OHD L-43
METHOD OF TEST FOR DETERMINING RUTTING SUSCEPTIBILITY USING THE ASPHALT PAVEMENT ANALYZER

1. SCOPE

1.1 This method describes a procedure for testing the rutting susceptibility of asphalt-aggregate mixtures using the Asphalt Pavement Analyzer (APA).

1.2 The values stated in SI units are used in the volumetric computations in the appendix but English units of measure are considered the norm. The values given in parentheses are for information only.

1.3 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 regulations prior to use.

2. Referenced Documents

2.1 AASHTO Standards:

T 168 Standard Practice for Sampling Bituminous Paving Mixtures

T 209 Standard Method of Test for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

T 248 Standard Method of Test for Reducing Samples of Aggregate to Testing Size

T 269 Standard Method of Test for Percent Air Voids in Compacted Dense and Open Bituminous Mixtures

TP 4 Method for Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

2.2 ASTM Standards:

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

E 178 Standard Practice for Dealing with Outlying Observations

2.3 OHD Standard:

L 45 Method of Test for Determining the Specific Gravity and Unit Weight of Compacted Bituminous Mixtures Using the CoreLok^{TM} Apparatus

3. APPARATUS

3.1. Asphalt Pavement Analyzer (APA**)** - A thermostatically controlled device designed to test the rutting susceptibility of hot mix asphalt by applying repetitive linear loads to compacted test specimens through pressurized hoses.

3.1.1 The APA shall be thermostatically controlled to maintain the test temperature and conditioning chamber at any set point between 39.2 ^{o} and 161.6 ^{o}F within 1.8 ^{o}F (4 ^{o} and 72 ^{o}C within 1 ^{o}C. The standard set point temperature will be 147.2 ^{o}F (64 ^{o}C).

3.1.2 The APA shall be capable of independently applying loads of 100 lbf (445 N) to each of the three wheels. The loads shall be calibrated to the desired test load by an external force transducer.

3.1.3 The pressure in the test hoses shall be adjustable and capable of maintaining pressure at 690 kPa (100 psi).

3.1.4 The APA shall be capable of testing three sets of specimens simultaneously.

3.1.5 The APA shall have a programmable master cycle counter which can be preset to the desired number of cycles for a test. The APA shall be capable of automatically stopping the test at the completion of the programmed number of cycles.

3.1.6 The hoses shall be Gates 77B Paint Spray and Chemical ¾ inch (19.0 mm), 750 psi (5.17 MPa) W.P. GL 07148. The hoses should be replaced when any of the outer rubber casing has worn through and threads are exposed. Follow the APA manufacturer's instructions for the technique on replacing hoses.

3.2 Balance, 12,000 gram capacity, accurate to 0.1 gram.

3.3 Mixing utensils (bowls, spoon, spatula)

3.4 Ovens for heating aggregate and binder.

3.5 Compaction device and molds

4. PREPARATION OF TEST SPECIMENS:

4.1 Number of test specimens - One test set will consist of two cylindrical 6 inch diameter x 3 inch (150 mm diameter x 75 mm) specimens. Three sets are a full run and shall be considered the standard for rut depth determinations.

4.2 Roadway core specimens shall be 6 inch (150 mm) diameter with all surfaces of the perimeter perpendicular to the surface of the core within 0.20 inch (5 mm). Cores shall be trimmed with a wet masonry saw or other suitable means to a height of 3 inch ± 0.12 inch (75 ± 3 mm) as measured in ASTM D 3549. Roadway Cores may be corrected to the proper dimensions with plaster of paris. The diameter should be not less than 5.5. inch (140 mm). Optionally, beam specimens 3 inch x 5 inch x 12 inch (75 mm x 125 mm x 300 mm) may be used for roadway core specimens. Plaster of paris may be used to correct specimen dimensions.
http://www.pavementtechnology.com/Tech%20Papers/tracker_page6.htm
Roadway cores obtained from coring or cut slabs may be reheated and recompacted with the SGC (Superpave Gyratory Compactor,) when such cores are damaged and approval is obtained from the Material's Engineer.

