Standard Method of Test for

Hamburg Wheel-Track Testing of Compacted Hot-Mix Asphalt (HMA)

AASHTO Designation: T 324-04

1. SCOPE

1.1. This test method describes a procedure for testing the rutting and moisture-susceptibility of hot-mix asphalt (HMA) pavement samples in the Hamburg Wheel-Tracking Device.

1.2. The method describes the testing of submerged, compacted HMA in a reciprocating rolling-wheel device. This test provides information about the rate of permanent deformation from a moving, concentrated load. A laboratory compactor has been designed to prepare slab specimens. Also, the Superpave© Gyratory Compactor (SGC) has been designed to compact specimens in the laboratory. Alternatively, field cores of large diameter, 255 mm (10 in.) or 300 mm (12 in.), or saw-cut slab specimens may be tested.

1.3. The test method is used to determine the premature failure susceptibility of HMA due to weakness in the aggregate structure, inadequate binder stiffness, or moisture damage. This test method measures the rut depth and number of passes to failure.

1.4. The potential for moisture damage effects are evaluated since the specimens are submerged in temperature-controlled water during loading.

1.5. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns, if any, 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. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- R 30, Mixture Conditioning of Hot-Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 312, Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

3. SIGNIFICANCE AND USE

3.1. This test measures the rutting and moisture susceptibility of an HMA specimen.

4. SUMMARY OF METHOD

4.1. A laboratory-compacted specimen of HMA, a saw-cut slab specimen, or a core taken from a compacted pavement, is repetitively loaded using a reciprocating steel wheel. The specimen is submerged in a temperature-controlled water bath of 40 to 50ºC (104 to 122ºF) or a temperature specified for the binder being used. The deformation of the specimen, caused by the wheel loading, is measured.

4.2. The impression is plotted as a function of the number of wheel passes. An abrupt increase in the rate of deformation coincides with stripping of the asphalt binder from the aggregate in the HMA specimen.

5. APPARATUS

5.1. *Hamburg Wheel-Tracking Machine*—An electrically powered machine capable of moving a 203.2-mm (8-in.) diameter, 47-mm (1.85-in.) wide steel wheel over a test specimen. The load on the wheel is 705 ± 4.5 N (158 lb ± 1.0 lb). The wheel shall reciprocate over the specimen, with the position varying sinusoidally over time. The wheel shall make approximately 50 passes across the specimen per minute. The maximum speed of the wheel shall be approximately 0.305 m/s (1 ft/sec) and will be reached at the midpoint of the specimen.

5.2. *Temperature Control System*—A water bath capable of controlling the temperature within ± 1.0ºC (1.8ºF) over a range of 25 to 70ºC (77 to 158ºF). This bath shall have a mechanical circulating system to stabilize the temperature within the specimen tank.

5.3. *Impression Measurement System*—An LVDT device capable of measuring the depth of the impression of the wheel within 0.01 mm (0.0004 in.), over a minimum range of 0 to 20 mm (0.8 in.). The system shall be mounted to measure the depth of the impression at the midpoint of the wheel's path on the slab specimen. The impression shall be measured at least every 400 passes of the wheel. This system must be capable of measuring rut depth without stopping the wheel. This measurement must be referenced to the number of wheel passes.

5.4. *Wheel Pass Counter*—A non-contacting solenoid that counts each wheel pass over the specimen. The signal from this counter shall be coupled to the wheel impression measurement, allowing for the rut depth to be expressed as a function of the wheel passes.

5.5. *Specimen Mounting System*—A stainless steel tray that can be mounted rigidly to the machine. This mounting must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing. The system shall suspend the specimen, allowing for free circulation of the water bath on all sides. The mounting system shall be designed to provide a minimum of 20 mm (0. 8 in.) of free circulating water on all sides of the specimen.

5.6. *Balance*—Balance of 12,000 g capacity, accurate to 0.1 g.

5.7. *Ovens*—Ovens for heating aggregate and asphalt binders.

