PAVEMENT TECHNOLOGY, INC.

AN ASTEC COMPANY

Proposed Method for a Performance Based Asphalt Mix Design and Production and Construction Control System

ROCDOC LAB™

FOREWORD

The following proposed method for designing and controlling asphalt mixes based on performance criteria is a work in progress. The method, procedures, and specifications described are the most current version of this proposal, but may change as research progresses.

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MODEL PROCEDURE FOR
PERFORMANCE BASED MIX DESIGN AND ACCEPTANCE
OF HOT MIX ASPHALT

1. SCOPE

This model demonstrates a proposed method for designing, testing, and accepting hot mix asphalt mixes and pavements based on performance related criteria. This method would be used by City and County Roadway Departments, State Departments of Transportation (DOT), and the Federal Highway Administration (FHWA).

2. MIX DESIGN

The performance based mix design used in this system is intended to provide a quick estimate of the optimum asphalt content which can then be verified through performance testing.

2.1 Asphalt Binder Requirements

The binder grade shall be selected in accordance with AASHTO MP1. Binder grades higher than the minimum required will be allowed if deemed necessary to achieve a certain level of performance.

2.2 Aggregate Requirements

Aggregate properties shall be determined through the following test procedures:

- ASTM D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- ASTM D 4791, Standard Test for Flat Particles Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
- AASHTO T 304, Uncompacted Void Content- Method A
- AASHTO T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- AASHTO T 96, Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
- AASHTO T 104, Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
- AASHTO T 112, Clay Lumps and Friable Particles in Aggregates
- AASHTO T 84, Specific Gravity and Absorption of Fine Aggregate
- AASHTO T 85, Specific Gravity and Absorption of Coarse Aggregate

Aggregate properties shall meet the requirements outlined in The Asphalt Institute's Superpave Level 1 Mix Design Manual (SP-2).

2.3 Gradation of Material

The gradation of the proposed mix design shall be in accordance with existing Superpave asphalt mixture gradation requirements as outlined in The Asphalt Institute's Superpave Level 1 Mix Design Manual (SP-2).

2.4 Estimation of Optimum Asphalt Content

The optimum asphalt content shall be estimated based on volumetric analysis of the materials to be utilized.

2.4.1 Determine the desired Voids in Mineral Aggregate (VMA) and Air Void (AV) Content based on Table 1.

Table 1. Desired Volumetric Criteria

Nominal Maximum Aggregate Size	Target VMA	Target AV Content
9.50	16.0%	4.0%
12.50	15.0%	4.0%
19.00	14.0%	4.0%
25.00	13.0%	4.0%
37.50	12.0%	4.0%

2.4.2 Determine the combined Bulk Specific Gravity (G_{sb}) and Absorption (%ABS) of the aggregate to be used

2.4.3 Calculate the theoretical volume of aggregate (cc) in a compacted sample as follows:

Vol. Of Bulk Aggregate = 100 – VMA

2.4.4 Calculate the theoretical volume of effective asphalt (cc) in a compacted sample as follows:

Vol. Of Effective Asphalt = VMA – AV

2.4.5 Calculate the theoretical weight of effective asphalt (g) in a compacted sample as follows:

Wt. Of Effective Asphalt = (Vol. Of Effective Asphalt) * (G_b)

2.4.6 Calculate the theoretical weight of aggregate (g) in a compacted sample as follows:

Wt. Of Aggregate = (Vol. Of Bulk Aggregate) * (G_{sb})

2.4.7 Calculate the theoretical weight of absorbed asphalt (g) in a compacted sample as follows:

Wt. Of Absorbed Asphalt = Wt. Of Aggregate * (%ABS)

2.4.8 Calculate the theoretical total sample weight (g) as follows:

Total Sample Weight =
Wt. Of Aggregate + Wt. Of Effective Asphalt + Wt. Of Absorbed Asphalt

2.4.9 Calculate the estimated optimum asphalt content as follows:

$$\text{Optimum \%AC} = \frac{(\text{Wt. Of Effective Asphalt} + \text{Wt. Of Absorbed Asphalt})}{\text{Total Sample Weight}} * (100)$$

2.5 Determine the maximum specific gravity (G_{mm}) according to AASHTO T 209 for two samples containing the optimum asphalt content found in section 2.4.9. Also calculate the effective specific gravity of the aggregate (G_{se}).