4.3 Plant Produced Mixtures. Samples of plant produced mixtures shall be obtained in accordance with AASHTO T 169 or by use of the Pavement Technology Incorporated (PTI) Remote Truck Sampling Device (RTSD). Mixture samples shall be reduced to the appropriate test size (AASHTO T 248) and compacted in the SGC (AASHTO TP 4) to 7% ± 1% air voids. Reheating of loose plant mixture over two hours should be avoided. The material should be heated to a constant temperature of 300 °F (149 °C) prior to compaction.

4.4 Laboratory Prepared Mixtures

4.4.1 Mixture proportions are batched in accordance to the desired Job Mix Formula (JMF). Required batch sizes are determined in accordance to APPENDIX X1.

4.4.2 The design mixture shall be mixed at 325 °F (163 °C).

4.4.3 Dry mix aggregates and hydrated lime (when lime is used) first, then add optimum percentage of binder and chemical anti-strip additive as shown on the mix design. The anti-strip additive shall be mixed with the binder at the mix design rate (0.5 to 1.0% by weight of the binder typically) at a temperature of 280 ± 5 °F (138 °C ± 3 °C) for seventy-two (72) hours prior to mixing with the job aggregate. Mix the materials until all aggregates are thoroughly coated.

4.4.4 Test samples will not require aging. A minimum of 2 hours and a maximum of 4 hours at 300 °F (149 °C) will be required to ensure removal of moisture prior to compaction. Field mixed material may be compacted when the material reaches a constant 300 °F (149 °C) but not to exceed 4 hours in the oven prior to compaction in the SGC.

4.5 Laboratory Compaction of Specimens

4.5.1 The SGC (AASHTO TP 4) shall be the only device used to compact a minimum of two cylindrical 6 inch diameter x 3 inch (150 mm diameter x 75 mm) specimens for rut testing in the APA. Beams specimens 3 inch x 5 inch x 12 inch (75 mm x 125 mm x 300 mm) will only be used when cylindrical specimens can not be cored and sawing does not damage the specimens. The height tolerance for both cylindrical and beam specimens shall be 3 inch ± 0.12 inch (75 mm ± 3mm) as measured by ASTM D 3549.

Note: Recent studies have shown that samples compacted with different laboratory compaction devices may have significantly different results.

4.5.2 Laboratory prepared specimens shall be compacted to contain 7.0 ± 1.0% air voids.

4.5.3 Compacted specimens should be left at room temperature (approximately 77 °F (25 °C)) to allow the entire specimen to cool for a minimum of 3 hours.

5. DETERMINING THE AIR VOID CONTENTS

5.1 Determine the bulk specific gravity of the test specimens in accordance with OHD L45.

5.2 Determine the maximum specific gravity of the test mixture in accordance with AASHTO T 209.

5.3 Determine the air void contents of the test specimens in accordance with AASHTO T 269.

6. SELECTING THE TEST TEMPERATURE

The test temperature shall be set to 147.2 °F (64 °C). For circumstances where the binder grade has been bumped, the APA test temperature will remain the same.

7. SPECIMEN PREHEATING

7.1 Place the specimens in the molds.

7.2 Specimens shall be preheated in the temperature calibrated APA test chamber or a separate calibrated oven for a minimum of 6 hours. Specimens should not be held at elevated temperatures for more than 24 hours prior to testing.

8. PROCEDURE

8.1 Set the hose pressure gage reading to 100 ± 5 psi (690 ± 35 kPa). Set the load cylinder pressure reading for each wheel to achieve a load of l00 ± 5 lbf (445 ± 22 N).