5.8. *Superpave Gyratory Compactor*—Superpave Gyratory Compactor (SGC) and molds conforming to T 312.

5.9. *Bowls, spoon, spatula, etc*.

6. SPECIMEN PREPARATION

6.1. *Number of Test Specimens*—There shall be two test specimens prepared for each test. Specimens may either be slab specimens or cylinders.

6.2. *Laboratory-Produced HMA*:

6.2.1. Mixture proportions are batched in accordance with the desired job-mix formula.

6.2.2. The temperature to which the asphalt binder must be heated to achieve a viscosity of 170 ± 20 cSt shall be the mixing temperature. For modified asphalt binders, use the mixing temperature recommended by the binder manufacturer.

6.2.3. Dry-mix the aggregates and mineral admixture (if used) first; then add the correct percentage of asphalt binder. Mix the materials until all aggregates are thoroughly coated. (Wet-mix the aggregates if a lime slurry or other wet materials are used.)

6.2.4. Test samples shall be conditioned at the appropriate compaction temperature in accordance with the short-term conditioning procedure in R 30.

6.2.5. The temperature to which the asphalt binder must be heated to achieve a viscosity of 280 ± 30 cSt shall be the compaction temperature. For modified asphalt binders, use the compaction temperature recommended by the binder manufacturer.

6.2.6. *Laboratory Compaction of Specimens*—Specimens compacted in the laboratory shall be either compacted slab specimens or SGC specimens.

6.2.6.1. *Compacting Slab Specimens*—Material shall be compacted into slab specimens using a Linear Kneading Compactor (or equivalent) and shall be 320 mm (12.5 in.) long and 260 mm (10.25 in.) wide. A slab specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The slab specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted slab specimen shall be cooled at normal room temperature on a clean, flat surface until the specimen is cool to the touch.

6.2.6.2. *Compacting SGC Specimens*—Material shall be compacted into specimens using an SGC according to T 312. A specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Two 150-mm (6 in.) diameter specimens are needed. Compacted specimens shall be cooled at normal room temperature on a clean, flat surface until the specimen is cool to the touch.

6.3. *Field-Produced HMA*—Loose Mix:

6.3.1. Obtain a sample of HMA according to T 168.

6.3.2. *Laboratory Compaction of Specimens*—Specimens compacted in the laboratory shall be either compacted slab specimens or SGC specimens.

6.3.2.1. *Compacting Slab Specimens*—Material shall be compacted into slab specimens using a Linear Kneading Compactor (or equivalent) and shall be 320 mm (12.5 in.) long and 260 mm (10.25 in.) wide. A slab specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The slab specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted slab specimens shall be cooled at normal room temperature on a clean, flat surface until the specimen is cool to the touch.

6.3.2.2. *Compacting SGC Specimens*—Material shall be compacted into specimens using an SGC according to T 312. A specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) can be used. The specimen thickness shall be at least twice the nominal maximum aggregate size. Compacted specimens shall be cooled at normal room temperature on a clean, flat surface until the specimen is cool to the touch.

6.4. *Field-Produced HMA*—Field Compacted (Core/Slab Specimen):

6.4.1. *Cutting*—Field cores or field slab specimens shall consist of wet saw-cut compacted specimens taken from HMA pavements. Field cores shall be 250 mm (10 in.) in diameter. Field slab specimens shall be wet saw-cut to approximately 260 mm (10.25 in.) wide and 320 mm (12.5 in.) long. A slab specimen thickness of 38 mm (1.5 in.) to 100 mm (4 in.) may be used. The height of a field core or field slab specimen is typically 38 mm (1.5 in.), but may be adjusted to fit the specimen mounting system by wet saw-cutting.

Note 1—Care should be taken to load the sample so it is level to the surface of the mold. The sample must be trimmed if it is too tall or shimmed up if it is too short (support with plaster if needed). The down pressure from the wheel is calibrated to be 705 N (158 lb) at the center, level to the top of the mold position. Even a small change in elevation will change the down pressure significantly.