2.6 Using the estimated volumes and weights found in section 2.4 and the G_{se} found in section 2.5, revise the estimated weight of absorbed asphalt and estimated optimum asphalt content using the following equations:

1. $\text{Vol. Of Effective Aggregate} = \frac{\text{Wt. Of Aggregate}}{G_{se}}$

2. Vol. Of Absorbed Asphalt = (Vol. Of Bulk Aggregate) – (Vol. Of Effective Aggregate)

3. Rev. Wt. Of Absorbed Asphalt = Vol. Of Absorbed Asphalt * G_b

4. Rev. Total Sample Weight =
   Wt. Of Aggregate + Rev. Wt. Of Absorbed Asphalt + Wt. Of Effective Asphalt

5. Rev. Optimum Asphalt Content =
   $$\frac{(\text{Wt. Of Effective Asphalt} + \text{Rev. Wt. Of Absorbed Asphalt})}{\text{Rev. Total Sample Weight}} * (100)$$

2.7 Prepare six samples to be used for verification of the optimum asphalt content through performance testing. Two samples shall be prepared at the estimated optimum asphalt content, two at an asphalt content 0.5% higher than the estimated optimum asphalt content, and two at an asphalt content 0.5% lower than the estimated optimum asphalt content. The samples shall be beam samples measuring 75 mm x 125 mm x 300 mm and shall be made in the Asphalt Vibratory Compactor.

The six beam samples shall be tested for rutting in the Asphalt Pavement Analyzer (APA) in accordance with the attached document “Standard Test Method for DETERMINING RUTTING SUSCEPTIBILITY USING THE ASPHALT PAVEMENT ANALYZER.”

The average rut depth (in millimeters) shall be reported for each asphalt content. A graph shall be constructed indicating the asphalt content versus average rut depth. The optimum asphalt content may be revised to any asphalt content meeting the requirements of Table 2. If none of the asphalt contents tested meets these requirements, the mix shall be redesigned.

Table 2. Maximum Allowable Rut Depth for Asphalt Pavement Types

Pavement Type	Maximum Allowable Rut Depth (mm)
Interstate and Primary Roads* (SMA, Superpave, other high performance mixes)	5.0**
Secondary Roads*	8.0**

* Agency will determine what is considered a primary or secondary road

**Rut depths based on samples containing 7% air voids.

2.8 Prepare six additional beam specimens measuring 75 mm x 125 mm x 300 mm to be tested for resistance to fatigue in the APA. Two samples shall be prepared at the optimum asphalt content, two at an asphalt content 0.5% higher than the optimum asphalt content, and two at an asphalt content 0.5% lower than the optimum asphalt content. Samples from the resistance to rutting test may be used provided that the rut depth on any sample reused is 5 mm or less. Perform the resistance to fatigue test for all six specimens in accordance with attached document "METHOD OF TEST FOR DETERMINING FATIGUE RESISTANCE OF BITUMINOUS MIXTURES USING THE ASPHALT PAVEMENT ANALYZER." The average cycles to failure shall be reported for each asphalt content. A graph shall be constructed indicating the asphalt content versus the average cycles to failure. The average cycles to failure for the mix design shall be greater than that indicated in Table 3.

Table 3. Minimum Allowable Cycles To Failure

Pavement Type	Minimum Allowable Cycles To Failure
All Pavement Types	20,000

2.9 The final Optimum Asphalt Content shall be any asphalt content meeting the requirements in both Table 1 and Table 2.

3. QUALITY CONTROL/QUALITY ASSURANCE TESTING OF PLANT PRODUCED MATERIAL

During field production of asphalt mixtures, the mix shall be tested for the criteria indicated in Table 4.

Table 4. Required QC/QA Tests

Criteria	Testing Rate	Comments
Asphalt Content	1 per 500 tons of mix	Agency Specifies Method
Gradation	1 per 500 tons of mix	Agency Specifies Method
Resistance to Rutting	1 per 500 tons of mix	Standard APA Rut Test

The resistance to rutting test shall be performed by molding two samples of the plant produced hot mix asphalt into beam specimens (75 mm x 125 mm x 300 mm) or cylindrical specimens (150 mm diameter x 75 mm –or- 150 mm diameter x 115 mm) for rut testing in either the APA or Mix Verification Tester (MVT). These samples will be immediately tested in the producer's on-site laboratory to verify that rut depths do not exceed the maximum criteria set forth in Table 2. Testing shall be in accordance with the attached document "Standard Test Method for DETERMINING RUTTING SUSCEPTIBILITY USING THE ASPHALT PAVEMENT ANALYZER." Tests that do not meet the requirements will be considered unacceptable. Two or more consecutively failing tests will require a stoppage of production of the mix until the plant produced mix results in acceptable rut depths. Sublots represented by failing tests may be paid at reduced rate as determined by the agency.

4. PERFORMANCE TESTING OF ROADWAY CORES

Upon completion of placement and compaction of the hot mix asphalt in the field, six core specimens (150 mm diameter) shall be randomly obtained for rut testing in either the APA or MVT. Testing and preparation of specimens shall be in accordance with the attached document "Standard Test Method for DETERMINING RUTTING SUSCEPTIBILITY USING THE ASPHALT PAVEMENT ANALYZER." The average rut depth of the six cylindrical specimens shall not exceed the criteria outlined in Table 2.

