DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

EASTERN REGION

LABORATORY PROCEDURES MANUAL

MARCH 2008

PREPARED BY:

AIRPOTS DIVISION
SAFETY AND STANDARDS BRANCH, AEA-620

PREFACE

This manual, the ninth edition, replaces the March 2003 and previous editions of the Eastern Region Laboratory Procedures Manual (ERLPM).

This manual incorporates changes to the Plant Mix Bituminous Material Specification, Item P-401, found in FAA Advisory Circular AC 150/5370-10C approved in Sepetember 29, 2007, and approved modification of standards applicable in the Estern Region. This manual dose not included procedures required under Engineering Brief 59 for Plant Bituminous Pavment using Superpave methodology. This edition incorporates comments and recommendations received from contractors, engineers and testing laboratories.

The purpose of this manual is to provide in a single document all the testing requirements for plant bituminous material intended for use in airport projects when Federal funds are used.

Comments on this publication will be appreciated.

CONTENTS

SECTION 1

Introduction

This manual presents procedures to be followed by:

1 - Contractor testing personnel in the development of the Job Mix Formula and in performing Quality Control testing during production of bituminous material and,

2 - By the airport's acceptance testing personnel in performing acceptance testing on bituminous material produced by the plant and placed on the job for a project funded under the Federal Airport Improvement Program (AIP) or Passenger Facility Charges (PFC)

The procedures required to obtain the desired results are outlined in considerable detail, and references are made where the methods are covered by either ASTM or AASHTO Standards.

The sections of the manual which are to be accomplished by the Contractor are:

Section 2 -Design of Bituminous Paving Mixture, Job Mix Formula.

Section 5 -Laboratory Equipment

Section 6 -Random Sampling Procedures, Method of Sampling Plant Produced Material

Section 7 -Contractor Quality Control

Section 8 –Method of Estimating Percent Within Limits

The sections of the manual which are to be accomplished by the engineer's testing laboratory are:

Section 2 -Design of Bituminous Pavement Mixture, Job Mix Formula. (Optional)

Section 3 -Marshall Test; Stability, Flow, Density, Percent Voids of Compacted Bituminous Paving Mixtures.

Section 4 -Pavement Density, Percent Compaction: Core Method.

Section 5 -Laboratory Equipment.

Section 6 -Random Sampling Procedures, Method of Sampling Plant Produced Material.

Section 8 –Method of Estimating Percent Within Limits

SECTION 2:

DESIGN OF BITUMINOUS PAVING MIXTURES, JOB MIX FORMULA MARSHALL METHODS.

2.0 General Information

The Job Mix Formula which is to be developed by the contractor shall be prepared on the standard forms in Appendix A. If independente testing laboratory is used to develop the Job Mix Formula, the laboratory shall meet the requirement of ASTM D 3666 including the requirement to be accredited by a national authority. The guidance provided in this Section was taken from the Sixt Edition of Asphalt Institute Manual "Mix Design Methods for Asphalt Concrete" MS-2.

2.1 Preliminary Procedures - Prior to the preparation of test specimens, the following is required:

(a) Ascertain that the materials proposed for use meet the project specification. See Appendix A, page 1. State certification of the material properties, when available, shall be acceptable in lieu of test values. All values shall be listed in the table found in Appendix A page 1. The Bulk Specific Gravity of Aggregates (G_{sb}) must be determined using ASTM C 127 for coarse aggregates and ASTM C 128 for fine aggregates. These bulk specific gravity of aggregates values shall be recorded on Appendix A pages 3 and 6.

(b) Development of the Job Mix Formula can be done using aggregate samples from plant bins or stockpiles. It is highly recommended that when a batch plant is used, samples are taken from hot bins.

(c) In determining the Optimum Asphalt Content it is required that one Maximum Theoretical Specific Gravity for each asphalt content be obtained, by means of ASTM D 2041, "Rice Method", Type C, D or E container using a minimum sample size of 2,000 gm.

2.2 Preparation of Test Specimen: In determining the optimum asphalt content for a particular blend or gradation of aggregate by the Marshall method, a series of test specimens is prepared for a range of different asphalt contents so that the test data curves show a well defined optimum value. Specimens shall be prepared on the basis of 1/2 percent by weight increments of asphalt content, with at least two asphalt contents above the optimum and at least two below the optimum.

