**FLORIDA DEPARTMENT OF TRANSPORTATION**
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# Florida Method of Test
# for
# COEFFICIENT OF PERMEABILITY - FALLING HEAD METHOD

Designation: FM 5-513

## 1. SCOPE

1.1 To determine the coefficient of permeability of a fine grained soil such as fine sand, silt, or clay. This test may also be used for coarse grained soils.

## 2. APPARATUS

2.1 Soil Test Compaction Permeameter.

## 3. GENERAL DISCUSSION

3.1 The falling head permeability set up is shown in Figure 2. The permeameter is a commercial product consisting of a standard 0.002124 ± 0.000021 $m^3$ (1/13.33 cu.ft.) compaction mold fixed with a base plate containing a porous stone and an outlet tube. The cover is fixed with a vent valve and connection for attaching a water supply. A light spring or any similar device should be placed between the cover and porous surcharge disc, to apply a light pressure that will minimize disturbance during saturation and testing. The standpipe is a 100 mL burette using a pinch clamp on the rubber hose connecting the burette and permeameter. A meter stick is used to obtain the initial head, ho. The burette calibration enables calculation of the cross sectional area, a. The final head reading yields h1, using the water level of the outlet tube as the base for the head measurements. Note that the outlet tube is submerged to ensure it is flowing full.

The equation applicable to this test is:

$$K20 = \frac{2.3\ a\ L}{A\ t} \times \log(ho/h1) \times (\mu T/\mu 20)$$

K20 = permeability at 20°C
a = cross-sectional area of burette (sq. cm.)
L = length of soil sample (cm)
A = cross-sectional area of soil sample (sq. cm.)
t = elapsed time of test (sec.)

ho = head across sample at beginning of test (cm)
h1 = head across sample at end of test (cm)
$\mu T/\mu 20$ = viscosity correction factor

3.2 It should be noted that this method of determining the coefficient of permeability is well adapted for long duration tests on fine grained soils where a relatively small volume of water will flow through the sample. For tests of long duration, provisions can be made to control evaporation from the standpipe by using a controlled-humidity room, or by placing a partially inflated rubber balloon over the standpipe end.

To check for sample saturation, and loss due to evaporation, the amount of water which flows through the sample can be compared to the volume which entered the sample. A typical data sheet for recording the information is presented in Figure 3.

4. PROCEDURE

4.1 Weigh the permeameter mold with the base plate and porous stone attached. Also measure the inside mold diameter and height in order to calculate the cross-sectional area and sample length, as well as the cross-sectional area of the burette, which can be determined from the distance between graduations.

4.2 Fill the mold with the soil sample by a method appropriate to the material and purpose of testing.

4.2.1 For tests on loose cohesionless soils: Assemble the permeameter base and mold, then using a large funnel let the dry cohesionless soil rain into the mold at a constant rate. The funnel should be kept about one inch above the soil surface and continuously moved in a spiral motion allowing the sand to accumulate uniformly. An oven-dry moisture determination (AASHTO T 265) shall be made in order to compute the dry density of the soil.

4.2.1 For tests on compacted soils: Using the permeameter molds, embankment type materials are compacted in accordance with AASHTO T-99, Method C, while base and stabilized subgrade type materials are compacted in accordance with AASHTO T 180. After compaction, the mold is removed from the compaction base and assembled in the permeameter base.

4.3 Weigh the assembled mold and base plate with soil and determine the density of dry soil. Measure the length of the soil sample L. If material is

loose, the length of the soil sample should be measured before and after the permeability tests to determine any change in length due to consolidation of soil. The final value of L is used for computations of K.

4.4 Place a piece of filter paper on top and bottom of the sample, then place the perforated disc. Making sure the rim is clean, place the gasket and seat the cover.

4.5 Using a vacuum pump or suitable aspirator, (Fig. 1) evacuate the specimen a minimum of 15 minutes to remove air adhering to soil particles and from the voids (Note 1). Follow the evacuation by a slow saturation of the specimen from the bottom upward, under vacuum, in order to free any remaining air in the specimen. Deaired water is recommended for the saturation of the specimen. The water supply should be slightly elevated in order to produce a small hydraulic head during saturation.

**Note 1:** A maximum vacuum of 250 mm (10 in.) mercury is recommended. Some sandy soils with a permeability greater than $10^{-3}$ should not be subjected to a vacuum greater than 125 mm (5 in.) mercury. In no case shall a combination of vacuum and hydraulic head be great enough to produce turbulent flow in the specimen during saturation.

