FLORIDA DEPARTMENT OF TRANSPORTATION
State Materials Office
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January 15, 2015

Florida Method of Test
for
MEASUREMENT OF WATER PERMEABILITY OF COMPACTED ASPHALT PAVING MIXTURES

Designation: FM 5-565

1. SCOPE

This test method covers the laboratory determination of the water conductivity of a compacted asphalt paving mixture sample. The measurement provides an indication of water permeability of that sample as compared to those of other asphalt samples tested in the same manner.

The procedure uses either laboratory compacted cylindrical specimens or field core samples obtained from existing pavements.

The values stated in metric (SI) units are to be regarded as standard. Values given in parenthesis are for information and reference purposes only.

This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, and health practices and determine the applicability of regulatory limitations prior to use.

2. APPLICABLE DOCUMENTS

Florida Test Methods

FM 1-T 166 Bulk Specific Gravity of Compacted Bituminous Mixtures.

3. SUMMARY OF TEST METHOD

A falling head permeability test apparatus, as shown in Figure 1, is used to determine the rate of flow of water through the specimen. Water in a graduated cylinder is allowed to flow through a saturated asphalt sample and the interval of time taken to reach a known change in head is recorded. The coefficient of permeability of the asphalt sample is then determined based on Darcy's law.

4. SIGNIFICANCE AND USE

This test method provides a means for determining water conductivity of water-saturated asphalt samples. It applies to one-dimensional, laminar flow of water. It is assumed that Darcy's law is valid.

This test method is primarily intended to be used for dense graded mixtures. However, if used to test open graded mixtures, water flow may not be one-dimensional and laminar, thereby affecting the accuracy of the results. When testing open graded mixtures, this test method is best utilized for comparison purposes and not to obtain absolute permeability values.

5. APPARATUS

5.1 *Permeameter* - See Figure 1. The device shall meet the following requirements:

5.1.1 A calibrated cylinder of 31.75 ± 0.5 mm (1.25 ± 0.02 in.) inner diameter graduated in millimeters capable of dispensing 500 ml of water.

5.1.2 A sealing tube using a flexible latex membrane 0.635 mm (0.025 in.) thick and capable of confining asphalt concrete specimens up to 152.4 mm (6.0 in.) in diameter and 80 mm (3.15 in.) in height.

5.1.3 An upper cap assembly for supporting the graduated cylinder and expanding an O-ring against the sealing tube. The opening in the upper cap shall have the same diameter as the inner diameter of the calibrated cylinder mentioned previously in Section 5.1a. The underside of the upper cap assembly should be tapered at an angle of 10 ± 1° (see Figure 1).

5.1.4 A lower pedestal plate for supporting the asphalt concrete specimen and expanding an O-ring against the sealing tube. The opening in the plate should have a minimum diameter of 18 mm (0.71 in.). The topside of the lower cap should be tapered at an angle of 10 ± 1° (see Figure 1).

5.1.5 O-rings of sufficient diameter and thickness for maintaining a seal against the sealing tube.

5.1.6 A frame and clamp assembly for supplying a compressive force to the upper cap assembly and lower pedestal necessary to expand the O-rings.

5.1.7 An air pump capable of applying 103.42 kPa (15 psi) pressure and capable of applying vacuum to evacuate the air from the sealing tube/membrane cavity.

5.1.8 A pressure gauge with range 0 to 103.42 kPa (0 to 15 psi) with +/- 2% accuracy.

5.1.9 Quick connects and pressure line for inflating and evacuating the sealing tube/membrane cavity.

5.1.10 An outlet pipe with a minimum inside diameter of 18 mm (0.71 in.) with shutoff valve for draining water.

NOTE 1: A device manufactured by Karol Warner Soil Testing Systems has been found to meet the above specifications.

5.2 *Water* - A continuous supply of clean, non-aerated water, preferably supplied by flexible hose from water source to top of graduated cylinder.