8.2 Stabilize the testing chamber temperature at the temperature selected in Paragraph 7.

8.3 Secure the preheated, molded specimens in the APA. The preheated APA chamber should not be opened more than 6 minutes when securing the test specimens into the machine. Close the chamber doors and allow 10 minutes for the temperature to restabilize prior to starting the test.

8.4 Set the PRESET COUNTER to the number of cycles for 8050. Fifty cycles are used for seating the specimens.

8.5 Start the test. When the test reaches the number cycles set on the counter, the APA will stop and the load wheels will automatically retract.

8.6 Manual measurements may be taken as a check on the automatic system rut depth measurement.

8.6.1 Open the chamber doors, unlock and pull out the sample holding tray.

8.6.2 Place the rut depth measurement template over the specimen. Make sure that the rut depth measurement template is properly seated and centered lengthwise and rests firmly on top the testing mold.

8.6.3 Zero the digital measuring gauge so that the display shows 0.00 mm with the gauge completely extended. The display should also have a bar below the “inc.” position. Take initial readings at each the five locations on the template. (For cylindrical specimens the center measurement is not used). Measurements shall be determined by placing the digital measuring gauge in the template slots and sliding the gauge slowly across each slot. Record the smallest (greatest rut depth) measurement for each location to the nearest 0.01 mm.

Note: Some Asphalt Pavement Analyzers have been equipped with automatic measurement systems. Some users have reported significant differences in rut depths between the automatic measurements and manual measurements. The automatic rut depth measurements shall be reported and a final manual measurement shall be reported when automatic measurements are not available and as a check on the automatic system compliance.

9. CALCULATIONS

9.1 Determine the average rut depth at each interval for each test position. For beam specimens, use only the three center measurements for calculating the average rut depth. For cylindrical specimens, use the average all four measurements to calculate the average rut depth for each set.

9.2 Calculate the average rut depth from the three test positions. Also, calculate the standard deviation for the three test positions.

9.3 Outlier evaluation – When three sets of the same mixture are tested, arrange the test values in order increasing magnitude: $x_1 \leq x_2 \leq x_3$. If the largest value is the suspected outlier, calculate the T-statistic as follows:

$$T_3 = (x_3 - \bar{x})/s$$

If the smallest value is the suspected outlier, calculate the T-statistic as follows:

$$T_1 = (\bar{x} - x_1)/s$$

where:
$\bar{x}$ = the average the three test values
s = the estimate the population standard deviation based on the sample data, that is, the standard deviation using (n-1) in the denominator. If the T- statistic is greater than or equal to $T_{critical\ (\alpha = 5\%)} = 1.153$, then there is only one chance in twenty that the value is from the same population as the other values. If the T- statistic is greater than or equal to $T_{critical\ (\alpha = 1\%)} = 1.155$, then there is only one chance in one hundred that the value is from the same population as the other values. Therefore, the aberrant value may be discarded, and the remaining rut depths averaged to represent the test result when the T-statistic is greater than or equal to 1.155. When this occurs, the testing procedure, device calibration and test specimens should be investigated to determine possible causes for the excessive variation.

9.4 The APA rut depth for the mixture is the average of three beam specimens or six cylindrical specimens (three sets). A full run is defined as an average of three sets testing simultaneously. A partial run of one set may be allowed upon approval by the Bituminous Branch Manager or Materials Engineer.

10. REPORT

10.1 The test report shall include the following information:

10.1.1 The laboratory name, technician name, and date of test.

10.1.2 The mixture type and description.

10.1.3 Specimen type.

10.1.4 Average air void content of the test specimens.

10.1.5 The test temperature.

10.1.6 The average automatic measured rut depth at 8000 cycles with 50 seating cycles.

10.1.7 Actual wheel load

10.1.8 Actual hose pressure.

11. Precision and Bias

11.1 Work is underway to develop a precision statement for this standard.

ANNEX
(Mandatory Information)

A. CALIBRATION

The following items should be checked for calibration no less than once per year: (1) preheating oven, (2) APA temperature, (3) APA wheel load, and (4) APA hose pressure. Instructions for each these calibration checks is included in this section.

