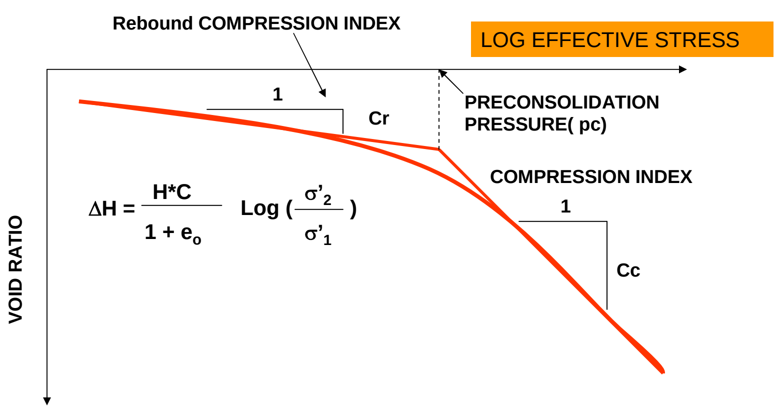
Time Rate of Consolidation

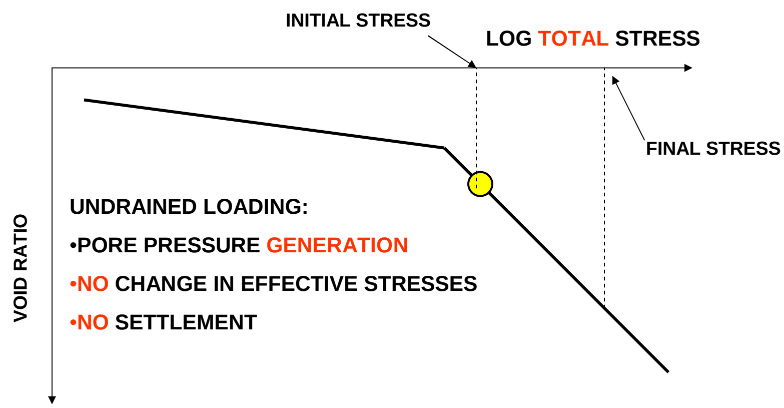
Primary Consolidation

1D THEORY OF CONSOLIDATION TIME-INDEPENDENT ANALYSIS



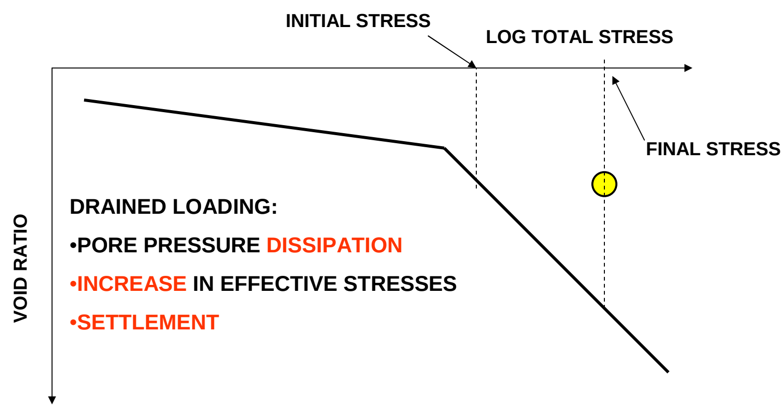
Primary Consolidation

1D THEORY OF CONSOLIDATION TIME-DEPENDENT ANALYSIS



Primary Consolidation

1D THEORY OF CONSOLIDATION TIME-DEPENDENT ANALYSIS



Terzaghi's 1D Theory

Assumptions:

- Clay water system is homogeneous
- Degree water saturation is 100%
- Compressibility of water is negligible
- Compressibility of solid is negligible
- Flow of water is vertical only
- Darcy's flow is valid

Flow of Water under Stress

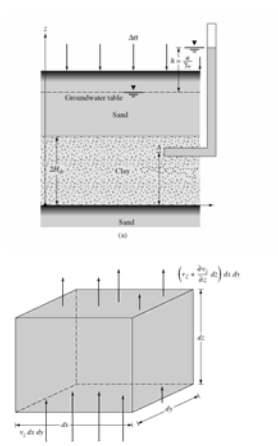


Figure 7.17 (a) Clay layer undergoing consolidation; (b) flow of water at *A* during consolidation