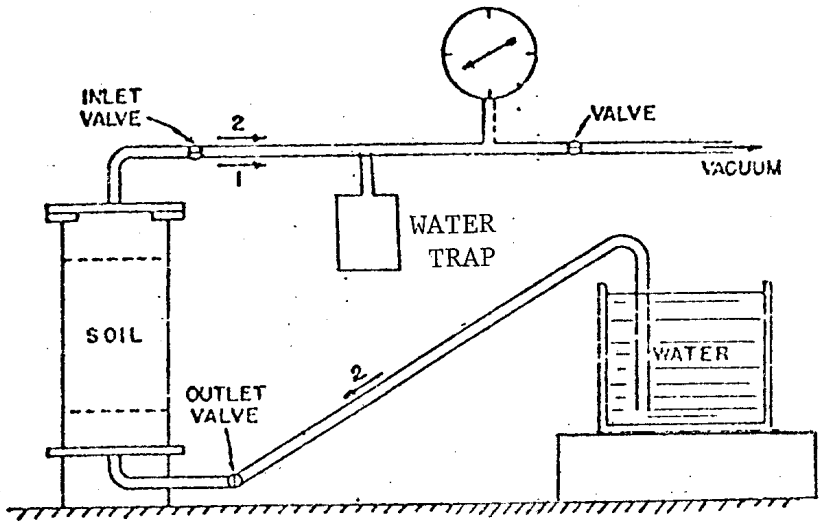



Fig. 1 - Device for Evacuating and Saturating Specimen

4.6 After the specimen has been saturated and the permeameter is full of water, partially close the valve on the outlet tube to produce a minimum steady state flow at the inlet, then disconnect the vacuum. Immediately attach the permeameter to the rubber tube at the base of the burette. The burette and the rubber tube should already be filled and flowing with water from a supply, which has been temperature stabilized and deaired. The permeameter should now be free of air bubbles.

4.7 Close the outlet valve and fill the burette to a convenient height. Remember that the inlet valve is partially open and should be completely opened at this point. Measure the hydraulic head across the sample to obtain ho.

4.8 Disconnect the outlet tube from the saturation reservoir and place it in a filled container as shown in Figure 2.

4.9 Open the outlet valve and simultaneously start timing the test. Allow water to flow through the sample until the burette is almost empty. Simultaneously record the elapsed time and clamp only the outlet tube. Measure the hydraulic head across the sample at this time to obtain h1. Take the temperature of the test.

4.10 Refill the burette and repeat step Section 4.9 two additional times. Take the temperature each time.

4.11 Compute the coefficients of permeability at the test temperature, kt, for each trial, and k at 20°C using the correction values from table 1. Average all three or the two closest values for k20.