A.1. Temperature calibration of the preheating oven.

A.1.1 The preheating oven must be calibrated with a NIST traceable thermometer (an ASTM 65 C calibrated thermometer is recommended) and a metal thermometer well to avoid rapid heat loss when checking the temperature. Calibrated thermocouples may be used as well.

A.1.2 Temperature Stability

A.1.2.1 Set the oven to the chosen temperature (e.g. 147.2 ^{o}F (64 ^{o}C)). Place the thermometer in the well and place them on the center the shelf where the samples and molds will be preheated. It usually takes an hour or so for the oven chamber, well and thermometer to stabilize. After one hour, open the oven door and read the thermometer without removing it from the well. Record this temperature. Close the oven door.

A.1.2.2 Thirty minutes after obtaining the first reading, obtain another readinthe thermometer. Record this temperature. If the readings from step 2.1 and 2.2 are within 1.0 ^{o}F (0.4 ^{o}C), then average the readings. If the readings differ by more than 1.0 ^{o}F (0.4 ^{o}C) then continue to take readings every thirty minutes until the temperature stabilizes within 1.0 ^{o}F (0.4 ^{o}C) on two consecutive readings.

A.1.3 Temperature Uniformity

A.1.3.1 To check the uniformity the temperature in the oven chamber, move the thermometer and well to another location in the oven so that they are on a shelf where samples and molds will be preheated, but as far as possible from the first location. Take and record readings the thermometer at the second location every thirty minutes until two consecutive readings at the second location are within 1.0 ^{o}F (0.4 ^{o}C).

A.1.3.2 Compare the average of the two readings at the first location with the average of the stabilized temperature at the second location. If the average temperatures from the two locations are within 1.0 ^{o}F (0.4 ^{o}C), then the oven temperature is relatively uniform and it is suitable for use preheating APA samples. If the average the readings at the two locations differ by more than 1.0 ^{o}F (0.4 ^{o}C) then you must find another oven that will hold this level uniformity and meets calibration.

A.1.4 Temperature Accuracy

A.1.4.1 Average the temperatures from the two locations. If that average temperature is within 1.0 °F (0.4 °C) of the set point temperature on the oven, then the oven is reasonably accurate and calibration is complete.

A.1.4.2 If the set point differs from the average temperature by more than 1.0 °F (0.4 Oc), then adjust the oven set point appropriately to raise or lower the temperature inside the chamber so that the thermometer and well will be at the desired temperature (e.g. 147.2 °F (64 °C)).

A1.4.3 Place the thermometer and well in the center the shelf. At thirty-minute intervals, take readings of the thermometer. When two consecutive readings are within 1.0 °F (0.4 °C), and the average the two consecutive readings are within 0.4 °C of the desired test temperature (e.g. 147.2 °F (64 °C)), then the oven has been properly adjusted and calibration is complete. If these two conditions are not met, then repeat steps A.1.4.2 and A.1.4.3.

A.2 APA Temperature Calibration

A.2.1 The APA must be calibrated with a NIST traceable thermometer (an ASTM 65 C or ASTM 75 F calibrated thermometer is recommended) and a metal thermometer well to avoid rapid heat loss when checking the temperature.

A.2.2 Temperature Stability

A.2.2.1 Turn on the APA main power and set the chamber temperature controller so that the temperature inside the testing chamber is about 147.2 °F (64 °C). The water temperature controller should not be set. (Note-experience with the APAC APA has shown that it is necessary to set the controller to about 124 °F (51 °C) to achieve a chamber temperature of 140 °F (60 °C). Place the thermometer in the well and place them on the left side the shelf where the samples and molds will be tested. (Note-it may be helpful to remove the hose rack from the APA during temperature calibration to avoid breaking the thermometer.)

