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CONSOLIDATION TEST- (OEDOMETER TEST)
(IS 2720-PART-15-1986) Reaffirmed-2002

THEORY:

When a compressive load is applied to soil mass, a decrease in its volume takes place, the decrease in volume of soil mass under stress is known as compression and the property of soil mass pertaining to its tendency to decrease in volume under pressure is known as compressibility. In a saturated soil mass having its void filled with incompressible water, decrease in volume or compression can take place when water is expelled out of the voids. Such a compression resulting from a long time static load and the consequent escape of pore water is termed as consolidation. Then the load is applied on the saturated soil mass, the entire load is carried by pore water in the beginning. As the water begins escaping from the voids, the hydrostatic pressure in water gets gradually dissipated and the load is shifted to the soil particles which increases effective stress on them, as a result the soil mass decrease in volume. The rate of escape of water depends on the permeability of the soil.

NEED AND SCOPE:

The test is conducted to determine the settlement due to primary consolidation.

a. Rate of consolidation under normal load.
b. Degree of consolidation at any time.
c. Pressure-void ratio relationship.
d. Coefficient of consolidation at various pressures.
e. Compression index.

The above information can be used to predict the time rate and extent of settlement of structures founded on fine-grained soils. It is also helpful in analyzing the stress history of soil.

APPARATUS REQUIRED:

1. Consolidometer consisting essentially;
   a) A ring of diameter = 60mm and height = 20mm,
   b) Two porous stones
   c) Guide ring.
   d) Outer ring.
   e) Water jacket with base.
   f) Pressure pad.
2. Loading device consisting of frame, lever system, loading yoke dial gauge fixing device and weights.
3. Dial gauge (accuracy of 0.01 mm), Thermostatically controlled oven, Stopwatch, sample extractor, balance, soil trimming tools, spatula, filter papers, sample containers.

SAMPLE PREPARATION:

1. Undisturbed Sample:

   From the sample tube, eject the sample into the consolidation ring. The sample should project about one cm from outer ring. Trim the sample smooth and flush with top and bottom of the ring by using wire saw. Clean the ring from outside and keep it ready for weighing.
2. Remolded sample:
   a. Choose the density and water content at which sample has to be compacted from the moisture-density curve, and calculate the quantity of soil and water required to mix and compact.
   b. Compact the specimen in compaction mould in three layers using the standard rammers.
   c. Eject the specimen from the mould using the sample extractor.

PROCEDURE:

1. Saturate two porous stones either by boiling in distilled water about 15 minute or by keeping them submerged in the distilled water for 4 to 8 hrs. Fittings of the Consolidometer which is to be enclosed shall be moistened.
2. Assemble the Consolidometer, with the soil specimen and porous stones at top and bottom of specimen, and providing a filter paper between the soil specimen and porous stone.
3. Position the pressure pad centrally on the top porous stone. Mount the mould assembly on the loading frame, and center it such that the load applied is axial. Make sure that the porous stone and pressure pad are not touching the walls of mould on their sides.
4. Position the dial gauge to measure the vertical compression of the specimen. The dial gauge holder should be set so that the dial gauge is in the beginning of its releases run, and also allowing sufficient margin for the swelling of the soil, if any.
5. Fill the mould with water and apply an initial load to the assembly. The magnitude of this load should be chosen by trial, such that there is no swelling. It should be not less than 50 g/cm^2 for ordinary soils & 25 g/cm^2 for very soft soils. The load should be allowed to stand until there is no change in dial gauge readings for two consecutive hours or for a maximum of 24 hours.
6. Note the final dial reading under the initial load. Apply first load of intensity 0.1 kg/cm^2(Approx.) and start the stop watch simultaneously. Record the dial gauge readings at various time intervals. The dial gauge readings are taken until 90% consolidation is reached. Primary consolidation is gradually reached within 24 hrs.
7. At the end of the period, specified above take the dial reading and time reading. Double the load intensity and take the dial readings at various time intervals. Repeat this procedure for successive load increments. The usual loading intensity is as follows (Approx.): 0.1, 0.2, 0.5, 1, 2, 4 and 8 kg/cm^2.
8. After the last loading is completed, reduce the load to ¼ of the value of the last load and allow it to stand for 24 hrs. Reduce the load further in steps of ¼ the previous intensity till an intensity of 0.1 kg/cm^2 is reached. Take the final reading of the dial gauge.
9. Reduce the load to the initial load, keep it for 24 hrs and note the final readings of the dial gauge.
10. Quickly dismantle the specimen assembly and remove the excess water on the soil specimen in oven, note its dry weight.