Sublots represented by failing tests may be paid at reduced rate as determined by the agency.

(ASTM Format)
Standard Test Method 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 to be regarded as the standard. 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 ASTM Standards

D 979 Standard Practice for Sampling Bituminous Paving Mixtures

D 2726 Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

D 2041 Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

D 3203 Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Mixtures

E 178 Standard Practice for Dealing With Outlying Observations

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 setpoint between 4 ^{o} and 72 ^{o} C within 1^{o}C.

3.1.2 The APA shall be capable of independently applying loads up to 450 N to 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 up to 830 kPa.

3.1.4 The APA shall be capable of testing three beam 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 asphalt cement.

3.5 Compaction device and molds

4. PREPARATION OF TEST SPECIMENS:

4.1 Number of test specimens - One test will use either three beam (75 mm x 125 mm x 300 mm) specimens or six cylindrical (150 mm diameter x 75 mm) specimens.

4.2 Roadway Core Specimens

4.2.1 Roadway core specimens shall be 150 mm diameter with all surfaces of the perimeter perpendicular to the surface of the core within 5 mm. Cores shall be trimmed with a wet masonry saw to a height of 75 ± 3 mm.

4.3 Plant Produced Mixtures

4.3.1 Samples of plant produced mixtures shall be obtained in accordance with ASTM D 979 (AASHTO T 169). Mixture samples shall be reduced to the appropriate test size and compacted while the mixture is still hot. Reheating of loose plant mixture should be avoided.

4.4 Laboratory Prepared Mixtures

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

4.4.2 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.

4.4.3 Dry mix aggregates and hydrated lime (when lime is used) first, then add optimum percentage of asphalt cement. Mix the materials until all aggregates are thoroughly coated.

4.4.4 Test samples shall be aged in accordance with the short-term aging procedure in AASHTO PP2

4.4.5 The temperature to which the asphalt binder must be heated to achieve a viscosity of 290 ± 30 cSt shall be the compaction temperature. For modified asphalt binders, use the compaction temperature recommended by the binder manufacturer. The mixture shall not be heated at the compaction temperature for more than one hour.

4.5 Laboratory Compaction of Specimens

4.5.1 One of several devices may be used to compact specimens in the laboratory. Details regarding the procedures for compacting specimens in each device should be referenced to the equipment manufacturer's instructions.

Note: Recent studies have shown that samples compacted with different laboratory compaction devices may have significantly different results. Each state agency should select one method as the standard for their agency.

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 25ºC) 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 ASTM D 2726 (AASHTO T 166).

5.2 Determine the maximum specific gravity of the test mixture in accordance with ASTM D 2041 (AASHTO T 209).

5.3 Determine the air void contents of the test specimens in accordance with ASTM D 3203 (AASHTO T 269).

6. SELECTING THE TEST TEMPERATURE

6.1 The test temperature shall be set to the high temperature of the standard Superpave binder Performance Grade for the specifying agency. For circumstances where the binder grade has been bumped, the APA test temperature will remain at the standard PG high temperature.

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 700 ± 35 kPa (100 ± 5 psi). Set the load cylinder pressure reading for each wheel to achieve a load of 445 ± 22 N (l00 ± 5 lb.).

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

8. 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 Apply 25 cycles to seat the specimens before the initial measurements. Make adjustments to the hose pressure as needed during the 25 cycles.

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

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

8.8 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 of 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 the each slot. Record the smallest measurement for each location to the nearest 0.01 mm.

8.9 Repeat steps 8.7 and 8.8 for each beam or set of cylinders in the testing position. All measurements shall be completed within six minutes.

8.10 Push the sample holding tray in and secure. Close the chamber doors and allow 10 minutes for the temperature to equalize.

8.11 Set the PRESET COUNTER to the number of cycles for the next interval. Measurements are typically taken at 500, 2000, 4000, and 8000 cumulative cycles.

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

8.13 Repeat steps 8.7 to 8.11 as necessary to complete the test.

Note: Some Asphalt Pavement Analyzers have been equipped with automatic measurement systems which makes steps 8.6 through 8.13 unnecessary. Some users have reported significant differences in rut depths between the automatic measurements and manual measurements.

9. CALCULATIONS

9.1 The rut depth at each location is determined by subtracting the measurement for each interval (500, 2000, 4000, and 8000 cycles) from the initial measurement.

9.2 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 of all four measurements to calculate the average rut depth.

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

9.4 Outlier evaluation – Arrange the test values in order of increasing magnitude: $x_1 \le x_2 \le x_3$. If the largest value is the suspected outlier, calculate the T-statistic as follows:

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

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

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

where:
$\underline{x}$ = the average of the three test values
s = the estimate of 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 two 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.

9.5 The APA rut depth for the mixture is the average of three beam specimens or six cylindrical specimens.

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 rut depths to the nearest 0.1 mm at 500, 2000, 4000, and 8000 cycles.