Table 1
Viscosity Corrections for μT/μ20

| C | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1.3012 | 1.2976 | 1.2940 | 1.2903 | 1.2867 | 1.2831 | 1.2795 | 1.2759 | 1.2722 | 1.2686 |
| 11 | 1.2650 | 1.2615 | 1.2580 | 1.2545 | 1.2510 | 1.2476 | 1.2441 | 1.2406 | 1.2371 | 1.2336 |
| 12 | 1.2301 | 1.2268 | 1.2234 | 1.2201 | 1.2168 | 1.2135 | 1.2101 | 1.2068 | 1.2035 | 1.2001 |
| 13 | 1.1968 | 1.1936 | 1.1905 | 1.1873 | 1.1841 | 1.1810 | 1.1777 | 1.1746 | 1.1714 | 1.1683 |
| 14 | 1.1651 | 1.1621 | 1.1590 | 1.1560 | 1.1529 | 1.1499 | 1.1469 | 1.1438 | 1.1408 | 1.1377 |
| 15 | 1.1347 | 1.1318 | 1.1289 | 1.1260 | 1.1231 | 1.1202 | 1.1172 | 1.1143 | 1.1114 | 1.1085 |
| 16 | 1.1056 | 1.1028 | 1.0999 | 1.0971 | 1.0943 | 1.0915 | 1.0887 | 1.0859 | 1.0803 | 1.0802 |
| 17 | 1.0774 | 1.0747 | 1.0720 | 1.0693 | 1.0667 | 1.0640 | 1.0613 | 1.0586 | 1.0560 | 1.0533 |
| 18 | 1.0507 | 1.0480 | 1.0454 | 1.0429 | 1.0403 | 1.0377 | 1.0351 | 1.0325 | 1.0300 | 1.0274 |
| 19 | 1.0248 | 1.0223 | 1.0198 | 1.0174 | 1.0149 | 1.0124 | 1.0099 | 1.0074 | 1.0050 | 1.0025 |
| 20 | 1.0000 | 0.9976 | 0.9952 | 0.9928 | 0.9904 | 0.9881 | 0.9857 | 0.9833 | 0.9809 | 0.9785 |
| 21 | 0.9761 | 0.9738 | 0.9715 | 0.9692 | 0.9669 | 0.9646 | 0.9623 | 0.9600 | 0.9577 | 0.9554 |
| 22 | 0.9531 | 0.9509 | 0.9487 | 0.9465 | 0.9443 | 0.9421 | 0.9399 | 0.9377 | 0.9355 | 0.9333 |
| 23 | 0.9311 | 0.9290 | 0.9268 | 0.9247 | 0.9225 | 0.9204 | 0.9183 | 0.9161 | 0.9140 | 0.9118 |
| 24 | 0.9097 | 0.9077 | 0.9056 | 0.9036 | 0.9015 | 0.8995 | 0.8975 | 0.8954 | 0.8934 | 0.8913 |
| 25 | 0.8893 | 0.8873 | 0.8853 | 0.8833 | 0.8813 | 0.8794 | 0.9774 | 0.8754 | 0.8734 | 0.8714 |
| 26 | 0.8694 | 0.8675 | 0.8656 | 0.8636 | 0.8617 | 0.8598 | 0.8579 | 0.8560 | 0.8540 | 0.8521 |
| 27 | 0.8502 | 0.8484 | 0.8465 | 0.8447 | 0.8428 | 0.8410 | 0.8392 | 0.8373 | 0.8355 | 0.8336 |
| 28 | 0.8318 | 0.8300 | 0.8282 | 0.8264 | 0.8246 | 0.8229 | 0.8211 | 0.8193 | 0.8175 | 0.8157 |
| 29 | 0.8139 | 0.8122 | 0.8105 | 0.8087 | 0.8070 | 0.8053 | 0.8036 | 0.8019 | 0.8001 | 0.7984 |
| 30 | 0.7967 | 0.7950 | 0.7934 | 0.7917 | 0.7901 | 0.7884 | 0.7867 | 0.7851 | 0.7834 | 0.7818 |
| 31 | 0.7801 | 0.7785 | 0.7769 | 0.7753 | 0.7737 | 0.7721 | 0.7705 | 0.7689 | 0.7673 | 0.7657 |
| 32 | 0.7641 | 0.7626 | 0.7610 | 0.7595 | 0.7579 | 0.7564 | 0.7548 | 0.7533 | 0.7517 | 0.7502 |
| 33 | 0.7486 | 0.7471 | 0.7456 | 0.7440 | 0.7425 | 0.7410 | 0.7395 | 0.7380 | 0.7364 | 0.7349 |
| 34 | 0.7334 | 0.7230 | 0.7305 | 0.7291 | 0.7276 | 0.7262 | 0.7247 | 0.7233 | 0.7218 | 0.7204 |

