CONSOLIDATION TEST

DEFINITION

The process whereby soil particles are packed more closely together over a period of time under the application of continued pressure. It is accompanied by drainage of water from the pore spaces between solid particles.

- For analytical purpose the compression (settlement) of clays under load can be divided into three phases as shown in Fig. (1):-

1- Initial settlement. 2- Primary settlement. 3- Secondary settlement.

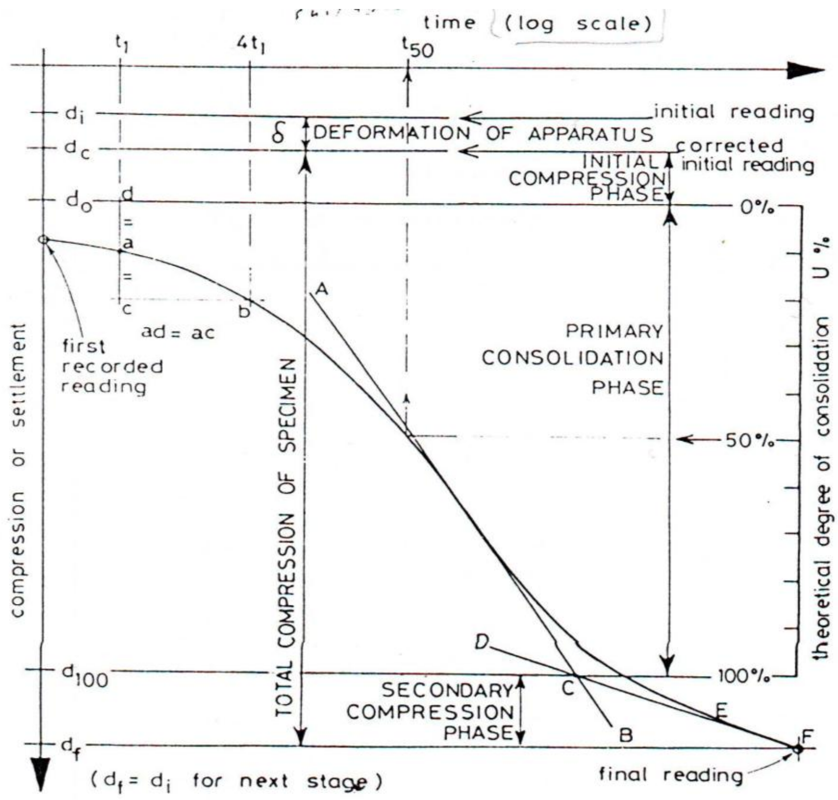

Figure **1**: Phases of settlement and analysis of log-time (settlement curve).

PURPOSES

The consolidation test is used to determine the compression index (C_c) which indicates the compressibility of the specimen, swelling index (C_s) and pre-consolidated pressure (σ_c') the coefficient of consolidation (C_v) which characterize the rate of primary compression.

APPARATUS

1. Consolidation loading frame as shown in Fig. (2).
2. Consolidation cell as shown in Fig. (3), which is consist of
   - Fixed ring.
   - Cell body and base water tight.
   - Consolidation ring retainer and fixing screws or nuts.
   - Loading cap.
   - Two porous discs.
3. One dial gauge for measuring vertical deformation.
4. Specimen trimmer and accessories.
5. Balance, drying oven, timer, and moisture content can.