CALCULATIONS:

1. **Height of solids** (H_S) is calculated from the equation

$$H_S = W_S / (G_S.\gamma_w A)$$

2. **Void ratio.** Voids ratio at the end of various pressures are calculated from equation

$$e = (H - H_S)/H_S$$

3. Coefficient of consolidation. The Coefficient of consolidation at each pressure increment is calculated by using the following equations:

i. $C_v = 0.197\ d^2/t_{50}$ (Log fitting method)

ii. $C_v = 0.848\ d^2/t_{90}$ (Square fitting method)

In the log fitting method, a plot is made between dial readings and logarithmic of time, and the time corresponding to 50% consolidation is determined.

In the square root fitting method, a plot is made between dial readings and square root of time, and the time corresponding to 90% consolidation is determined. The values of C_v are recorded in TableII.

4. Compression Index. To determine the compression index, a plot of voids ratio (e) Vslog (t) is made. The virgin compression curve would be a straight line and the slope of this line would give the compression index C_c.

5. Coefficient of compressibility. It is calculated as follows

$a_v = \Delta e / \Delta\sigma'$

Δe – Change in void ratio

$\Delta\sigma'$ - Change in vertical stress

6. Coefficient of permeability. It is calculated as follows

$k = C_v.a_v.\gamma_w / (1+e_o)$.

GRAPHS:

1. Dial reading V_S log of time or
2. Dial reading V_S square root of time.
3. Voids ratio V_S logσ' (average pressure for the increment).

General Remarks:

1. While preparing the specimen, attempts has to be made to have the soil strata orientated in the same direction in the consolidation apparatus.
2. During trimming care should be taken in handling the soil specimen with least pressure.
3. Smaller increments of sequential loading have to be adopted for soft soils.

OBSERVATION AND READING (LOADING):

TableI: Data Sheet for Consolidation Test: Time-Displacement Relationship

Ring Dimensions: Diameter (cm): _____ Area (cm^2): _____ Height (cm): _____

Initial Data: Specimen Ht (cm)._____ Specific Gravity of Soil: _____

Weight of wet soil + Ring (g): _____ Weight of Ring (g): _____ Bulk Density (g/cc): _____

Pressure Intensity (Kg/cm^2)	0.1	0.2	0.5	1	2	4	8
Time (min)							
0							
0.25							
1							
2							
4							
8							
15							
30							
1 hr							
2 hrs							
4 hrs							
8 hrs							
24 hrs							

OBSERVATION AND READING (UNLOADING):

Removed Pressure (kg/cm^2)	Retained Pressure (kg/cm^2)	Dial Gauge reading
0	8	
4	4	
2	2	
1	1	
0.5	0.5	
0.3	0.2	
0.1	0.1	
0.1	0.05 (Seating pressure)	

Water Content determination:

Weight of Saturated Sample + Ring (g): _____

Weight of oven dried soil +Ring (g): _____

Water Content (%): _____

Table II: Data Sheet for Consolidation Test: Pressure-Voids Ratio

Applied Pressure	Final dial reading	Change in Specimen Height	Final Specimen Height	Height of solids	Height of voids	Void ratio	Average Height during Consolidation	Fitting Time, t_{90}	Coefficient of Consolidation, c_v
0									
0.1									
0.2									
0.5									
1.0									
2.0									
4.0									
8.0									
2.0									
0.5									
0.1									