	0.0522	0.0881	0.1100	0.1257	0.1380
37	0.0541	0.0912	0.1139	0.1302	0.1429
38	0.0560	0.0943	0.1178	0.1347	0.1479
39	0.0579	0.0975	0.1218	0.1393	0.1529
40	0.0598	0.1008	0.1259	0.1439	0.1580
41	0.0618	0.1041	0.1300	0.1487	0.1632
42	0.0638	0.1075	0.1342	0.1535	0.1685
43	0.0658	0.1109	0.1385	0.1584	0.1739

Average Degree of Consolidation Due to Vertical Drainage Only

Referring to Figure 12.30a, for instantaneous surcharge application, the average degree of consolidation due to vertical drainage only may be obtained from Eq. (1.77) and (1.78):

$$T_v = \frac{\pi}{4}\left[\frac{U_v(\%)}{100}\right]^2 \quad \text{(for } U_v = 0\text{–}60\%) \tag{1.77}$$

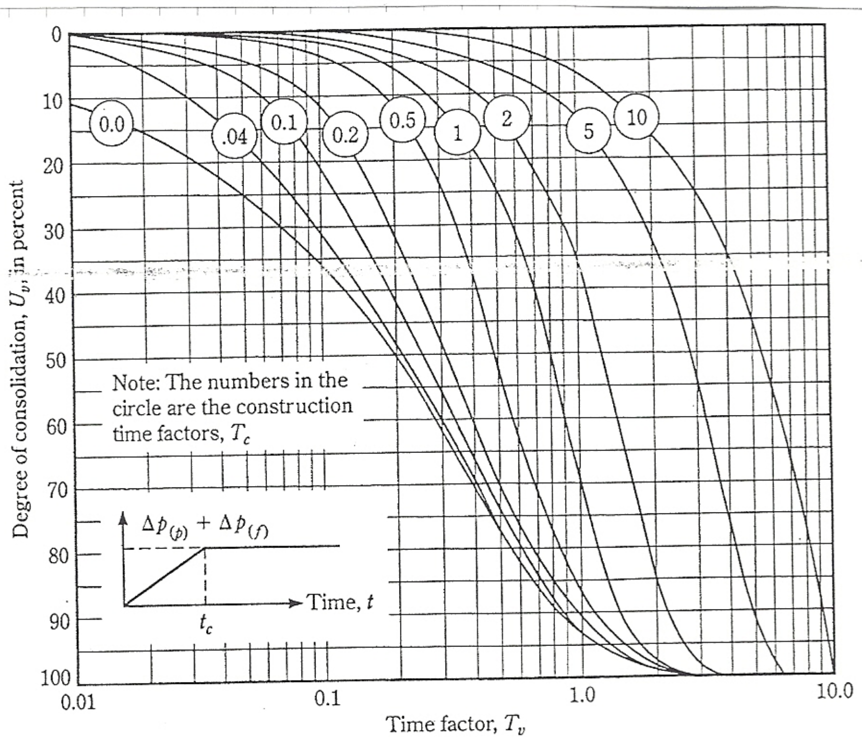
and

$$T_v = 1.781 - 0.933 \log(100 - U_v(\%)) \quad \text{(for } U_v > 60\%) \tag{1.78}$$

where U_v = average degree of consolidation due to vertical drainage only

$$T_v = \frac{C_v t_2}{H^2} \tag{1.72}$$

C_v = coefficient of consolidation for vertical drainage



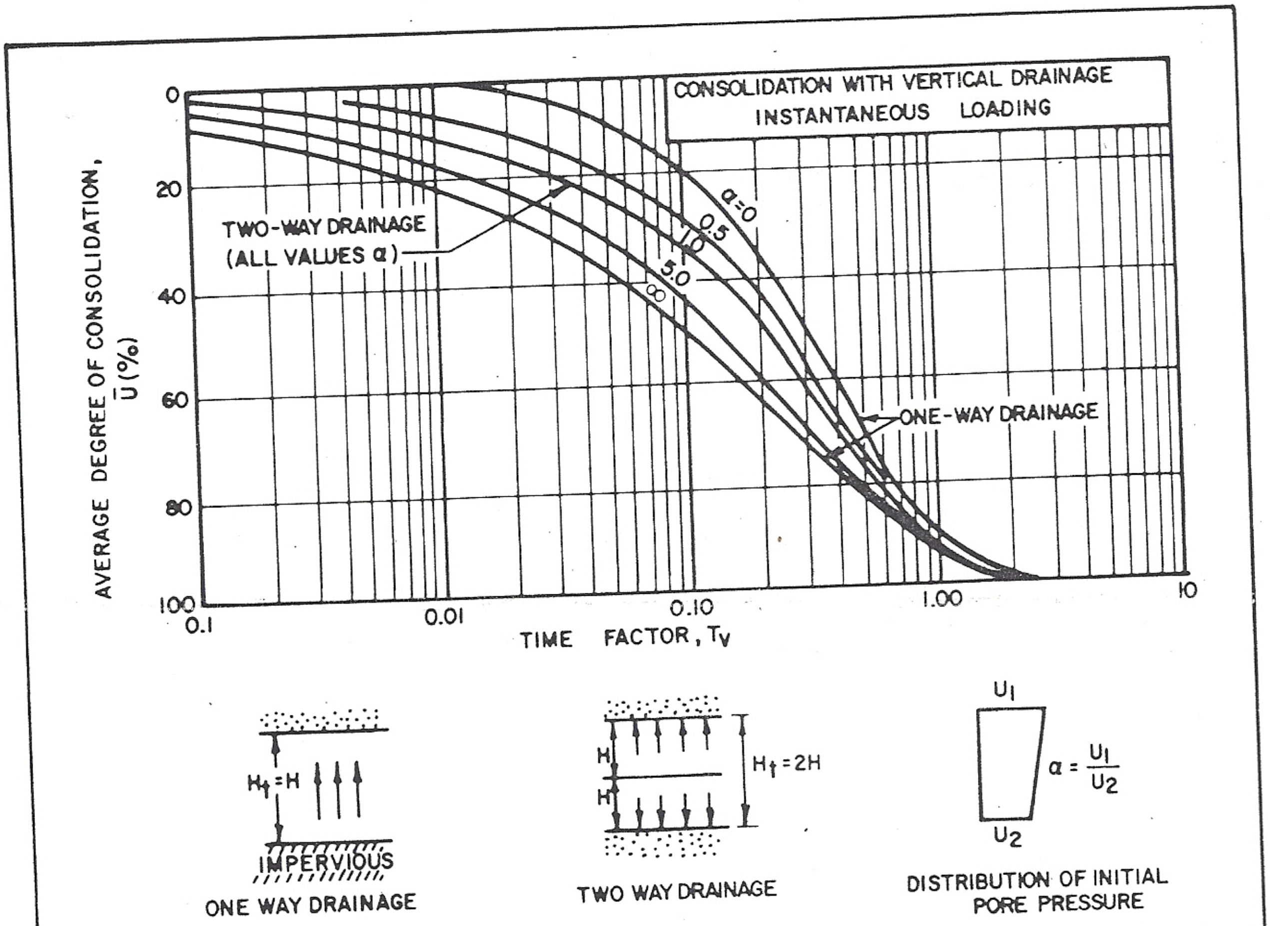
▼ FIGURE 12.31 Variation of U_v with T_v and T_c (after Olson, 1977)