Terzaghi's 1D Theory

rate of outflow of water - rate of inflow of water = rate of volume change

$$-\frac{K}{\gamma_w}\frac{\partial^2 u}{\partial z^2} = \frac{a_v}{1+e_0}\frac{\partial u}{\partial t} = m_v \frac{\partial u}{\partial t}$$

$$\frac{\partial u}{\partial t} = c_v \frac{\partial^2 u}{\partial z^2}$$

where :

$$c_v = \textit{coefficient} \text{ of consolidation} = \frac{K}{\gamma_w m_v}$$

Terzaghi's 1D Theory

$$T_v = \frac{c_v t}{H^2_{dr}} = \textit{Time factor}$$

where : t is time, H_{dr} is maximum drainage path

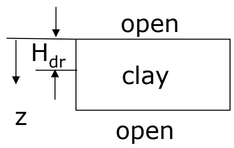
$$U_z = \text{deg}\textit{ree of} \text{ consolidation} = \frac{u_0 - u_z}{u_0} = 1 - \frac{u_z}{u_0}$$

$u_z = \textit{excess}$ porewater pressure at time t

u_o = initial excess porewater pressure at t = 1

Excess PWP Variation with Depth

Two way drainage



z=0 top open

z=1 middle

z=2 bottom open

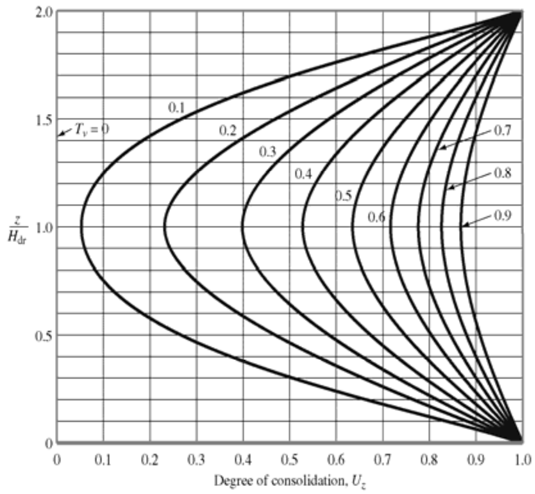
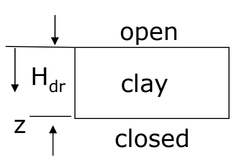


Figure 7.18 Variation of U_z with T_v and z/H_{dr}

Excess PWP variation with Depth

One way drainage



z=0 top open

z=0.5 middle

z=1 bottom closed

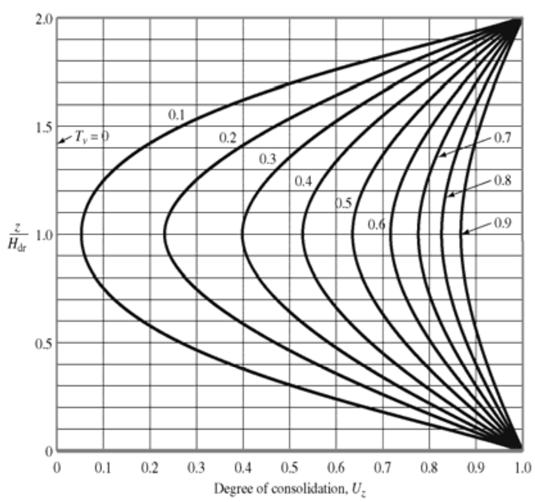


Figure 7.18 Variation of U_z with T_v and z/H_{dr}

Excess PWP variation with Depth

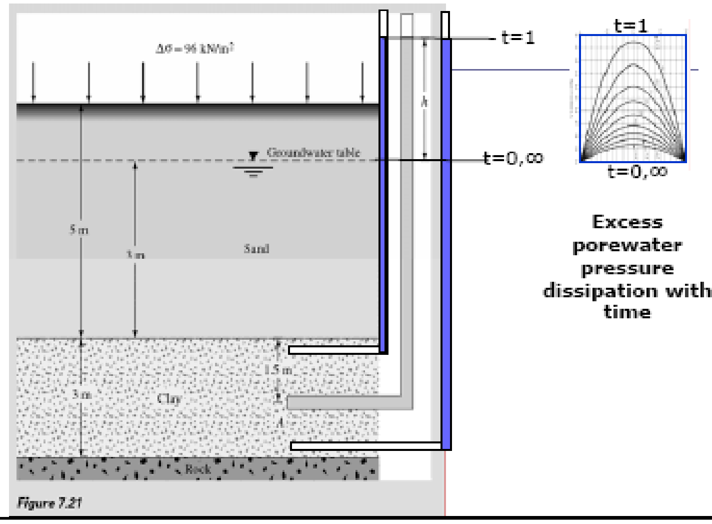


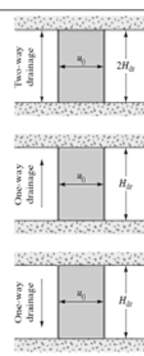
Figure 7.21

Time Factors for constant Excess pwp with depth

Table 7.1 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	79	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	0.304	99	1.781
32	0.0803	66	0.352	100	∞
33	0.0855	67	0.364		

* u_0 constant with depth.