5.3 *Thermometer* - A mercury or thermocouple device capable of measuring the temperature of water to the nearest 0.1°C (0.2°F).

5.4 *Beaker* - A 600 ml beaker or equivalent container to be used while measuring the temperature of a water sample.

5.5 *Timer* - A stop watch or other timing device graduated in divisions of 0.1 s or less and accurate to within 0.05% when tested over intervals of not less than 15 min.

5.6 *Measuring Device* - A device used to measure the dimensions of the specimen, capable of measuring to the nearest 0.5 mm or better.

5.7 *Saw* - Equipment for wet cutting the specimen to the desired thickness. Dry cut type saws are not to be used.

5.8 *Sealing Agent* - Petroleum jelly.

5.9 *Spatula* - Used for applying the petroleum jelly to the sides of laboratory compacted specimens.

5.10 *Fan* - An electric fan for drying the wet cut asphalt specimen.

5.11 *Container* - A five gallon bucket or equivalent container for soaking the specimens prior to testing.

6. PREPARATION OF TEST SAMPLES

6.1 Saw cut the field core or the laboratory compacted specimen to the desired test sample thickness. For field cores, the thickness shall be as close to the actual in-place thickness as possible.

For laboratory compacted specimens, trim the top and bottom faces at least the thickness of the nominal maximum aggregate size of the mixture.

6.2 Wash the test sample thoroughly with water to remove any loose, fine material resulting from saw cutting.

6.3 Determine the bulk specific gravity of the specimen, if necessary. Use

Method A of FM 1-T 166.

6.4 Measure and record, to the nearest 0.5 mm (0.02 in.) or better, the height and diameter of the sample at three different locations. The three height measurements shall not vary by more than 5 mm (0.2 in.). The diameter of the specimen shall not be less than 144 mm (5.67 in.).

NOTE 2: During the permeability test, the sample will need to reach a saturated state as defined in Section 7.8. As an aid in saturating the sample, and if time permits, place it in the container described in Section 5.11 and fill with a sufficient quantity of water to completely cover the sample. Let the sample soak for a period of one to two hours.

6.5 For laboratory compacted specimens it is necessary to apply a thin layer of petroleum jelly to the sides of the specimen. This will fill the large void pockets around the sides of the specimen, which are not representative of the level of compaction of the interior of the specimen. If the sample is wet, wipe the sides with a towel to remove any freestanding water. Use a spatula or similar device and apply the petroleum jelly to the sides of the specimen only.

7. TEST PROCEDURE

7.1 Evacuate the air from the sealing tube/membrane cavity.

NOTE 3: Complete evacuation of the air is aided by pinching the membrane and slightly pulling it away from the hose barb fitting as the pump is stroked.

7.2 Place the specimen on top of the lower pedestal plate and center it.

7.3 Place the sealing tube over the specimen and lower pedestal plate making sure that the sealing tube is oriented so that the hose barb fitting will be located between the O-rings on the upper cap and lower pedestal.

7.4 Insert the upper cap assembly into the sealing tube and let it rest on the top of the asphalt concrete specimen.

NOTE 4: Insertion of the upper cap assembly is aided if the graduated cylinder is already inserted into the upper cap assembly. The graduated cylinder can then be used as a handle.

7.5 Install the two clamp assemblies onto the permeameter frame and evenly tighten each one, applying a moderate pressure to the upper cap assembly. This action seals the O-rings against the membrane and sealing tube.

7.6 Inflate the membrane to 68.9 ± 3.4 kPa (10 ± 0.5 psi). Maintain this pressure throughout the test.

7.7 Fill the graduated cylinder with water approximately half way and rock the permeameter back, forth, and sideways enough to dislodge any trapped air from the upper cavity.

7.8 Fill the graduated cylinder to a level above the upper timing mark, see Figure 1. Start the timing device when the bottom of the meniscus of the water reaches the upper timing mark. Stop the timing device when the bottom of the meniscus reaches the lower timing mark. Record the time to the nearest second. Perform this test three times and check for saturation. While checking for saturation, do not allow the remaining water in the graduated cylinder to run out, as this will allow air to re-enter the specimen.