11. Precision and Bias

11.1 Work is underway to develop a precision statement for this standard. This test method should not be used to accept or reject materials until the precision statement is available.

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 of 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.

A.1.2 Temperature Stability

A.1.2.1 Set the oven to the chosen temperature (e.g. 60 C). Place the thermometer in the well and place them on the center of 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 reading of the thermometer. Record this temperature. If the readings from step2.1 and 2.2 are within 0.4 C, then average the readings. If the readings differ by more than 0.4 C then continue to take readings every thirty minutes until the temperature stabilizes within 0.4 C on two consecutive readings.

A.1.3 Temperature Uniformity

A.1.3.1 To check the uniformity of 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 of the thermometer at the second location every thirty minutes until two consecutive readings at the second location are within 0.4 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 0.4 C, then the oven temperature is relatively uniform and it is suitable for use preheating APA samples. If the average of the readings at the two locations differ by more than 0.4 C then you must find another oven that will hold this level of 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 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 0.4 C, 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. 60 C).

A1.4.3 Place the thermometer and well in the center of the shelf. At thirty-minute intervals, take readings of the thermometer. When two consecutive readings are within 0.4 C, and the average of the two consecutive readings are within 0.4C of the desired test temperature (e.g. 60 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 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 60 C. Also, set the water temperature controller to achieve approximately 60 C water temperature. (Note-experience with the APAC APA has shown that it is necessary to set the controller to about 124 F to achieve a chamber temperature of 60 C.)

Place the thermometer in the well and place them on the left side of 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 of the thermometer. Record this temperature. If the readings from step A.2.2.2 and A.2.2.3 are within 0.4 C, then average the readings. If the readings differ by more than 0.4 C then continue to take readings every thirty minutes until the temperature stabilizes within 0.4 C on two consecutive readings.

A.2.3 Temperature Uniformity

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

A.2.3.2 Compare the average of the two readings at the left side with the average of the stabilized temperature at the right side. If the average temperatures from the two locations are within 0.4 C, then the APA temperature is relatively uniform and it is suitable for use. If the average of the readings at the two locations differ by more than 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 0.4 C of the desired temperature of 60 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 of 60 C by more than 0.4 C, then adjust the APA temperature controller so that the thermometer and well will be at the desired temperature of 60 C.

A.2.4.3 Place the thermometer and well in the center of the shelf. At thirty minute intervals, take readings of the thermometer. When two consecutive readings are within 0.4 C, and the average of the two consecutive readings are within 0.4C of the desired test temperature of 60 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 of 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 of approximately the same height as a test sample. Calibration of 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 of 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 of the load cell by screwing it in or out until the total height of the load cell-load bar assembly is 105 mm.

A.3.1.5 Position the load cell under one of 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 of 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 100 ∀ 1 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 lbs.

A.4 Replacement of 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 of 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 of previously tested samples at a temperature of 55 C (131 F) 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 of the right-most hose. The pressure should not fluctuate outside of the range of 700 ± 35 kPa (100 ± 5 psi) 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 of Specimen Masses

X1.1 Beam Specimens

X1.1.1 Volume of specimen = 75 mm x 125 mm x 300 mm = 2812.5 cm^3.

X1.1.2 Total mass of 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 of layers.

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

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

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

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

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

X1.2 Cylindrical Specimens

X1.2.1 Volume of Specimen = (3B x $(150\ mm)^2$ x 75 mm)/1000 = 1325.4 cm^3

X1.2.2 Total mass of 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 of asphalt cement, g = grams/layer x % A. C. @ Opt.

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

X.1.2.3.3 Mass of aggregate excluding lime, g = grams of aggregate/1.01

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

Revised: April 19, 2001

METHOD OF TEST FOR DETERMINING FATIGUE RESISTANCE OF BITUMINOUS MIXTURES USING THE ASPHALT PAVEMENT ANALYZER

1. SCOPE

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

2. APPARATUS

2.1. Asphalt Pavement Analyzer (APA) – A thermostatically controlled device designed to determine the fatigue properties of hot mix asphalt by applying repetitive linear loads to compacted test specimens through a loaded wheel.

2.1.1 The APA shall be thermostatically controlled to maintain the test temperature and conditioning chamber at any set point between 5 and 70° ± 1°C.

2.1.2 The APA shall be capable of independently applying loads up to 1113 N (250 pounds) to each of the three wheels. These loads shall be calibrated to 1113 N (250 pounds) or other desired test load by an external force transducer.

2.1.3. The APA shall be capable of testing up to three beam specimens independently or simultaneously.

2.1.4 The APA shall have a programmable master cycle counter which can be preset to 50,000 or other desired number of cycles for a test. The APA shall be capable of stopping the counter when a specimen strain gauge breaks.