A.2.2.2 It usually takes about five hours for the APA to stabilize. After the temperature display on the controller has stabilized, open the chamber doors and read the thermometer without removing it from the well. Record this temperature. Close the chamber doors.

A.2.2.3 Thirty minutes after obtaining the first reading, obtain another reading the thermometer. Record this temperature. If the readings from step A.2.2.2 and A.2.2.3 are within 1.0 °F (0.4 C), then average the readings. If the readings differ by more than 1.0 °F (0.4 °C) then continue to take readings every thirty minutes until the temperature stabilizes within 1.0 °F (0.4 °C) on two consecutive readings.

A.2.3 Temperature Uniformity

A.2.3.1 To check the uniformity the temperature in the APA chamber, move the thermometer and well to the right side the shelf where the samples are tested. Take and record readings the thermometer at the second location every thirty minutes until two consecutive readings at the second location are within 1.0 °F (0.4 °C).

A.2.3.2 Compare the average the two readings at the left side with the average the stabilized temperature at the right side. If the average temperatures from the two locations are within 1.0 °F (0.4 °C), then the APA temperature is relatively uniform and it is suitable for use. If the average the readings at the two locations differ by more than 1.0 °F (0.4 °C) then consult with the manufacturer on improving temperature uniformity.

A.2.4 Temperature Accuracy

A.2.4.1 Average the temperatures from the two locations. If that average temperature is within 1.0 °F (0.4 °C) the desired temperature 147.2 °F (64 °C), then the APA temperature is reasonably accurate and calibration is complete.

A.2.4.2 If the average temperature differs from the desired temperature 147.2 °F (64 °C) by more than 1.0 °F (0.4 °C), then adjust the APA temperature controller so that the thermometer and well will be at the desired temperature 147.2 °F (64 °C).

A**.2.4.3** Place the thermometer and well in the center the shelf. At thirty minute intervals, take readings the thermometer. When two consecutive readings are within 1.0 °F (0.4 °C), and the average the two consecutive readings are within 1.0 °F (0.4 °C) the desired test temperature 147.2 °F (64 °C), then the APA temperature has been properly adjusted and calibration at that temperature is complete. Record the current set points on the temperature controllers for later reference. If these two conditions are not met, then repeat steps A.2.4.2 and A.2.4.3.

A.3 APA Wheel Load calibration the air cylinders at the three test positions

A.3.1 The APA wheel loads will be checked with the calibrated load cell provided with the APA. The loads will be checked and adjusted one at a time while the other wheels are in the down position and bearing on a dummy sample or wooden block approximately the same height as a test sample. Calibration the wheel loads should be accomplished with the APA at room temperature. A sheet is provided to record the calibration loads.

A.3.1.1 Remove the hose rack from the APA.

A.3.1.2 Jog the wheel carriage until the wheels are over the center the sample tray when the wheels are in the down position.

A.3.1.3 Raise and lower the wheels 20 times to heat up the cylinders.

A.3.1.4 Adjust the bar on top the load cell by screwing it in or out until the total height the loadcell-load bar assembly is 4 1/8 inch (105 mm).

A.3.1.5 Position the load cell under one the wheels. Place wooden blocks or dummy samples under the other two wheels.

A.3.1.6 Zero the load cell.

A.3.1.7 Lower all wheels by turning the cylinder switch to CAL.

A.3.1.8 If the load cell is not centered left to right beneath the wheel, then raise the wheel and adjust the position the load cell. To determine if the load cell is centered front to back beneath the wheel, unlock the sample tray and move it SLOWLY until the wheel rests in the indention on the load cell bar (where the screw is located).

A.3.1.9 After the load cell has been properly centered, adjust the pressure in the cylinder to obtain 445 N (100 lbs). Allow three minutes for the load cell reading to stabilize between adjustments. Record the pressure and the load.