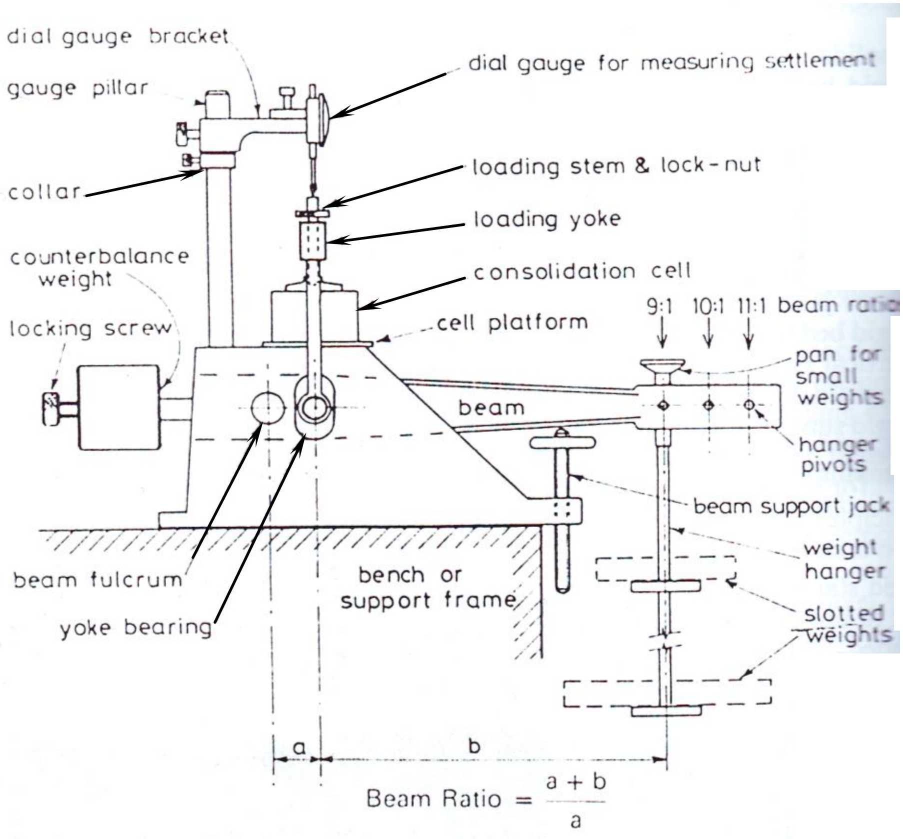

Figure **2**: General arrangement of a typical oedometer loading frame.

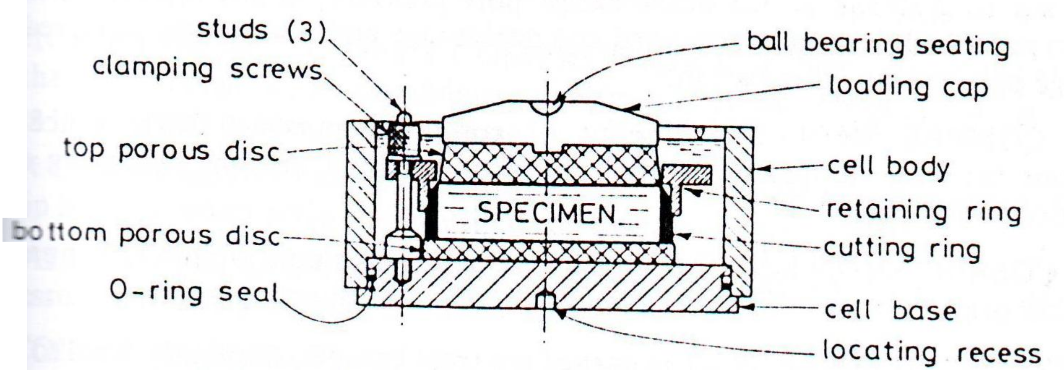

Figure **3**: Details of a typical oedometer consolidation cell (Fixed ring).

PROCEDURE

1. Prepare and check apparatus.
2. Weigh and measure the diameter of consolidation ring.
3. Cut and trim specimen into ring. Determine water content and specific gravity from trimmings.
4. Weigh specimen in ring and measure the initial height (Hi) of the specimen.
5. Assemble specimen in consolidation cell.
6. Fit cell in the load frame and set up loading yoke.
7. Set the vertical displacement dial so that its full range is available during compression.
8. Apply the first increment of load to give a pressure intensity of 1/2 Kg/cm^2 on the soil specimen (the applied load are (1/4 ,1/2 ,1 ,2 ,4 ,8 ,16 Kg) take dial reading at exactly 0,0.25 ,0.5 ,1 ,2 ,4 ,8 ,16 ,30 ,and 60 min and 2,4,8 and 24 hr of elapsed time.
9. After 24 hr change the load to the next value and take readings at the same elapsed time intervals as those give in step 8.
10. Repeat step 9 until all loading steps are completed.
11. The load is decreased to 4 Kg (2Kg/cm^2) and then to 1/4 Kg (1/2 Kg/cm^2) rebound loads; no time readings are normally taken during the rebound (unloading).
12. Quickly dismantle the consolidometer cell and weigh the wet sample.
13. Dry the specimen in the oven and measure its weigh of solids W_s to determine final water content w_f

CALCULATION

1- Find height of soil solids (H_s), initial height of voids (H_v), and initial void ratio of the sample (e_i) as follow:-

$$H_s = \frac{(H_i * A) - (\Delta H_{final} * A + V_{w\,final})}{A} \quad ., \qquad V_w = W_{w\ (final)} / \gamma_w$$

Where A = area of the sample. V_w = volume of water.

W_w = weight of water at end of the test. Hi= initial height of the sample.

$$H_v = H_i - H_s \qquad e_i = \frac{H_v}{H_s}.$$

2- Find e at any load increment:-

$$e = e_i - \frac{\Delta H\ any_{increment}}{H_s} = e_i - \Delta e.$$

3- Find average height at any load increment:

$$\text{Average height} = H_i - \frac{(\Delta H_{a-1} + \Delta Ha)}{2}$$

Where ΔH_a= is any final dial reading of a load increment.

4- Find coefficient of consolidation (C_v) as follows:

$$c_v = \frac{0.197(H^2{}_{avr.})}{t_{50}} \text{ mm}^2 / \text{min}$$

H: length of drainage.

Note: Take H= 1/2 H ---- if drainage **two** way.

Take H = H ---- if drainage **one** way.

Find t_{50} from relationship between dial reading versus log time as shown in Fig. (1) and table (1) .

The above steps are applied for each stress to find c_v for each stress.