2.1.5 Fatigue Molds – High density polyethylene molds to hold the asphaltic concrete beam. The top of each end of the mold will securely hold the beam in place while the lower portion of the beam is free to move as load repetitions are applied and the beam flexes.

2.1.6 Automated measurement – The APA shall be equipped with an Automated Vertical Measurement System including a computer program to plot measurements received from transducer signals which represent vertical movement of the beam. The computer program will plot two lines to represent each beam. The solid line is an average of the vertical movement at the ends of the beam and is called the reference line. The dotted line is the deformation of the center of the beam length less the average deformation at the ends. As the test progresses, the two lines diverge at a constant rate until the beam approaches fatigue failure. The lines then diverge rapidly.

TEST SPECIMENS

3.1 Number of test specimens – One test will consist of three beams (75 mm x 125 mm x 300 mm) specimens tested simultaneously.

3.2 Specimens shall be compacted to 7 ± 1% air voids (VTM).

3.3 Laboratory prepared mixtures – Mixtures shall be proportioned in accordance with the job mix formula.

3.3.1 Following mixing, lab prepares mixtures shall be short-term aged in accordance with AASHTO PP2.

3.4 Plant produced mix – Plant produced mix shall be sampled in accordance with AASHTO T-168 and reduced to the size needed for a beam with 7 ± 1% air voids. It may be necessary to make small adjustments to the reduced sample weight to obtain the desired void content prescribed above.

4. COMPACTION

4.1 Compacting temperature – The temperature to which the asphalt binder must be heated to achieve a viscosity of 280 ± 30 centistokes shall be the compacting temperature. This applies to plant mix and laboratory prepared specimens. Mixture shall not be heated at the compacting temperature more than one hour. It is preferred that the mixture not be reheated therefore compacting should be accomplished before the material cools.

5. AGING TEST SPECIMENS

5.1 Following compaction, the test specimen shall be is long-term aged.

5.1.1 Place the compacted test specimen on a shelf in a forced draft oven for 120 ± 0.5 hours at a temperature of 85° ± 3°C.

5.1.2 After 120 hours, turn the oven off, open the doors, and allow the test specimen to cool to room temperature. Do not touch or removed the specimen until it has cooled to room temperature.

5.1.3 After cooling to room temperature, remove the test specimen from the oven. The aged specimen is now ready for testing as required.

6. DETERMINING THE AIR VOIDS CONTENTS

6.1 Determine the bulk specific gravity of the test specimens in accordance with AASHTO T166.

6.2 Determine the maximum specific gravity of the test mixture in accordance with AASHTO T209.

6.3 Determine the air void contents of the test specimens in accordance with AASHTO T269.

7. PROCEDURE FOR FATIGUE TESTING

7.1 Place the test specimens into the molds so that the top of the specimen during compaction is the top of the specimen during the test.

7.2 Set the APA temperature to 20°C (68°F) until the specimens reach this or agency specified temperature. A dummy specimen with an embedded thermometer shall be placed near the test specimens to determine when test temperature is reached.

7.3 Set the precalibrated pressure gauge reading to 1113 ± 4.5 N (250 ± 1 pound).

7.4 Preset the counter to 50,000 cycles (or other agency specified cycles).

7.5 Start the testing. The APA will stop at the end of the test cycle, or when all three beams have failed the fatigue.

8. REPORT

8.1 The test report shall include the following information:

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

8.1.2 The mixture type and description.

8.1.3 Air void content of test specimens.

8.1.4 Number of cycles (fatigue life) of each specimen.

9. ESTIMATE BEAM BATCH MASS

9.1 Volume of specimen (should be measured for each individual mold) = 75 mm x 125 mm x 300 mm = 2812.5 cm^3

9.2 Total mass beam specimen (g) = Gmm @ Optimum AC x 0.93 x 2812.5 cm^3

Sample Performance Based Mix Design

Introduction

Work is currently underway to test and validate this performance based mix design procedure. In a separate study performed by Pavement Technology, Inc., performance testing was used to evaluate the optimum asphalt content of several mixes. The optimum asphalt content of each mix was first determined through a Superpave mix design and then verified through performance testing. Although this study did not follow the previously described performance based mix design procedure, it may serve as an indicator of the validity of using performance testing to determine the optimum asphalt content.

Testing & Results

Three 12.5 mm Superpave mixes approved by the Arkansas DOT were used for this study. The job mix formulas for these mixes are designated West Fork, Avoca, and Lowell. The optimum asphalt content for each mix was as follows:

Mix Designation	Optimum Asphalt Content (%)
West Fork	6.3
Avoca	6.1
Lowell	6.0

Each mix was tested for both resistance to rutting and resistance to fatigue at the mix's optimum asphalt content, 0.2% below optimum, and 0.4 below optimum. The results for the resistance to rutting and resistance to fatigue tests are shown in Figures 1 through 6.