Different types of drainage with u_0 constant

Average Degree of Consolidation

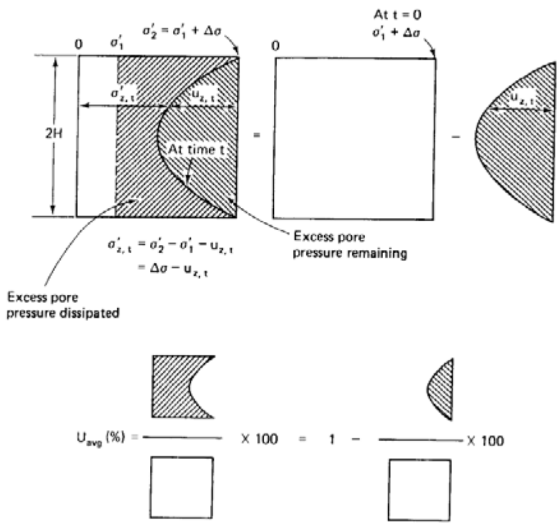


Fig. 9.4 Average degree of consolidation, U_{avg}, defined.

Average Degree of Consolidation wrt Time

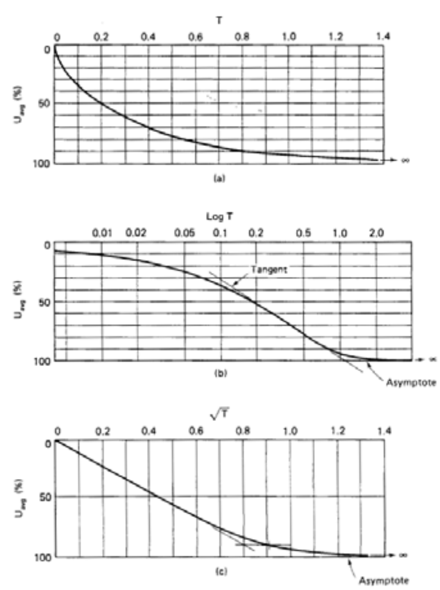


Fig. 9.5 U_{avg} versus T: (a) arithmetic scale; (b) log scale; (c) square root scale.

Excess pwp Distributions

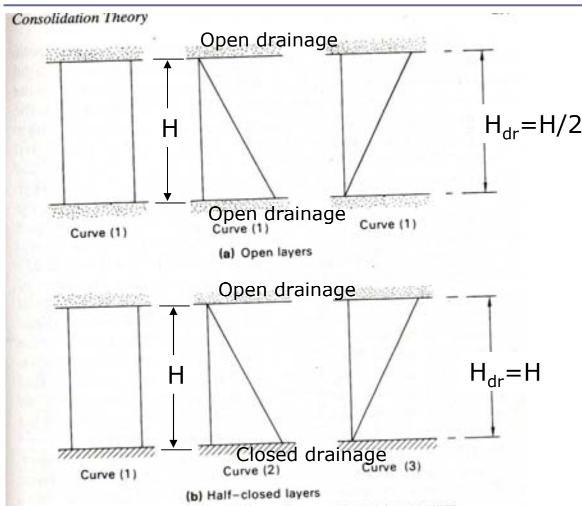


Fig. 7.19 Initial variations of excess pore water pressure.