For the case of ramp loading as shown in Figure 12.30b, the variation of $U_v(\%)$ with T_v and T_c (Olson, 1977) is given in Figure 12.31. Note that

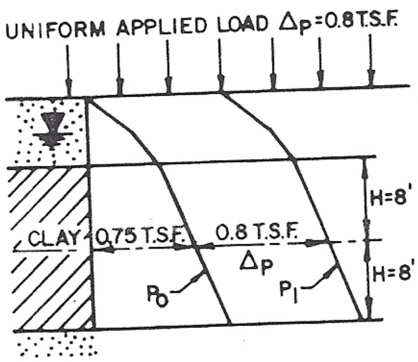
$$T_c = \frac{C_v t_c}{H^2} \tag{12.26}$$

where H = length of maximum vertical drainage path

Degree of consolidation U_r (%)	Time factor T_r for value of $n(= r_e/r_w)$				
	5	10	15	20	25
44	0.0679	0.1144	0.1429	0.1634	0.1793
45	0.0700	0.1180	0.1473	0.1684	0.1849
46	0.0721	0.1216	0.1518	0.1736	0.1906
47	0.0743	0.1253	0.1564	0.1789	0.1964
48	0.0766	0.1290	0.1611	0.1842	0.2023
49	0.0788	0.1329	0.1659	0.1897	0.2083
50	0.0811	0.1368	0.1708	0.1953	0.2144
51	0.0835	0.1407	0.1758	0.2020	0.2206
52	0.0859	0.1448	0.1809	0.2068	0.2270
53	0.0884	0.1490	0.1860	0.2127	0.2335
54	0.0909	0.1532	0.1913	0.2188	0.2402
55	0.0935	0.1575	0.1968	0.2250	0.2470
56	0.0961	0.1620	0.2023	0.2313	0.2539
57	0.0988	0.1665	0.2080	0.2378	0.2610
58	0.1016	0.1712	0.2138	0.2444	0.2683
59	0.1044	0.1759	0.2197	0.2512	0.2758
60	0.1073	0.1808	0.2258	0.2582	0.2834
61	0.1102	0.1858	0.2320	0.2653	0.2912
62	0.1133	0.1909	0.2384	0.2726	0.2993
63	0.1164	0.1962	0.2450	0.2801	0.3075
64	0.1196	0.2016	0.2517	0.2878	0.3160
65	0.1229	0.2071	0.2587	0.2958	0.3247
66	0.1263	0.2128	0.2658	0.3039	0.3337
67	0.1298	0.2187	0.2732	0.3124	0.3429
68	0.1334	0.2248	0.2808	0.3210	0.3524
69	0.1371	0.2311	0.2886	0.3300	0.3623
70	0.1409	0.2375	0.2967	0.3392	0.3724
71	0.1449	0.2442	0.3050	0.3488	0.3829
72	0.1490	0.2512	0.3134	0.3586	0.3937
73	0.1533	0.2583	0.3226	0.3689	0.4050
74	0.1577	0.2658	0.3319	0.3795	0.4167
75	0.1623	0.2735	0.3416	0.3906	0.4288
76	0.1671	0.2816	0.3517	0.4021	0.4414
77	0.1720	0.2900	0.3621	0.4141	0.4546
78	0.1773	0.2988	0.3731	0.4266	0.4683
79	0.1827	0.3079	0.3846	0.4397	0.4827
80	0.1884	0.3175	0.3966	0.4534	0.4978
81	0.1944	0.3277	0.4090	0.4679	0.5137
82	0.2007	0.3383	0.4225	0.4831	0.5304
83	0.2074	0.3496	0.4366	0.4992	0.5481
84	0.2146	0.3616	0.4516	0.5163	0.5668
85	0.2221	0.3743	0.4675	0.5345	0.5868
86	0.2302	0.3879	0.4845	0.5539	0.6081
87	0.2388	0.4025	0.5027	0.5748	0.6311
88	0.2482	0.4183	0.5225	0.5974	0.6558
89	0.2584	0.4355	0.5439	0.6219	0.6827
90	0.2696	0.4543	0.5674	0.6487	0.7122
91	0.2819	0.4751	0.5933	0.6784	0.7448
92	0.2957	0.4983	0.6224	0.7116	0.7812
93	0.3113	0.5247	0.6553	0.7492	0.8225
94	0.3293	0.5551	0.6932	0.7927	0.8702
95	0.3507	0.5910	0.7382	0.8440	0.9266
96	0.3768	0.6351	0.7932	0.9069	0.9956
97	0.4105	0.6918	0.8640	0.9879	1.0846
98	0.4580	0.7718	0.9640	1.1022	1.2100
99	0.5391	0.9086	1.1347	1.2974	1.4244



① INSTANTANEOUS LOADING, VERTICAL DRAINAGE ONLY



FROM LABORATORY TESTS ON THE CLAY STRATUM:

$e_o = 1.00$ $\quad C_c = 0.21$ $\quad C_v = 0.03\ FT.^2/DAY$ $\quad C_\alpha = 0.010$

LOAD INCREMENT, $\Delta p = 0.8$ TSF (VIRGIN COMPRESSION)

(1) FOR 100% PRIMARY CONSOLIDATION:

$$\Delta H = \frac{H_t C_c}{1+e_o} \text{LOG}\left(\frac{P_o+\Delta P}{P_o}\right) = \frac{12\,(16)(0.21)}{2.00}\,(0.315) = \underline{6.35 \text{ IN.}}$$

(2) SECONDARY COMPRESSION FOR I CYCLE OF TIME:

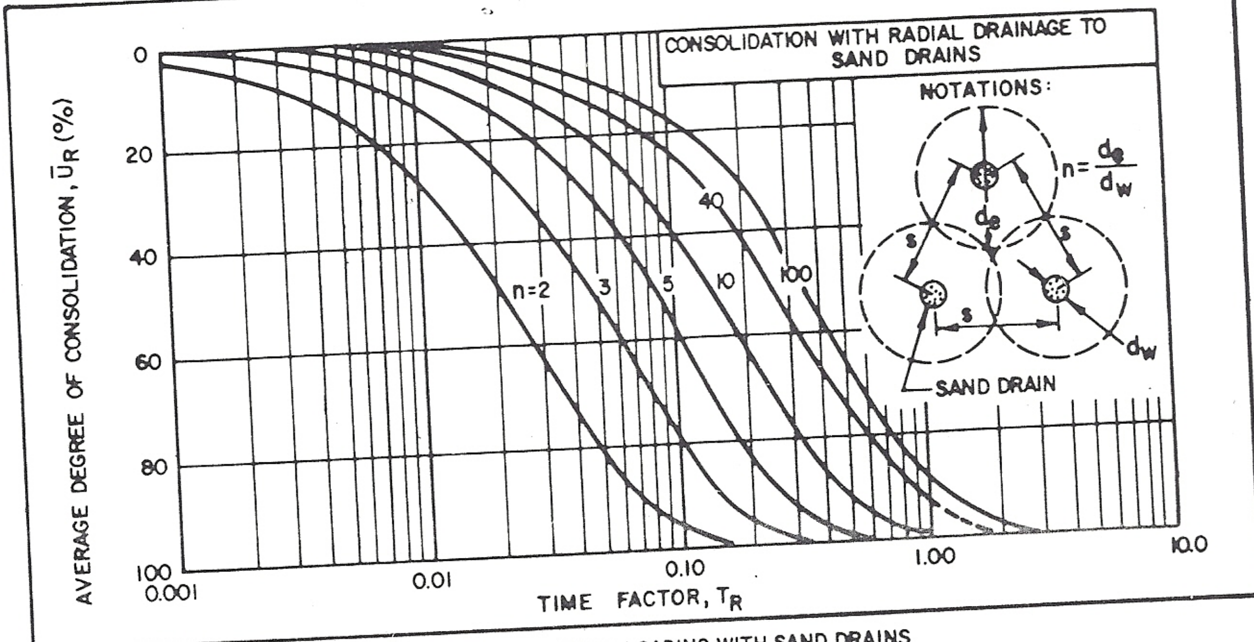
$$\Delta H_{SEC} = C_\alpha H_t \text{ LOG}\left(\frac{t_{SEC}}{t_P}\right) = 0.01\,(12)(16)\,\text{LOG}\,(10) = \underline{1.92 \text{ IN.}}$$

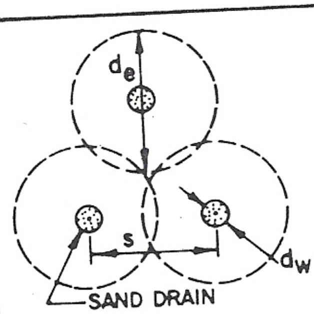
(3) TIME-CONSOLIDATION RELATIONSHIP: $T_v = \dfrac{t\,c_v}{H^2}$ $\begin{cases} T_v = \text{TIME FACTOR FOR VERTICAL DRAINAGE.} \\ t = \text{TIME FOLLOWING LOADING.} \end{cases}$

$T_v = t\dfrac{(0.03)}{8^2}$ $\quad \underline{t = 2130\ T_v \text{ DAYS}}$

USE UPPER PANEL FOR T_v VS $\bar{U}$. PLOT SETTLEMENT VS TIME-SEE CURVE ① IN FIGURE 10 (LOWER PANEL)

FIGURE 9
Time Rate of Consolidation for Vertical Drainage
Due to Instantaneous Loading





③ INSTANTANEOUS LOADING WITH SAND DRAINS

ANALYZE SAND DRAINS FOR ACCELERATION OF CONSOLIDATION. DRAINS IN TRIANGULAR ARRAY SPACING, S=10' d_e=10.5', WELL DIAMETER, d_w=18"

HORIZONTAL COEFFICIENT OF CONSOLIDATION, $C_h = 0.06\ FT^2/DAY$

$$T_R = \frac{t\ C_h}{(d_e)^2}, \quad t = 1840\ T_R \quad n = \frac{d_e}{d_w} = \frac{10.5}{1.5} = 7$$

USE CURVE IN GRAPH ABOVE FOR n=7 TO OBTAIN T_R VS $\bar{U}_R$. PLOT (t VS $\bar{U}_R$) AS CURVE ②. BELOW COMBINED EFFECT OF VERTICAL AND RADIAL DRAINAGE:

$$\bar{U}_C = 100 - \left[\frac{(100-\bar{U}_R)(100-\bar{U}_V)}{100}\right].$$ PLOT (t VS $\bar{U}_C$) AS CURVE ③ BELOW.