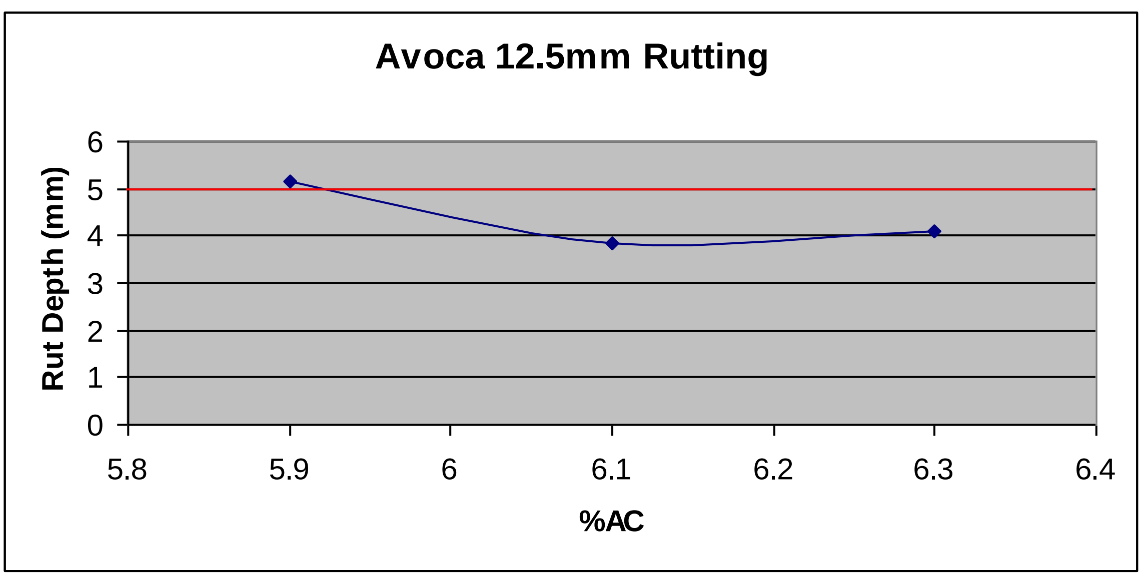

Figure 1. Rut Results for the Avoca 12.5 mm Mix

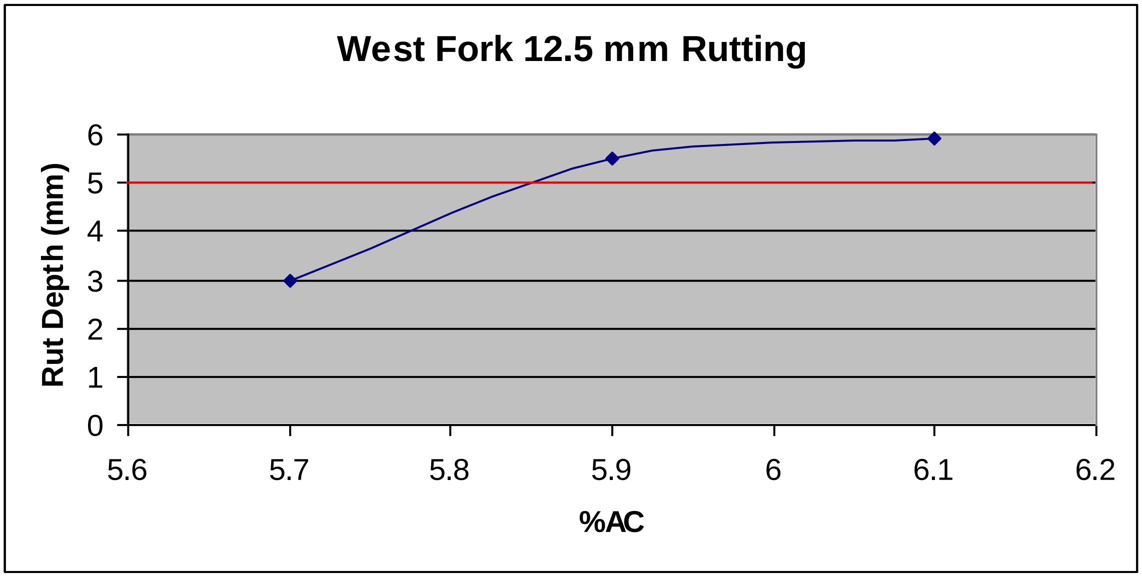

Figure 2. Rut Results for the West Fork 12.5 mm Mix

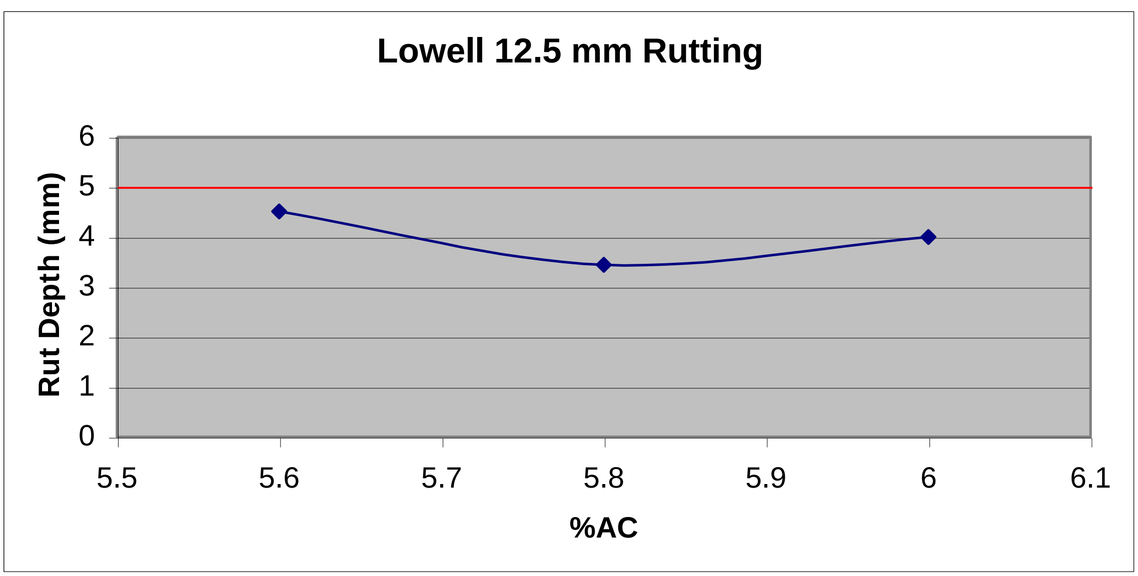