$$T_v = \frac{C_v t}{H^2_{dr}}$$

1D Average Degree of Consolidation across a layer

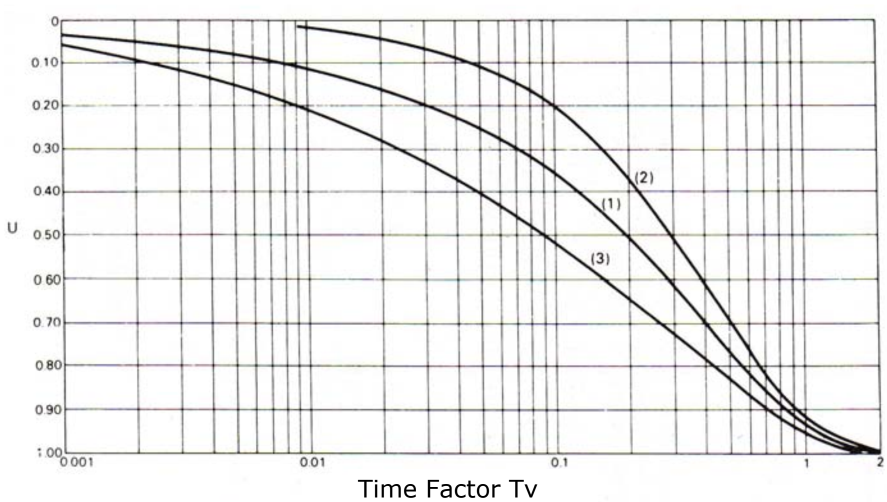


Fig. 7.18 Relationships between average degree of consolidation and time factor.

Oedometer Test

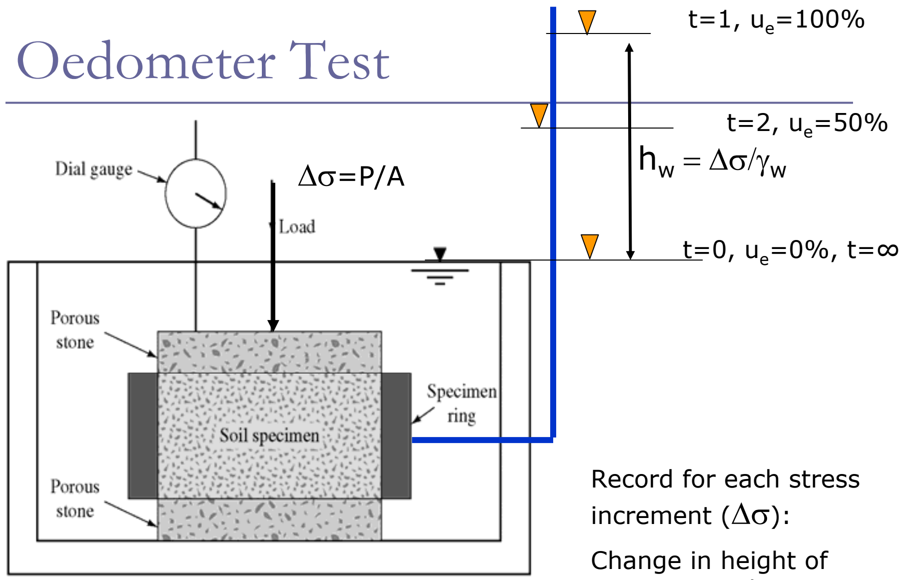
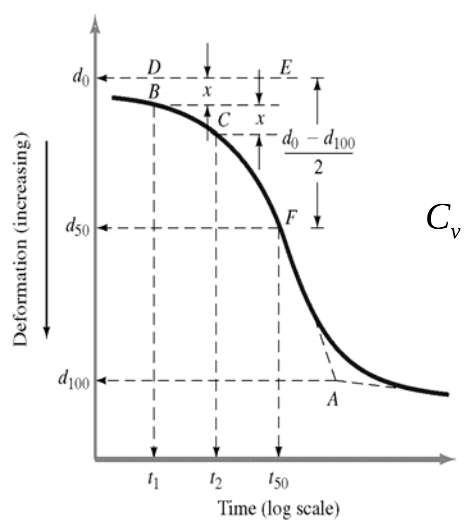


Figure 7.2 Consolidometer

Record for each stress increment (Δσ):

Change in height of specimen with time

Determining C_v using Log Time Method



$$T_v = \frac{C_v t}{H^2_{dr}}$$

$$C_v = \frac{T_{V50} H^2_{dr}}{t_{50}} = \frac{0.196\left[\frac{H}{2}\right]^2}{t_{50}}$$

Figure 7.19
Logarithm-of-time method for determining coefficient of consolidation