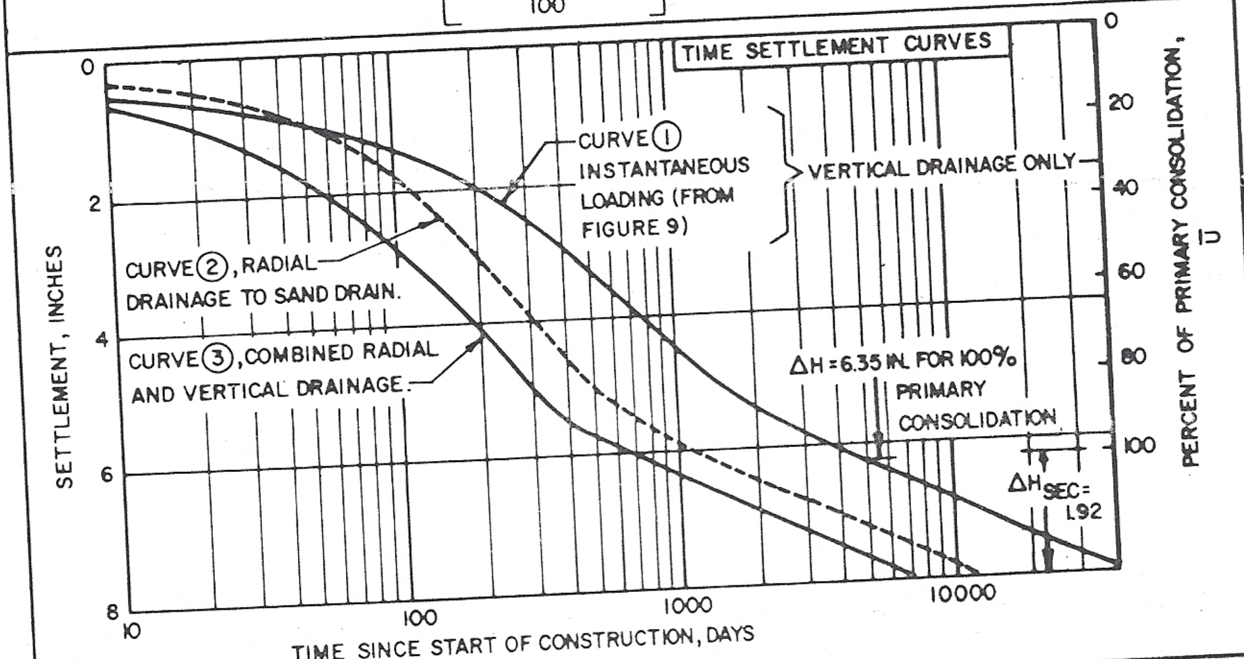


FIGURE 10
Vertical Sand Drains and Settlement Time Rate

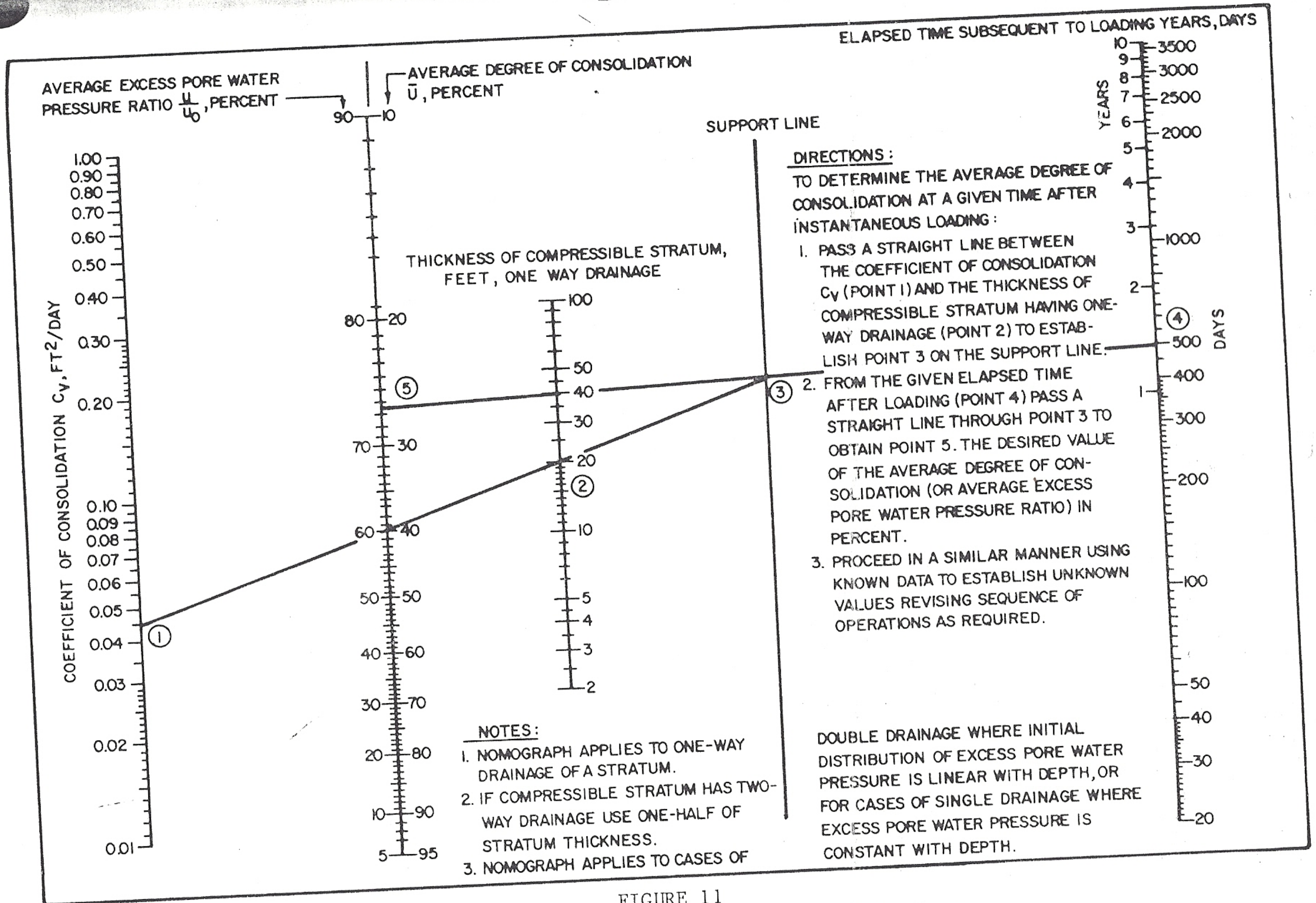
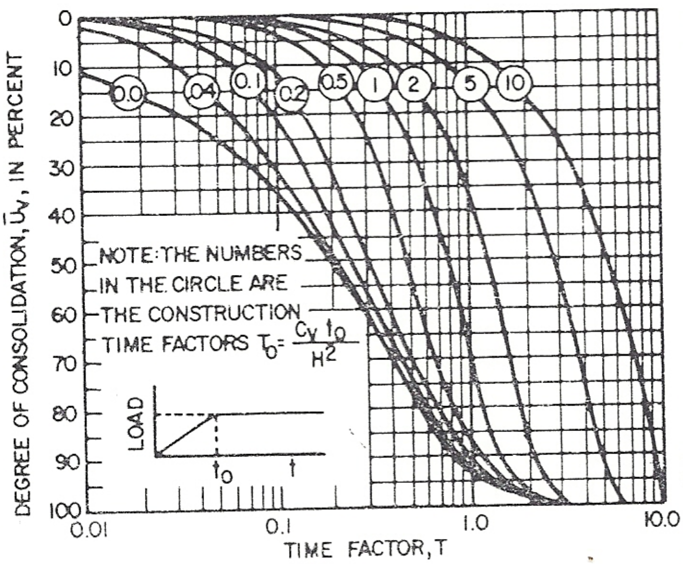


FIGURE 11
Nomograph for Consolidation With Vertical Drainage



FIND DEGREE OF CONSOLIDATION 15 DAYS AND 100 DAYS AFTER THE START OF CONSTRUCTION.

(1) CONSOLIDATION WITH VERTICAL DRAINAGE

CONSTRUCTION TIME t_0 = 30 DAYS.

THICKNESS OF COMPRESSIBLE STRATUM = 10 FT.