A.3.1.10 With the wheel on the load cell remaining in the down position, raise and lower the other wheels one time. Allow three minutes for the load cell reading to stabilize. Record the pressure and the load.

A.3.1.11 With the other wheels remaining in the down position, raise and lower the wheel over the load cell. Allow three minutes for the load cell reading to stabilize. Record the pressure and the load.

A.3.1.12 Repeat steps A.3.1.5 through A.3.1.11 for each wheel/cylinder.

A.3.1.13 Return the load cell to the first wheel and repeat steps A.3.1.5 through A.3.1.11.

A.3.1.14 Place the load cell under the second wheel and repeat steps A.3.1.5 through A.3.1.11.

A.3.1.15 Place the load cell under the third wheel and repeat steps A.3.1.5 through A.3.1.11. The current cylinder pressures will be used to set wheel loads to 100 lbf (445 N).

A.4 Replacement the APA hoses.

A.4.1 New hoses shall be placed in service in accordance with 2.1.6

A.4.1.1 Remove the hose rack from the APA.

A.4.1.2 Remove the used hoses from the hose rack. Place the new hoses on the barbed nipples and secure with the hose clamps.

A.4.1.3 Position the hoses in the rack such that the hose curvature is vertical. Tighten the nuts at the ends the hoses only until the hoses are secure. Over-tightening will effect the contact pressure and hose life.

A.4.1.4 Place the hose rack back into the APA and make sure that the hoses are aligned beneath the wheels.

A.4.1.5 Prior to testing, break in the new hoses by running 8000 cycles on a set previously tested samples at a temperature 131 ^{o}F (55 ^{o}C) or higher.

A.5 APA Hose Pressure Check

A.5.1 The air pressure in the APA test hoses shall be checked with a NIST traceable test gauge or transducer with a suitable range. The check shall be made while the APA is operating. Since the hoses are connected in series, it is satisfactory to connect the test gauge to the end the right-most hose. The pressure should not fluctuate outside the range 100 ± 5 psi (690 ± 35 kPa) during normal operation. Adjust the pressure as necessary with the hose pressure regulator.

Note: The Ashcroft test gauge model 450182As02L200# has been found to be satisfactory for this purpose. This gauge may available through Grainger (Stock No. 2F008).

APPENDIX

(Nonmandatory Information)

X1. Calculation Specimen Masses

X1.1 Beam Specimens

X1.1.1 Volume specimen (75 mm x 125 mm x 300 mm) = 812.5 cm^3.

X1.1.2 Total mass beam specimen, g = Gmm @ Opt. A.C. x 0.93 x 2812.5 cm^3

X1.1.3 Beams may be batched in 1, 2 or 3 layers. Divide the total mass by the number layers.

X1.1.4 Individual weights for dry aggregate, lime and liquid A. C. per layer

X1.1.4.1 Mass binder, g = grams/layer x % A. C. @ Opt.

X1.1.4.2 Mass aggregate, g = grams/layer - grams A. C. (This includes lime, if used in the mixture).

X1.1.4.3 Mass aggregate excluding lime, g = grams aggregate/1.01

X1.1.4.4 Mass lime, g = grams aggregate - grams aggregate excluding lime

X1.2 Cylindrical Specimens

X1.2.1 Volume Specimen = (π x (150 mm)^2 x 75 mm)/1000 = 1325.4 cm^3

X1.2.2 Total mass cylindrical specimen, g = Gmm @ Opt. A.C. x 0.93 x 1325.4 cm^3

X1.2.3 Individual weights for dry aggregate, lime and liquid A. C. per layer

X1.2.3.1 Mass binder, g = grams/layer x % A. C. @ Opt.

X1.2.3.2 Mass aggregate, g = grams/layer - grams A. C. (This includes lime, if used in the mixture).

X1.2.3.3 Mass aggregate excluding lime, g = grams aggregate/1.01

X1.2.3.4 Mass lime, g = grams aggregate - grams aggregate excluding lime.