7. DETERMINING AIR VOID CONTENT

7.1. Determine the bulk specific gravity of the specimens in accordance with T 166.

7.2. Determine the maximum specific gravity of the mixture in accordance with T 209.

7.3. Determine the air void content of the specimens in accordance with T 269. It is recommended, for laboratory-compacted specimens, that the target air void content be 7.0 ± 2.0 percent. Field specimens may be tested at the air void content at which they are obtained.

8. PROCEDURE

8.1. *Specimen Mounting*—Use Plaster-of-Paris to rigidly mount the specimen in the mounting trays. The plaster shall be mixed at approximately a 1:1 ratio of plaster to water. Pour the plaster to a height equal to that of the specimen so that the air space between the specimen and the tray is filled. The plaster layer underneath the specimen shall not exceed 2 mm (0.08 in.). Allow the plaster at least one hour to set. If other mounting material is used, it should be able to withstand 890 N (200 lb) of load without cracking.

8.2. *Selecting the Test Temperature*—The test temperature shall be selected based upon the applicable specifications.

8.3. Be sure the drain valve(s) is closed. Fill the wheel-tracking device with hot water until the float device floats to a horizontal position. The water temperature may vary and should be adjusted if necessary.

8.4. When the water has reached the test temperature for 30 minutes, lower the wheels onto the specimens. Ensure that the micro-control unit's LVDT readout reads between 10 mm (0.4 in.) and 18 mm (0.7 in.). To adjust the LVDT height, loosen the two screws on the LVDT mount and slide the LVDT up or down to the desired height. Tighten the screws.

8.5. Start the test.

8.6. The wheel-tracking device shall shut off when 20,000 passes have occurred. The device will also shut off if the average LVDT displacement (read from the micro-control unit, not the screen) is 40.90 mm (1.6 in.) or greater for an individual specimen. Note that the screen readout subtracts the initial LVDT reading from the total displacement.

8.7. Turn off the machine and the main power supply. To drain the baths, open the valve(s) beneath the tanks. Raise the wheels and remove the rutted specimens and the spacers.

8.8. Clean the water baths, heating coils, wheels, and temperature probe with water and scouring pads or as per the manufacturer's recommendations. Use a wet-dry vacuum to remove particles that have settled to the bottom of the baths. Clean the filter element and spacers after every test.

8.9. Turn the steel wheels after each test so the same section of the steel wheel surface is not in contact with the test specimen from test to test. This rotation will provide for even wear over the entire wheel. The test should run with a smooth movement across the test specimen.

9. CALCULATIONS

9.1. Plot the rut depth versus number of passes for each test. A typical plot of the output produced by the Hamburg Wheel-Tracking Device is shown in Figure 1. From this plot, obtain the following values:

Slope and intercept of the first steady-state portion of the curve.

Slope and intercept of the second steady-state portion of the curve.

9.2. Calculate the following test parameters: *(1)*

All of the test parameters below are expressed in 'Passes.'

$$Stripping\ Inflection\ Point\ (SIP) = \frac{Intercept\ (second\ \ portion) - Intercept\ (first\ \ portion)}{Slope\ (first\ \ portion) - Slope\ (second\ \ portion)}$$

where:

Failure Rut Depth is the specified maximum allowable rut depth for the test.