DRAINAGE CONDITION = DOUBLE DRAINAGE

$C_V = 0.05\ FT^2/DAY$

$$T_0 = \frac{C_V t_0}{H^2} = \frac{(0.05)(30)}{(5)^2} = 0.06$$

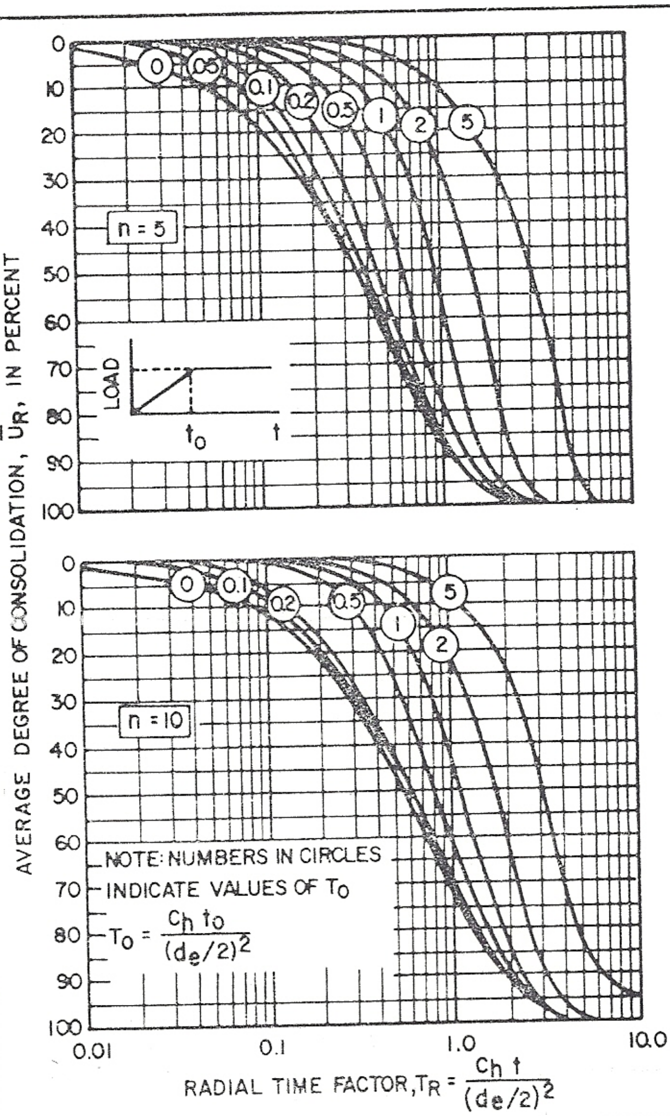
FOR:

$$t = 15\ DAYS,\ T = \frac{0.05\,(15)}{(5)^2} = 0.03,\ \bar{U}_V = 7\%$$

AND FOR

$$t = 100\ DAYS,\ T = \frac{0.05\,(100)}{(5)^2} = 0.2,\ \bar{U}_V = 47\%$$

CONSOLIDATION WITH VERTICAL DRAINAGE. GRADUAL CONSTRUCTION TIME (U_n FOR DISTRIBUTION OF INITIAL PORE PRESSURE).



(2) CONSOLIDATION WITH RADIAL DRAINAGE

$C_h = 0.1\ FT.^2/DAY$

$d_w = 1.0\ FT.;\ d_e = 10\ FT.$

$$n = \frac{d_e}{d_w} = 10,\ T_R = \frac{t\,C_h}{(d_e/2)^2}$$

$$T_0 = \frac{(0.1)(30)}{(10/2)^2} = 0.12\ \text{FOR}$$

$$t = 15\ DAYS,\ T_R = \frac{t\,C_h}{(d_e/2)^2} = \frac{15 \times 0.1}{(10/2)^2} = 0.06,\ \bar{U}_R = 2\%$$

$$\text{AND } t = 100\ DAYS,\ T_R = \frac{100 \times 0.1}{(10/2)^2} = 0.4,\ \bar{U}_R = 35\%$$

(3) COMBINED ($\bar{U}_C$) VERTICAL AND RADIAL FLOW

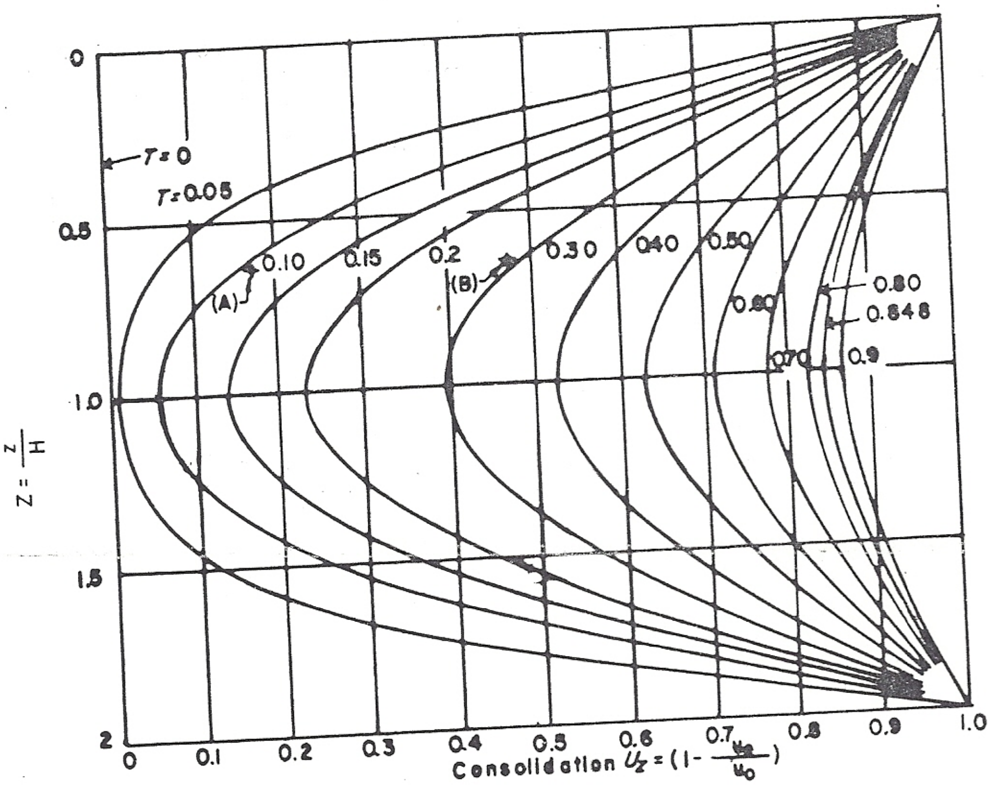
$$\bar{U}_C = 100 - \frac{[100 - \bar{U}_R]\,[100 - \bar{U}_V]}{100}\ \text{FOR}$$

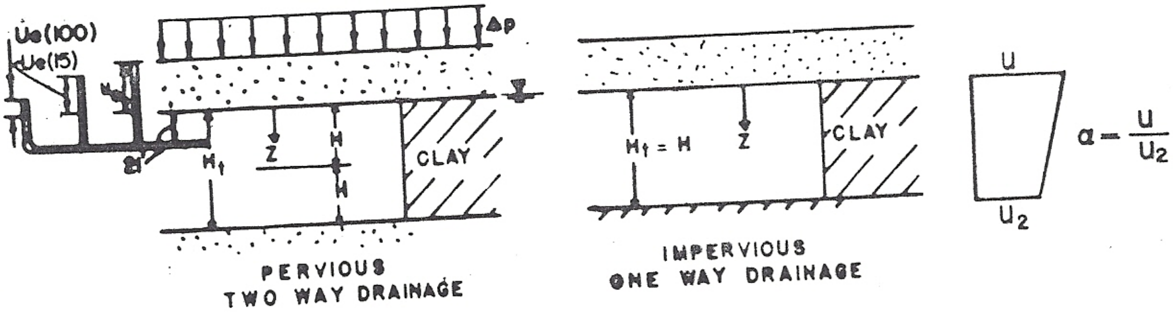
$$t = 100\ DAYS,\ \bar{U}_C = 100 - \frac{[100-35]\,[100-47]}{100} = 65.55\%$$

CONSOLIDATION WITH RADIAL DRAINAGE TO SAND DRAINS.