Saturation is defined as the repeatability of the time to run 500 ml of water through the specimen. A specimen will be considered saturated when the % difference between the first and third test is ± 4.0%. Therefore, a minimum of three tests will be required for each asphalt concrete specimen except as stated in Note 6. Saturation of the specimen may require many test runs prior to achieving the ± 4.0% requirement. One technique that aids in achieving saturation is to nearly fill the graduated cylinder with water and adjust the water inflow so that it equals the outflow. Allow the water to run in this manner for five or ten minutes and then begin the timed testing. If more than three test runs are required, which is typically the case, then the ± 4.0% requirement shall apply to the last three testing times measured.

NOTE 5: If after the third run, the test run time is greater than ten minutes, then the tester can use judgment and consider ending the test, using the lowest time recorded in the permeability calculation.

NOTE 6: If the test time is approaching thirty minutes during the first test run without the water level reaching the lower timing mark, then the tester may mark the water level at thirty minutes and record this mark and time. Run the test one more time and record the mark and time. Use the mark and time, which will result in the highest permeability value.

7.9 Obtain a sample of water in a beaker or other suitable container and determine the temperature to the nearest 0.1°C (0.2°F).

7.10 After the saturation has been achieved and the final time and mark recorded, then release the pressure from the container and evacuate the sealing tube/membrane cavity. Remove the clamp assemblies, upper cap, and specimen. If petroleum jelly was used on the specimen, wipe off any excess left on the latex membrane.

8. CALCULATIONS

8.1 The coefficient of permeability, k, is determined using the following equation:

$$k = \frac{aL}{At} \ln(h_1 / h_2) * t_c$$

Where: k = coefficient of permeability, cm/s;
a = inside cross-sectional area of the buret, cm^2;
L = average thickness of the test specimen, cm;
A = average cross-sectional area of the test specimen, cm^2;
t = elapsed time between h_1 and h_2, s;
h_1 = initial head across the test specimen, cm; see Figure 1.
h_2 = final head across the test specimen, cm; see Figure 1.
t_c = temperature correction for viscosity of water; see Tables 1 and 2. A temperature of 20°C (68°F) is used as the standard.

NOTE 7: It is beneficial to determine a set of constant dimensional values for a particular permeameter. The dimensions from the underside of the top cap assembly to the lower timing mark and from the underside of the top cap assembly to the upper timing mark are constants. Add the average specimen thickness to these two dimensions and h_1 and h_2 are determined. If the test is stopped at a mark other than the 0 ml lower mark, then add the difference to the h_2 value to arrive at the new h_2 value for this sample. It is helpful to create a spreadsheet that will calculate these values and permeability values automatically.

8.3 For each sample, the coefficient of permeability is computed based on the time and lower mark recorded in Section 7.8. The result is reported in whole units x 10^{-5} cm/s.

