Florida Method of Test for Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

Designation: FM 1-T 283

1. SCOPE

This method covers preparation of specimens and measurement of the change of diametral tensile strength resulting from the effects of saturation and accelerated water conditioning of compacted bituminous mixtures in the laboratory. The results may be used to predict long-term stripping susceptibility of the bituminous mixtures, and to evaluate liquid anti-stripping additives that are added to the asphalt cement or pulverulent solids, such as hydrated lime, which are added to the mineral aggregate.

The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

AASHTO Standards:

R 30 Standard Practice for Mixture Conditioning of Hot-Mix Asphalt (HMA)
T 312 Standard Method for Preparing and Determining the Density of Hot-Mix Asphalt (HMA) by Means of the Superpave Gyratory Compactor
T 245 Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus

ASTM Standards:

D 3549 Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens

Florida Method of Test

FM 1-T 166 Bulk Specific Gravity of Compacted Bituminous Mixtures
FM 1-T 168 Sampling Bituminous Paving Mixtures
FM 1-T 209 Maximum Specific Gravity of Bituminous Paving Mixtures

3. SIGNIFICANCE AND USE

3.1 As noted in the scope, this method is intended to evaluate the effects of saturation and accelerated water conditioning of compacted bituminous mixtures in the laboratory. This method can be used (a) to test bituminous mixtures in conjunction with mixture design testing, (b) to test bituminous mixtures produced at mixing plants, and (c) to test bituminous concrete cores obtained from in-place pavements of any age.

3.2 Numerical indices of retained indirect tensile properties are obtained by comparing the retained indirect properties of saturated, accelerated water-conditioned laboratory specimens with the similar properties of dry specimens.

4. SUMMARY OF METHOD

4.1 Test specimens for each set of mix conditions, such as plain asphalt, asphalt with anti-stripping agent and aggregate treated with lime. Each set of specimens is divided into subsets. One subset is tested in dry condition for indirect tensile strength. The other subset is subjected to vacuum saturation, followed by a freeze and a warm-water cycle before being tested for indirect tensile strength. Numerical indices or retained indirect tensile strength properties are computed from the test data obtained on the two subsets: dry and conditioned.

5. APPARATUS

5.1 Equipment for determining the theoretical maximum specific gravity (G_{mm}) of the asphalt mixture from FM 1-T 209[1].

5.2 Balance and water bath from FM 1-T 166.

5.3 Water bath capable of maintaining a temperature of 60 ± 1 °C (140 ± 2°F).

5.4 Freezer maintained at –18 ± 3°C (0 ± 5°F).

5.5 A supply of plastic film for wrapping, heavy-duty leak-proof plastic bags to enclose the saturated specimens, and masking tape.

5.6 10 mL graduated cylinder.

5.7 Aluminum pans having a surface area of 4840 – 6450 cm^2 (75 – 100 $in.^2$) in the bottom and a depth of approximately 25 mm (1 in.).

5.8 Forced-draft oven from AASHTO R 30, thermostatically controlled, capable of maintaining any desired temperature setting from room temperature to 176 ± 3°C (349 ± 5°F).

[1]The vacuum pycnometer Model SG-16, from Gilson Company, Inc., has been found satisfactory for this purpose

5.9 Loading jack and ring dynamometer from AASHTO T 245 to provide a range of accurately controllable rates of vertical deformation including 50 mm per minute (2 in. per minute).

5.10 Steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. The loading strips shall be 12.7 mm (0.5 in.) wide. The length of the loading strips shall exceed the thickness of the specimens. The edges of the loading strips shall be rounded by grinding.

6. PREPARATION OF CORE TEST SPECIMENS

6.1 Select locations on the completed pavement to be sampled and obtain cores four inches in diameter. The number of cores shall be at least six for each set of mix conditions. Additional cores may be required to conduct G_{mm} testing.

6.2 Separate core layers as necessary by sawing or other suitable means and store layers to be tested at room temperature.

7. PREPARATION OF LABORATORY TEST SPECIMENS

7.1 Make at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning.

Note 1 – It is recommended that two additional samples for the set be prepared. These specimens can then be used to establish the vacuum saturation technique as given in Section 9.3.

7.2 Specimens 100.0 mm (3.937 in.) in diameter by 63.5 ± 2.5 mm (2.50 ± 0.10 in.) thick shall be used for this procedure.

7.3 After mixing, the samples shall be conditioned in a pan for two hours at the compaction temperature per AASHTO R 30. After conditioning, compact the samples to 7.0 ± 1.0 percent air voids in accordance with either AASHTO T 312 or T 245.

7.4 Determine theoretical maximum specific gravity of the mixture by FM 1-T 209.

7.5 Calculate the gyratory pill height to achieve 7 ± 1.0 percent air voids:

$$\text{Pill height (mm)} = \frac{(\text{Sample weight w/ Asphalt Binder})}{G_{mm} * 0.93 * \pi * (\text{radius})^2}$$

where:
Sample weight is in grams
π = 3.14
radius = 5 cm

7.6 Calculate the volume of air voids:

$$V_{va} = \frac{(V_a * V_{mb})}{100}$$

where:

V_{va} = volume of air voids
V_a = percent of air voids
V_{mb} = volume of the compacted specimen (cm^3)

8. EVALUATION OF TEST SPECIMENS AND GROUPING

8.1 Determine specimen thickness by ASTM D 3549

8.2 Determine the bulk specific gravity by FM 1-T 166 (non-destructive method). Express volume of specimens in cubic centimeters.