FIGURE 13

Time Rate of Consolidation for Gradual Load Application





$U_z = 1 - \frac{u_e}{u_o}$ (consolidation ratio)

u_e = Excess pore pressure at some time t

u_o = Excess pore pressure at time t = 0 (due to external loading)

FIGURE 14
Coefficient of Consolidation from Field Measurements

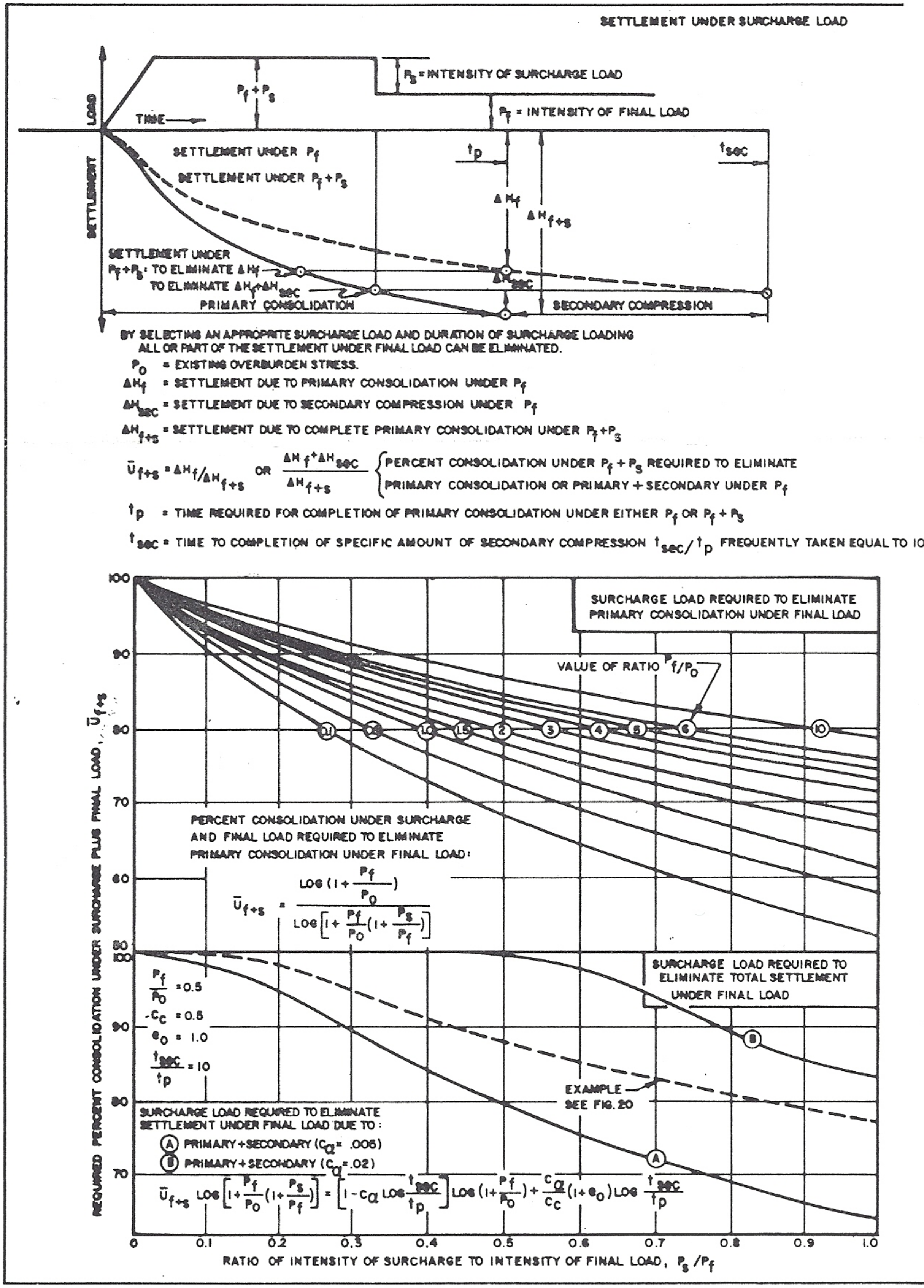
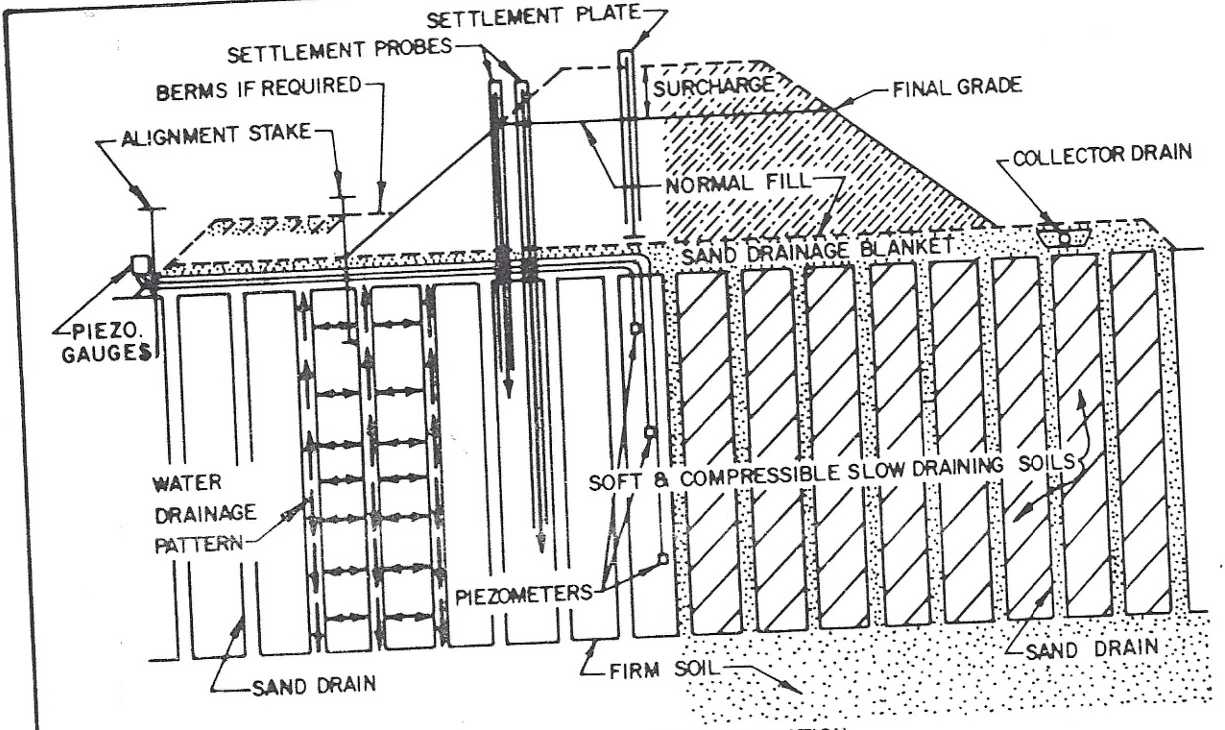