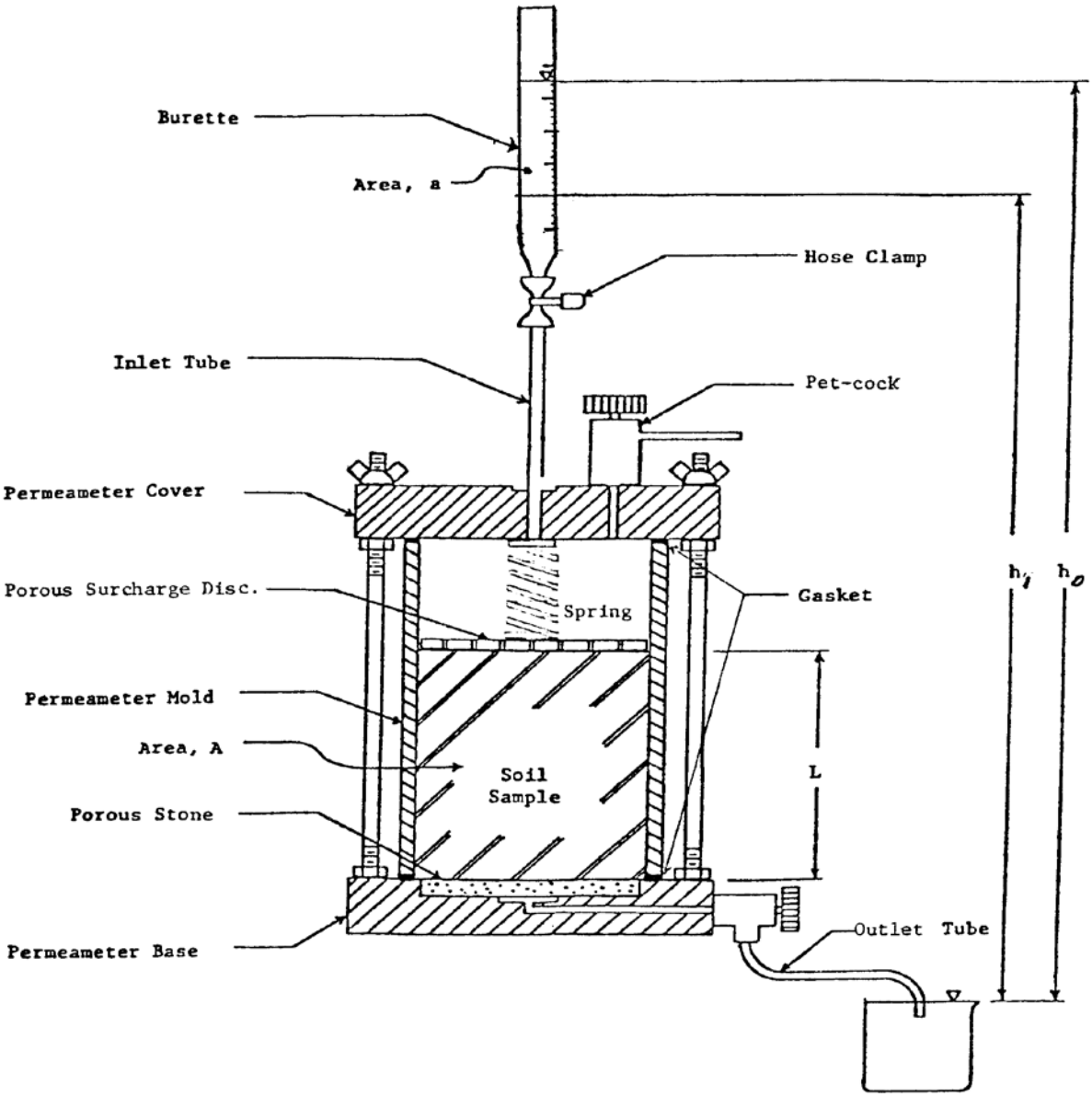



Figure 2
Variable Head Permeameter

Project_____ Lab No. _____

Location of Project_____

Description of Soil_____

Tested by_____ Date of Testing _____

Mold dimensions: Diam_____ Ht._____ Area_____ Vol_____ cu ft

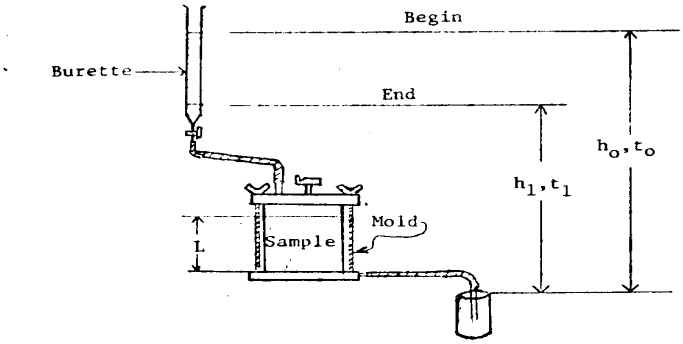
Wt. of mold + gasket + base =_____ lbs.

Wt. of mold + gasket + base + soil =_____ lbs. Unit wt. _____pcf

Wt. of soil =_____ lbs.

Area of burette, = _____ sq cm

Remarks _____




| MOLD NO | TEST | $h_o$ | $h_1$ | t(sec) | $T^oC$ | $K_T$ | $\mu T/\mu 20^oC$ | $K20^o$ |
|---|---|---|---|---|---|---|---|---|
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$$K_{20^o} = \frac{2.3aL}{At} \log (h_o/h_1) \frac{\mu T}{\mu_{20^o}}$$

where KT = coefficient of permeability at T temperature
L = length of soil sample
t = elapsed time in seconds ($t_1 - t_o$)
$h_o$ = head across sample at beginning of test (cm)
$h_1$ = head across sample at end of test (cm)
A = cross-sectional area of sample
a = cross-sectional area of burette (sq. cm.)

where $\mu_T$ = Viscosity of water at T temperature
$\mu_{20^o}$ = Viscosity of water at $20^o$ centigrade

Figure 3
Worksheet