Figure 3. Rut Results for the Lowell 12.5 mm Mix

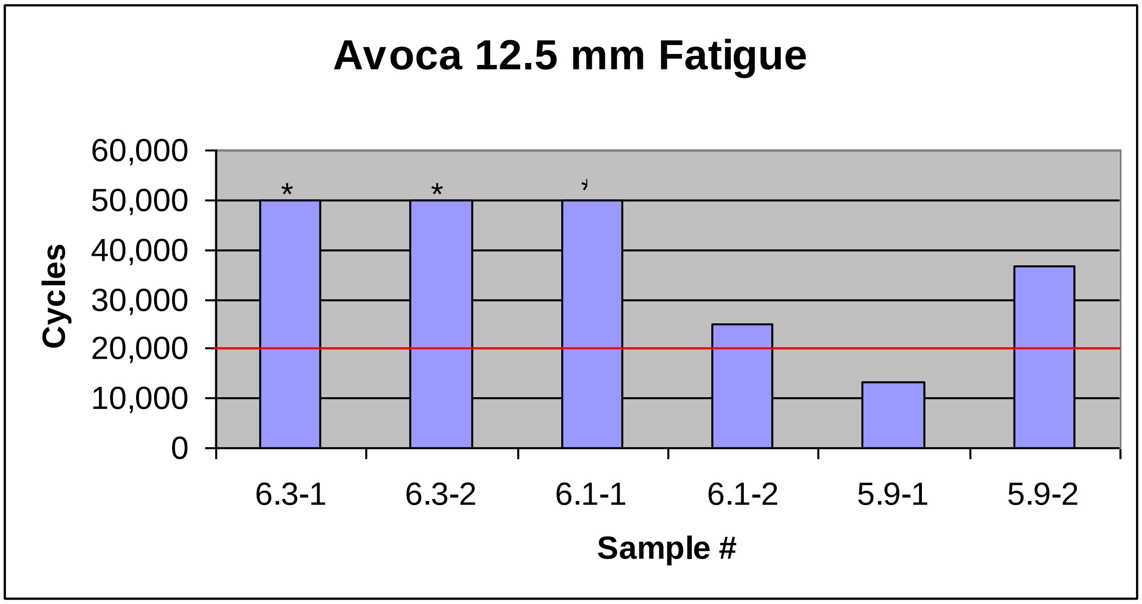

Figure 4. Fatigue Results for Avoca 12.5 mm Mix.
* indicates that the test was stopped to decrease test time.