FIGURE 17

Surcharge Load Required to Eliminate Settlement Under Final Load



TYPICAL SAND DRAIN INSTALLATION

DIAMETER OF DRAINS RANGES FROM 6 TO 30 IN., GENERALLY BETWEEN 16 AND 20 IN.

SPACING OF DRAINS RANGES FROM 6 TO 20 FT ON CENTER, GENERALLY BETWEEN 6 AND 10 FT.

PRINCIPAL METHODS FOR INSTALLING DRAINS ARE CLOSED OR OPEN MANDRELS ADVANCED BY DRIVING OR JETTING, OR ROTARY DRILLING WITH OR WITHOUT JETS. DRIVING CLOSED MANDREL IS THE MOST COMMON.

DRAIN BACKFILL MATERIAL SHOULD HAVE SUFFICIENT PERMEABILITY TO DISCHARGE PORE WATER FLOW ANTICIPATED, BUT USUALLY DOES NOT MEET FILTER REQUIREMENTS AGAINST FOUNDATIONS SOILS. CLEAN SANDS WITH NO MORE THAN 3% BY WEIGHT PASSING No. 200 SIEVE IS USUALLY SUITABLE. A TYPICAL GRADATION IS AS FOLLOWS:

SIEVE No.	4	16	50	100	200
% FINER BY WEIGHT:	90-100	40-85	2-30	0-7	0-3

SAND DRAINAGE BLANKET MATERIAL IS SIMILAR TO THAT USED FOR DRAIN BACKFILL. IN SOME CASES GRAVEL WINDROWS OR PERFORATED, CORRUGATED, METAL PIPE ARE PLACED IN DRAINAGE BLANKET TO REDUCE HEAD LOSS IN DRAINAGE BLANKET. LONGITUDINAL DITCH OR COLLECTOR DRAIN MAY BE PLACED AT TOE. GRANULAR WORKING MAT IS SOMETIMES PLACED BELOW DRAINAGE BLANKET TO SUPPORT EQUIPMENT.

SURCHARGE LOAD IS PLACED TO REDUCE OR ELIMINATE POSTCONSTRUCTION CONSOLIDATION BENEATH NORMAL FILL. GENERALLY THE SURCHARGE LOAD IS NO MORE THAN ABOUT 30% OF NORMAL EMBANKMENT LOAD.

FIELD CONTROL DEVICES:

PIEZOMETERS OF STANDPIPE OR CLOSED SYSTEM TYPE TO OBSERVE PORE WATER PRESSURES;

SETTLEMENT PLATES, MINIMUM 3 FT SQUARE, PLACED AT BASE OF FILL TO RECORD TOTAL SETTLEMENT;

SETTLEMENT PROBES DRIVEN OR AUGERED INTO FOUNDATION STRATUM TO MEASURE COMPRESSION WITHIN FOUNDATION.

ALIGNMENT STAKES, T-SHAPED STAKES PLACED AT OR OUTSIDE EMBANKMENT TOE TO OBSERVE LATERAL MOVEMENT AND HEAVE.