Determining C_v using Root Time Method

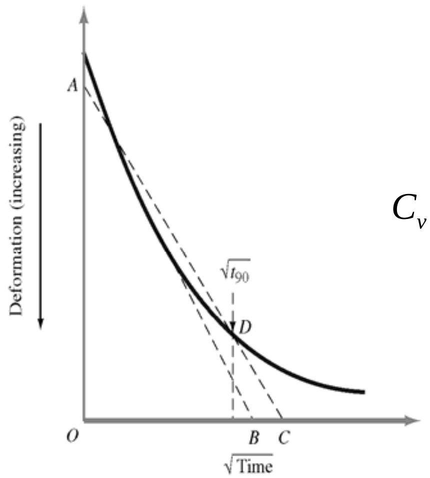


Figure 7.20 Square-root-of-time fitting method

$$T_v = \frac{C_v t}{H^2_{dr}}$$

$$C_v = \frac{T_{V90} H^2_{dr}}{t_{90}} = \frac{0.848\left[\frac{H}{2}\right]^2}{t_{90}}$$

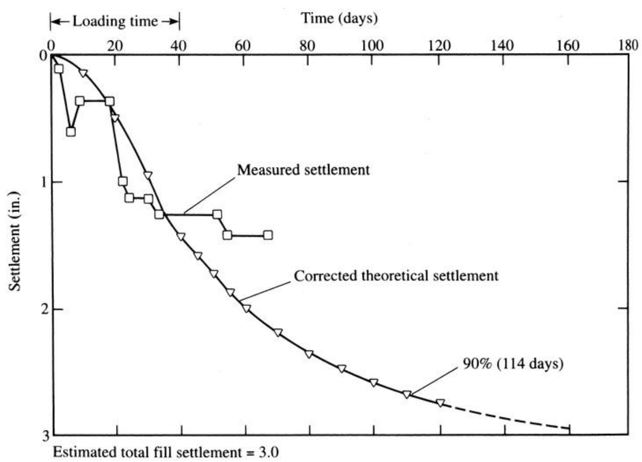
Settlement Magnitude wrt Time

$$U = \frac{S_{c(time)}}{S_c}$$

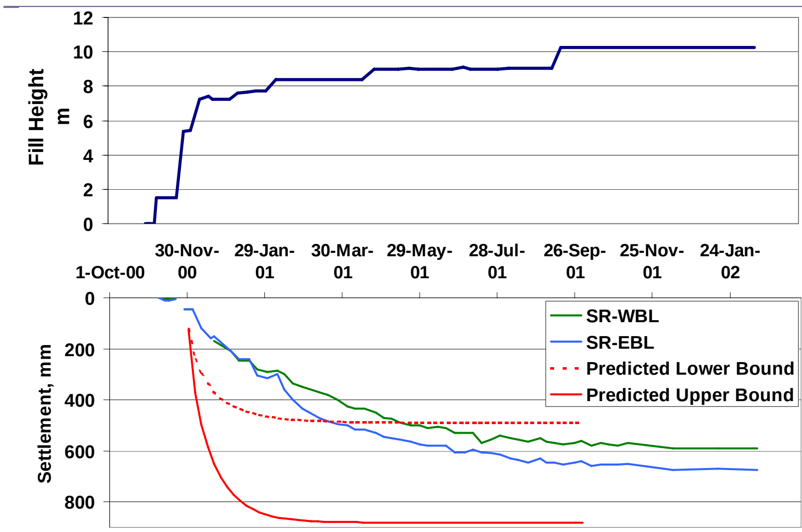
$$S_{c(time)} = U\ S_c$$

Where U is degree of consolidation

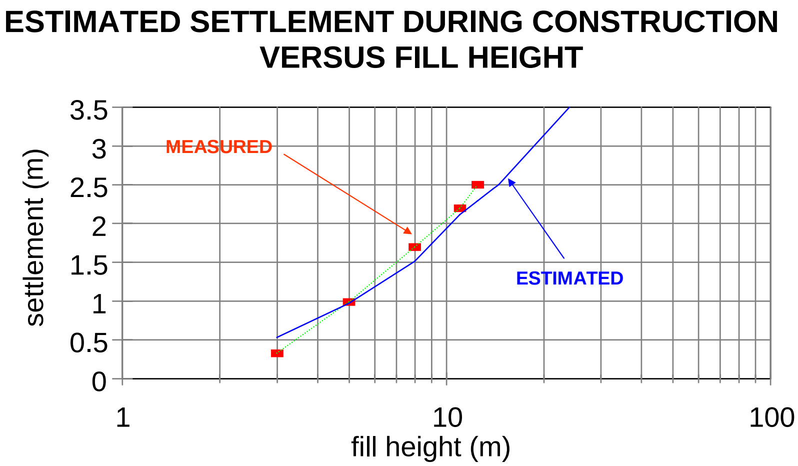
Settlement Magnitude wrt Time



How good are predictions



How good are predictions



Time Rate Predictions