8.3 Calculate the percentage of air voids:

$$V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} * 100$$

where:
V_a = Percent air voids
G_{mm} = Theoretical maximum specific gravity
G_{mb} = Bulk specific gravity

8.4 Sort specimens into two subsets of at least three specimens each so that the average air voids of the two subsets are approximately equal.

9. CONDITIONING OF TEST SPECIMENS

9.1 One subset will be tested dry and the other will be conditioned before testing.

9.2 The dry subset shall be stored at 25 ± 0.5°C °C (77 ± 1°F) in an environmental chamber until testing. The specimens are then tested as described in Section 10.2.

9.2.1 As an alternative to the environmental chamber, the specimens shall be wrapped with plastic or placed in a heavy-duty, leakproof plastic bag. The specimens shall then be placed in a 25 ± 0.5°C (77 ± 1°F) water bath for 2 hours ± 10 minutes with a minimum 25 mm (1 in.) of water above their surface.

9.3 The other subset shall be conditioned as follows:

9.4 Place the specimen in the vacuum container supported above the container bottom by a spacer. Fill the container with potable water at room temperature so that the specimen has at least one inch of water above its surface. Apply a vacuum of 13 to 67 kPa absolute pressure (10 to 26 in. Hg partial pressure), for 5 to 10 minutes. Remove the vacuum and leave the specimen submerged in water for 5 to 10 minutes.

9.5 Determine the bulk specific gravity by FM 1-T 166. Compare saturated surface-dry (SSD) mass with SSD mass determined in Section 8.3. Calculate the volume of absorbed water as SSD mass after vacuum saturation minus dry mass. Measure the masses in grams.

9.6 Calculate the volume of absorbed water:

$$V_{wa} = M_{ssd} - M_{air}$$

where:
V_{wa} = volume of absorbed water
M_{ssd} = saturated surface dry mass of the wet (conditioned) specimens
M_{air} = dry mass of the wet (conditioned) specimens

9.7 Determine the percent of vacuum saturation by comparing volume of absorbed water with volume of air voids from Section 8.4. If the volume of water is at least 70 percent of the volume of the air, proceed to Section 9.3.4. If the volume of water is less than 70 percent, repeat the procedure beginning with Section 9.3.1 using more vacuum and/or time. If the volume of water is more than 80 percent, the specimen has been damaged and is discarded. Repeat the procedure beginning with Section 9.3.1 using less vacuum and/or time.

9.8 Calculate the percent of vacuum saturation:

$$P_{st} = \frac{V_{wa}}{V_{va}} * 100$$

where:
P_{st} = percent saturation
V_{wa} = volume of absorbed water
V_{va} = volume of air voids

9.9 Moisture condition the specimens using the following procedure:

9.10 Cover each of the vacuum-saturated specimens tightly with plastic film. Place each wrapped specimen in a plastic bag containing 10 ± 0.5 mL of water and seal the bag. Place the plastic bags containing the specimens in a freezer at a temperature of –18 ± 3°C (0 ± 5°F) for a minimum of 16 hours. After removal from the freezer, place the specimens in a bath containing potable water at 60 ± 1°C (140 ± 2°F) for 24 ± 1 hour. As soon as possible after placement in the bath, remove the plastic bag and film from each specimen.

9.11 After 24 ± 1 hours in the 60 ± 1°C (140 ± 2°F) water bath, remove the specimens and place them in a water bath already at 25 ± 0.5°C (77 ± 1°F) for 2 hours ± 10 minutes. It may be necessary to add ice to the water bath to prevent the water temperature from rising above 25°C (77°F). Not more than 15 minutes should be required for the water bath to reach 25 ± 0.5°C (77± 1°F). Test the specimen as described in Section 10.

10. TESTING

10.1 Determine the indirect tensile strength of dry and unconditioned specimens at 25 ± 0.5°C (77 ± 1°F).

10.2 Place the specimen between the two bearing plates in the testing machine. Care must be taken so that the load will be applied along the diameter of the specimen. Apply the load to the specimen by means of the constant rate of movement of the testing machine head of 52.4 mm per minute (2.0 in. per minute).

10.3 Steel loading strips shall be used. Record the maximum compressive strength noted on the testing machine and continue loading until a vertical crack appears.

10.4 Calculate the diametral tensile strength as follows:

SI Units:

$$S_t = \frac{2000P}{\pi * h * d}$$

where:

S_t	=	tensile strength, kPa
P	=	maximum load, N
π	=	3.14
h	=	specimen thickness, mm
d	=	specimen diameter, mm

10.5 Express the numerical index or resistance of asphalt mixtures to the detrimental effect of water as the ratio of the original strength that is retained after the freeze-warm water conditioning. Calculate as follows:

$$\text{Tensile Strength Ratio} = \frac{S_2}{S_1} * 100$$

where:

S_1	=	average tensile strength of dry subset, and
S_2	=	average tensile strength of conditioned subset.

11. PRECISION

11.1 Precision values for both unconditioned and conditioned samples are for single operator, within-laboratory only. Precision values for multi-operator, multi-laboratory have not been established.

11.2 Unconditioned specimens: the maximum difference in tensile strength between the highest and lowest value in a set of three test specimens shall not exceed 26 psi.

11.3 Conditioned specimens: the maximum difference in tensile strength between the highest and lowest value in a set of three test specimens shall not exceed 29 psi.