FIGURE 18

Data for Typical Sand Drain Installation

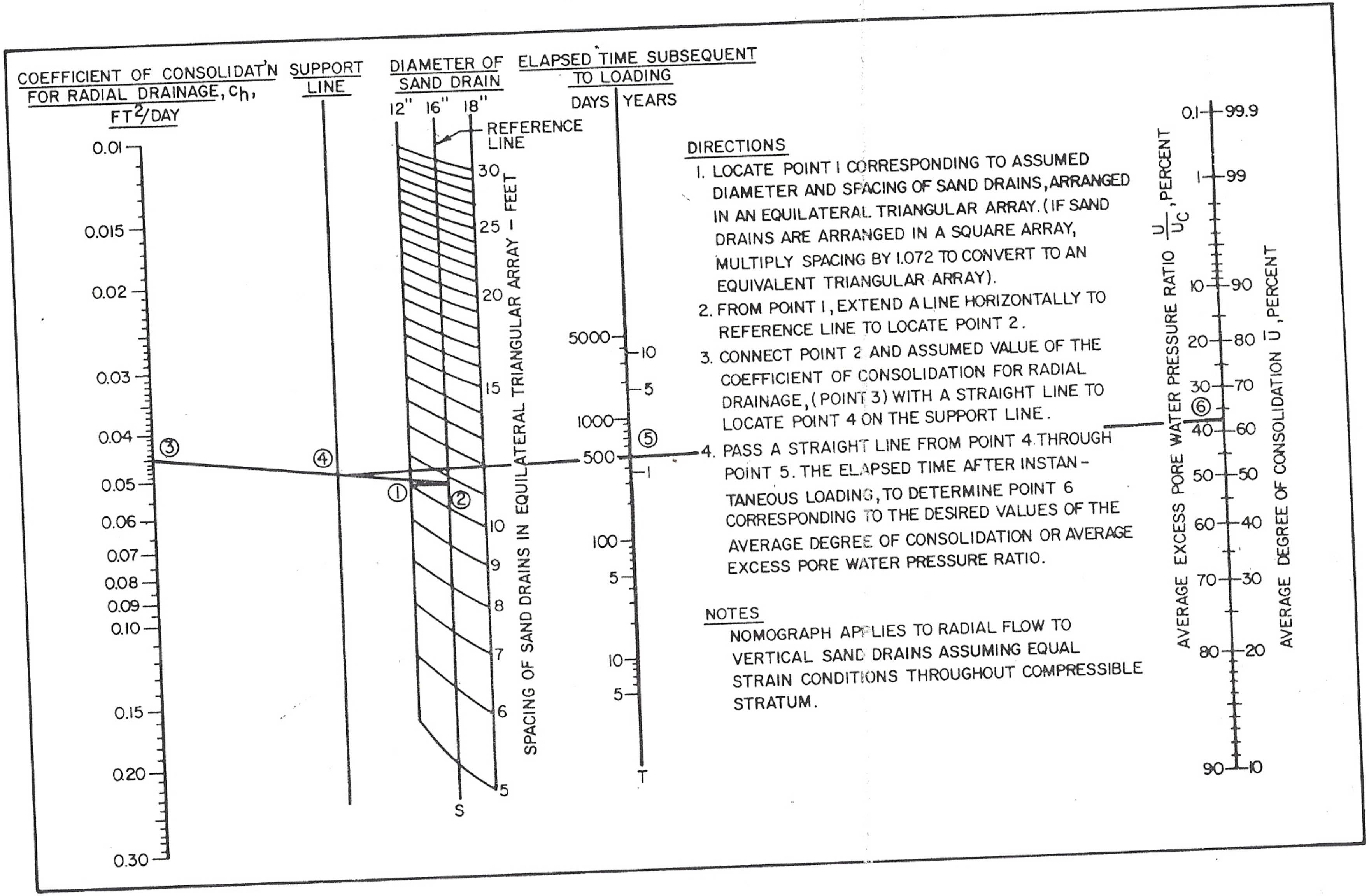


FIGURE 19
Nomograph for Consolidation with Radial Drainage to Vertical Sand Drain

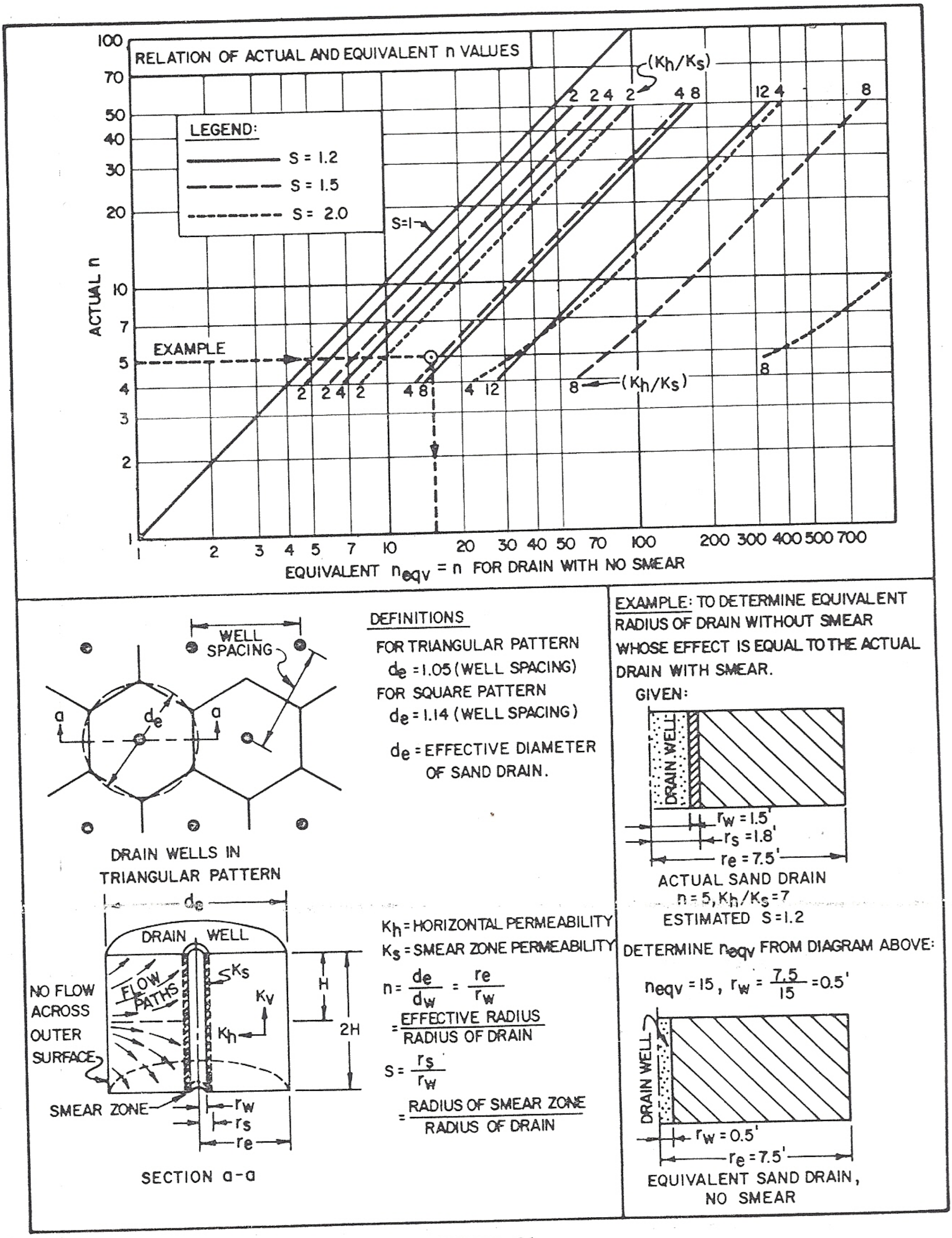


FIGURE 21
Allowance for Smear Effect in Sand Drain Design

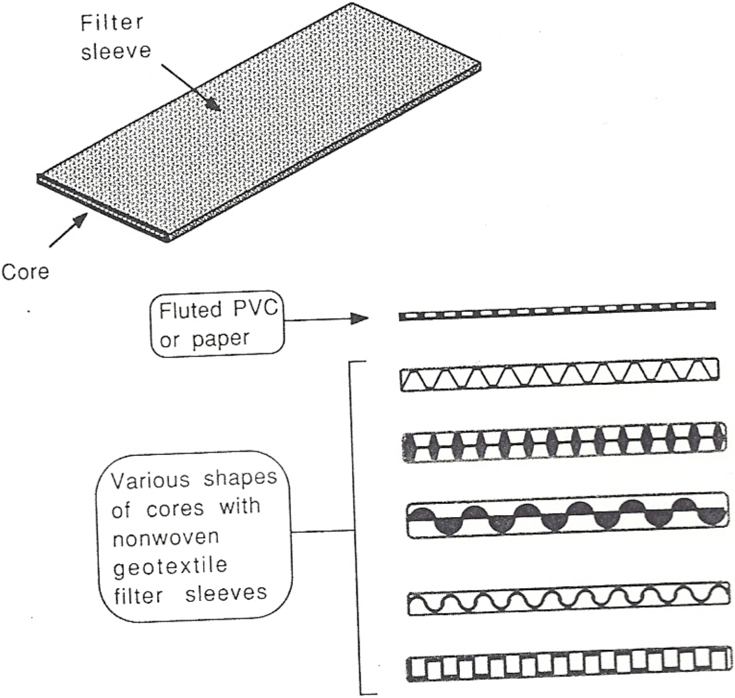


FIGURE 11.2
Typical core shapes of strip drains.