Table (1): **Dial gage reading (settlement) mm**

Elapsed (min)	$\sigma 1$ **25Kpa**	$\sigma 2$ **50Kpa**	$\sigma 3$ **100Kpa**	$\sigma 4$ **200Kpa**	$\sigma 5$ **400Kpa**	$\sigma 6$ **800Kpa**	$\sigma 7$ **1600Kpa**	$\sigma 9$ **25Kpa**
0	0.00	0.085	0.265	0.53	0.942	1.63	2.518	3.50
0.5	-	-	0.270	-	-	-	2.59	-
1.0	-	-	0.280	-	-	-	2.67	-
2.0	-	-	0.30	-	-	-	2.70	-
4.0	-	-	0.335	-	-	-	2.75	-
10	-	-	0.40	-	-	-	2.87	-
15	-	-	0.425	-	-	-	3.00	-
25	-	-	0.455	-	-	-	3.10	-
40	-	-	0.475	-	-	-	3.18	-
50	-	-	0.480	-	-	-	3.21	-
60	-	-	0.487	-	-	-	3.24	-
80	-	-	0.495	-	-	-	3.27	-
100	-	-	0.50	-	-	-	3.30	-
150	-	-	0.505	-	-	-	3.35	-
200	-	-	0.510	-	-	-	3.37	-
400	-	-	0.520	-	-	-	3.40	-
1000	-	-.	0.525	-	-	-	3.470	-
1440 (24hr)	0.085	0.265	0.530	0.942	1.63	2.518	3.50	2.45

5- Find initial, primary and secondary settlement on the graph as same as shown in Fig. (2) by using elapsed time vs dial gauge reading (settlement) for 100 KPa only in table1.

6- Find compression index (C_c) & swell index (C_s):

From the semi-log plot of void ratio vs log pressure (e-log σ) curve as shown in Fig. (4), we obtain the straight line part, the compression index C_c as

$$C_c = \frac{\Delta e}{\log \dfrac{\sigma_2}{\sigma_1}}$$

From the unloading branch of the curve obtain the swell index C_s as

$$C_s = \frac{\Delta e}{\log \dfrac{\sigma_2}{\sigma_1}}$$

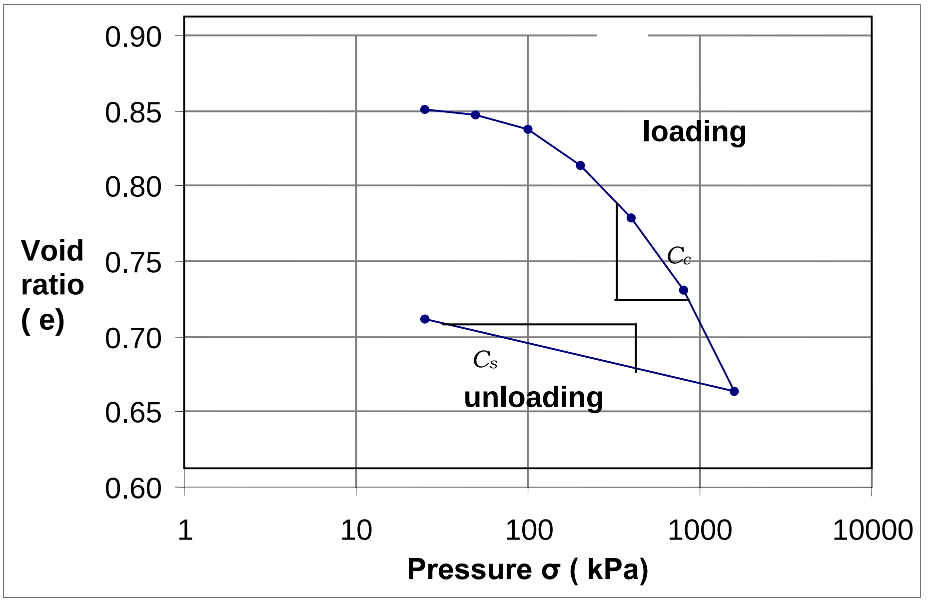

Figure **4**: Typical e/log σ curve.

DISCUSSION

1- What are the factors that affect on the rate of drainage in consolidation test?
2- What is the affect of soil skeleton on the consolidation test?
3- When the greatest amount of the total compression of the sample occurs?

CONSOLIDATION TEST DATA SHEET

Analyst name: Class: Group:

Hi = initial height of the sample =20 mm.

D = diameter of the sample = 50 mm.

Cross sectional Area = mm^2.

$W_{w\ final}$ = gm.

Load increment kPa	**Dial reading at end of load**	**Change in sample height ΔH (cm)**	**Δe = ΔH/H_s**	**e = ei - Δe**	**Average height for load (cm)**	**Time for 50% consoli. t_{50} min.**	**Coeff. Of consol. c_v cm^2/min**
1	***2***	***3***	***4***	***5***	***6***	***7***	***8***
0							
25							
50							
100							
200							
400							
800							
1600							
50							

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