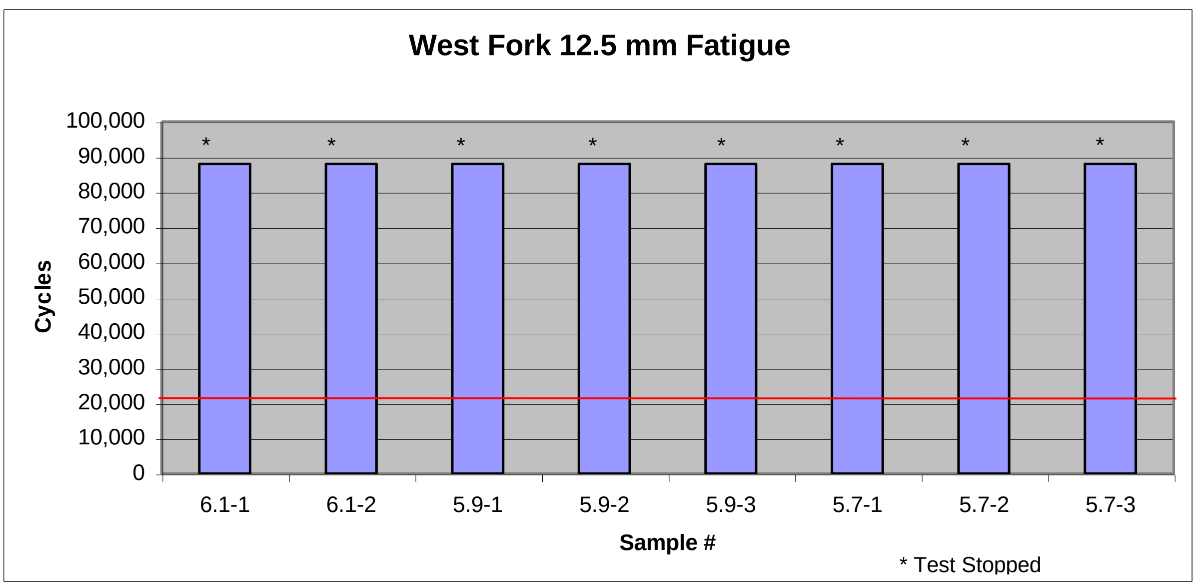

Figure 5. Fatigue Results for West Fork 12.5 mm Mix.
* indicates that the test was stopped to decrease test time.

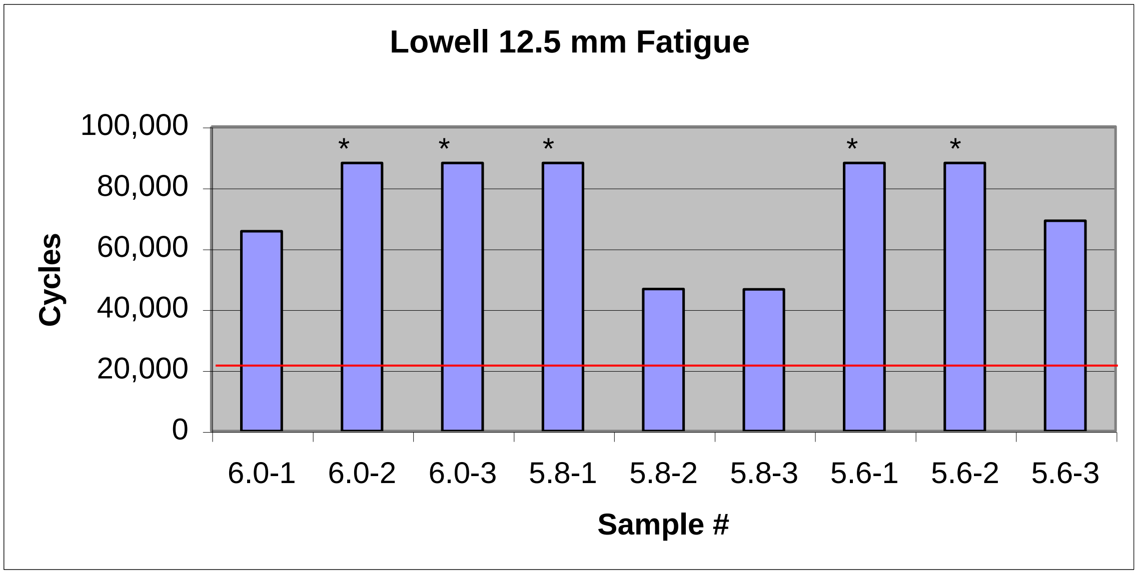

Figure 6. Fatigue Results for Lowell 12.5 mm Mix.
* indicates that the test was stopped to decrease test time.

Conclusions

The test results for both rutting and fatigue from this study indicate that decreasing the asphalt content by 0.2 for all mixes and as much as 0.4 for the West Fork and Lowell mixes, does not decrease performance properties below acceptable levels. Individual conclusions are as follows:

- Decreasing the asphalt content by 0.2 for all mixes improves resistance to rutting.
- Decreasing the optimum asphalt content by 0.2 results in mixes that resist fatigue failure beyond 20,000 cycles
- Decreased asphalt contents may reduce field rutting.
- Reduction of the asphalt content of these mixes may result in a decrease in problems related to flushing and bleeding.

Furthermore, these results indicate that performance testing can be used to determine a final optimum asphalt content that will result in desired performance properties.