Table 1 - Temperature Correction for Viscosity of Water, Celsius

°C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
10	1.30	1.30	1.29	1.29	1.29	1.28	1.28	1.27	1.27	1.27
11	1.26	1.26	1.26	1.25	1.25	1.25	1.24	1.24	1.24	1.23
12	1.23	1.23	1.22	1.22	1.22	1.21	1.21	1.21	1.20	1.20
13	1.20	1.19	1.19	1.19	1.18	1.18	1.18	1.17	1.17	1.17
14	1.16	1.16	1.16	1.16	1.15	1.15	1.15	1.14	1.14	1.14
15	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.11	1.11
16	1.10	1.10	1.10	1.10	1.09	1.09	1.09	1.09	1.08	1.08
17	1.08	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.06	1.05
18	1.05	1.05	1.05	1.04	1.04	1.04	1.03	1.03	1.03	1.03
19	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.01	1.00	1.00
20	1.00	1.00	1.00	0.99	0.99	0.99	0.99	0.98	0.98	0.98
21	0.98	0.97	0.97	0.97	0.97	0.96	0.96	0.96	0.96	0.96
22	0.95	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.94	0.93
23	0.93	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.91	0.91
24	0.91	0.91	0.91	0.90	0.90	0.90	0.90	0.90	0.89	0.89
25	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.87	0.87
26	0.87	0.87	0.87	0.87	0.86	0.86	0.86	0.86	0.86	0.85
27	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84	0.84	0.84
28	0.83	0.83	0.83	0.83	0.83	0.83	0.82	0.82	0.82	0.82
29	0.82	0.81	0.81	0.81	0.81	0.81	0.81	0.80	0.80	0.80
30	0.80	0.80	0.80	0.79	0.79	0.79	0.79	0.79	0.79	0.78
31	0.78	0.78	0.78	0.78	0.78	0.78	0.77	0.77	0.77	0.77
32	0.77	0.77	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.75
33	0.75	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74	0.74
34	0.74	0.74	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.72
35	0.72	0.72	0.72	0.72	0.72	0.72	0.71	0.71	0.71	0.71

Table 2 - Temperature Correction for Viscosity of Water, Fahrenheit

°F	0.0	0.2	0.4	0.6	0.8
50	1.30	1.30	1.29	1.29	1.28
51	1.28	1.28	1.27	1.27	1.26
52	1.26	1.26	1.25	1.25	1.24
53	1.24	1.24	1.23	1.23	1.23
54	1.22	1.22	1.21	1.21	1.21
55	1.20	1.20	1.20	1.19	1.19
56	1.19	1.18	1.18	1.17	1.17
57	1.17	1.16	1.16	1.16	1.15
58	1.15	1.15	1.14	1.14	1.14
59	1.13	1.13	1.13	1.12	1.12
60	1.12	1.11	1.11	1.11	1.10
61	1.10	1.10	1.10	1.09	1.09
62	1.09	1.08	1.08	1.08	1.07
63	1.07	1.07	1.06	1.06	1.06
64	1.06	1.05	1.05	1.05	1.04
65	1.04	1.04	1.04	1.03	1.03
66	1.03	1.02	1.02	1.02	1.02
67	1.01	1.01	1.01	1.01	1.00
68	1.00	1.00	0.99	0.99	0.99
69	0.99	0.98	0.98	0.98	0.98
70	0.97	0.97	0.97	0.97	0.96
71	0.96	0.96	0.96	0.95	0.95
72	0.95	0.95	0.94	0.94	0.94
73	0.94	0.93	0.93	0.93	0.93
74	0.92	0.92	0.92	0.92	0.92
75	0.91	0.91	0.91	0.91	0.90
76	0.90	0.90	0.90	0.89	0.89
77	0.89	0.89	0.89	0.88	0.88
78	0.88	0.88	0.88	0.87	0.87
79	0.87	0.87	0.86	0.86	0.86
80	0.86	0.86	0.85	0.85	0.85
81	0.85	0.85	0.84	0.84	0.84
82	0.84	0.84	0.83	0.83	0.83
83	0.83	0.83	0.82	0.82	0.82
84	0.82	0.82	0.81	0.81	0.81
85	0.81	0.81	0.81	0.80	0.80
86	0.80	0.80	0.80	0.79	0.79
87	0.79	0.79	0.79	0.79	0.78
88	0.78	0.78	0.78	0.78	0.77
89	0.77	0.77	0.77	0.77	0.77
90	0.76	0.76	0.76	0.76	0.76
91	0.76	0.75	0.75	0.75	0.75
92	0.75	0.75	0.74	0.74	0.74
93	0.74	0.74	0.74	0.73	0.73
94	0.73	0.73	0.73	0.73	0.72
95	0.72	0.72	0.72	0.72	0.72