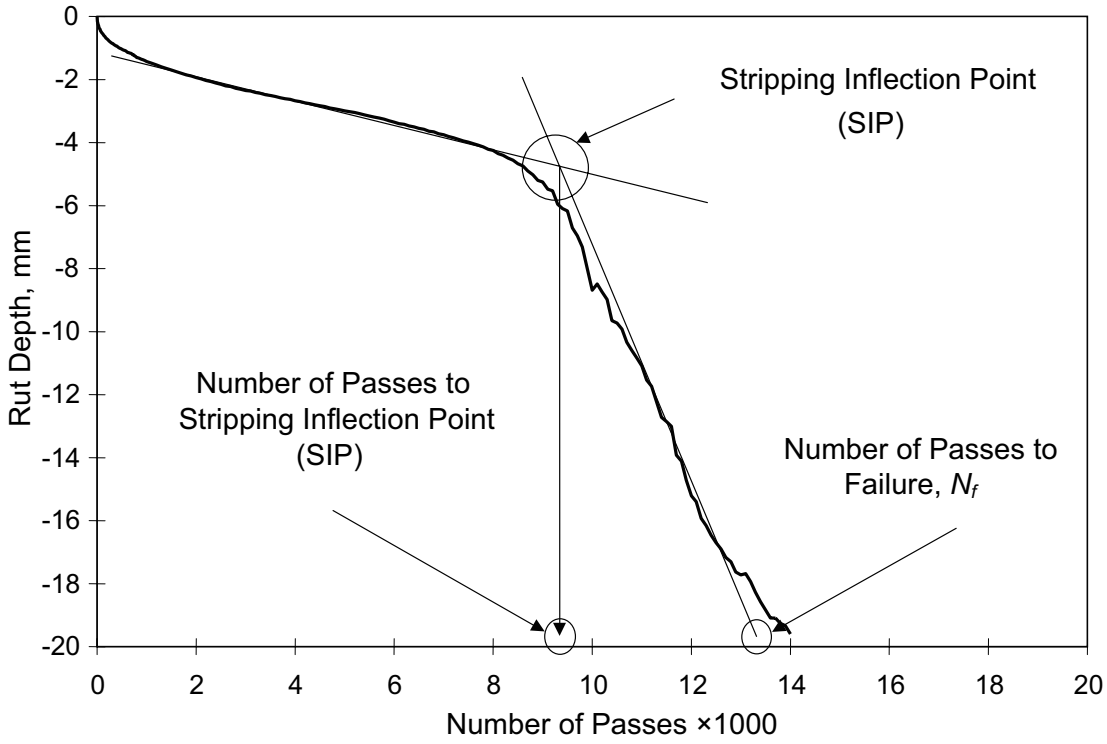

Figure 1—Hamburg Curve with Test Parameters

10. REPORT

10.1. *The report shall include the following parameters*:

10.2. HMA Production (Field or Lab);

10.3. Compaction method (slab or SGC specimen);

10.4. Number of passes at maximum impression;

10.5. Maximum impression;

10.6. Test temperature;

10.7. Specimen(s) air voids;

10.8. Type and amount of anti-stripping additive used;

10.9. Creep slope;

10.10. Strip slope; and

10.11. Stripping inflection point.

11. PRECISION AND BIAS

11.1. Work is underway to develop precision and bias statements for this standard.

12. KEYWORDS

12.1. Compacted Hot-mix asphalt; moisture-susceptibility; rutting; Wheel-track testing.

APPENDIX

(Nonmandatory Information)

A1. MAINTENANCE:

A1.1. All eight of the grease fittings shall be greased with fresh grease every 20 tests (not to exceed two months) per the manufacturer's recommendations.

A2. CALIBRATION/EQUIPMENT VERIFICATION

A2.1. Verify that the water bath temperature is within ±1.0ºC (1.8ºF) of the temperature readout on the micro-control unit every six months.

A2.2. Verify that the LVDT height is within ±0.05 mm (0.002 in.) between the three (10, 20, and 30 mm) (0.4. 0.8, and 1.2 in.) calibration blocks.

A2.3. Verify that the load on the wheel, in the middle of the stroke on the sample, at the correct level elevation, to be 705 ± 4.5 N (158 ±1.0 lb). A calibrated load cell, accurate to 0.4 N (0.1 lb) is sufficient for this check.

A2.4. Verify that the steel wheel is reciprocating back and forth on the test sample at 50 ± 5 passes per minute.