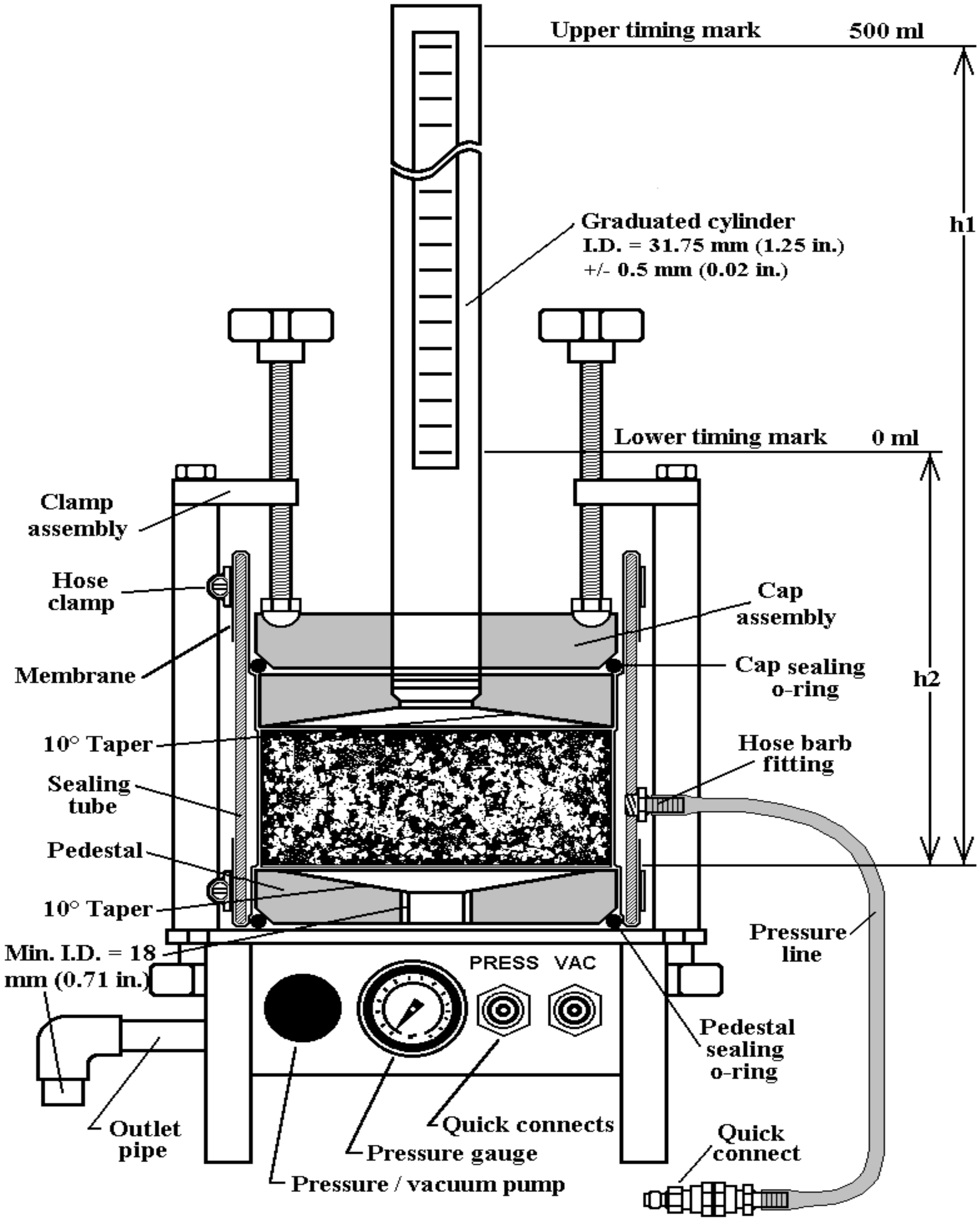

Figure 1 - Water Permeability Testing Apparatus (not to scale).