When the aggregate gradation is plotted on a 0.45 power gradation chart, the aggregate gradation for the job mix formula shall produce a grading curve with no abrupt changes and shall be approximately parallel to the curves of the specified grading limits. A 0.45 power gradation chart is provided in Appendix A, page 4.

To provide for adequate data, a minimum of three test specimens shall be prepared for each asphalt content used. However, it is recommended that four specimens are prepared for each asphalt content. With the minimum three specimens for asphalt content, a design study using six different asphalt content shall require a minimum of 18 test specimens. Each test specimen will usually require approximately 1.2 Kg. (2.6 lbs.) of aggregate. Therefore, the minimum aggregate requirement for one series of 18 test specimens of a given blend or gradation will be approximately 22.6 Kg. (46.8 lb.). Approximately 4 liters of asphalt will be required.

2.3 Equipment:

The equipment required for the preparation of test specimens is as follows:

(a) *Pans*, metal, flat bottom for the heating of aggregates.

(b) *Pans,* metal, round, approximately 4 liter (4 quart) capacity, for mixing asphalt and aggregate.

(c) *Oven and hot plate,* for heating aggregates, asphalt and equipment as required.

(d) *Scoop,* for batching aggregates.

(e) *Containers*, gill-type tins, breakers, pouring pots, or sauces pans, for heating asphalt.

(f) *Thermometers,* armored, glass, or dial-type with metal stem, 50^{o} to 450^{o} F (10^{o} to 235^{o} C) with sensitivity of 5.0^{o} F (2.8^{o} C) or less, for determining temperatures of aggregates, asphalt and asphalt mixture. Thermometers shall be properly calibrated.

(g) *Balance,* 5 Kg. minimum capacity, sensitive to 1 gm. for weighing aggregates and asphalt. B*alance* 2 Kg. capacity sensitive to 0.1 gm. for weighing compacted specimens. Balances shall be properly calibrated.

(h) *Mixing spoon*, large, or *trowel,* for placing mixture in specimen molds.

(i) *Mechanical shaker* and appropriate *sieves* conforming to the requirement of current ASTM designation E-11 for determining gradation of coarse and fine aggregates.

(j) *Spatula,* large, for spading and hand mixing.

(k) *Mixing apparatus*, mechanical recommended, commercial bread dough mixer 4 liter (4 quart) capacity or larger, with two metal mixing bowls and two wire stirrers.

(l) *Boiling Water Bath,* consisting of hot plate and bucket for water, for heating compaction hammer and mold.

(m) *Compaction pedestal,* consisting of an 8 x 8 x 18 in. (200 x 200 x 460 mm.) wooden post capped with a 12 x 12 x 1 in. (305 x 305 x 25 mm) steel plate. The wooden post shall be oak, yellow pine or other wood having dry weight of 42 to 48 lbs./cu. ft. (673 to 769 Kg./m^3). The wooden post shall be secured by four angles brackets to a solid concrete slab. The steel shall be firmly fastened to the post. The pedestal shall be installed so that the post is plumb, the cap level, and the entire assembly free from movement during compaction.

(n) *Compaction Mold*, consisting of a base plate, forming mold and a collar extension. The forming mold has an inside diameter of 4 in. (101.6 mm.) and a height of approximately 3 in. (76 mm.); the base plate and collar extension are designed to be interchangeable with either end of the forming mold.

(o) *Compaction Hammer*, consisting of a flat circular tamping face 3-7/8 in. (98.4 mm.) diameter and equipped with a 10 lb. (4.5 Kg.) weight constructed to obtain a specified 18 in. (457 mm.) height of drop.

NOTE: A mechanical compactor using the equivalent compaction hammer as described above may be used for compacting specimens.

(p) *Mold Holder*, consisting of spring tension devise designed to hold the compaction mold in place on compaction pedestal.

(q) *Extrusion Jack* or Harbor Press, for extruding compacted specimens from mold.

(r) *Gloves*, insulated, for handling hot equipment. *Gloves*, rubber, for removing specimens from water bath.

(s) *Marking Crayons*, for identifying specimens.

2.4 Test Specimens:

The actual preparation of the test specimens shall be as follows:

(a) *Number of specimens:* prepare at least three but no more than five specimens for each combination of aggregate and asphalt content. Four specimens is recommended.

(b) *Preparation of aggregate:* aggregates shall be dried to constant weight at 221^{o} to 230^{o} F (105^{o} to 110^{o} C) and separated by dry-sieving into the desired fractions.

(c) *Determination of Mixing and Compaction Temperatures* - The temperature to which the asphalt must be heated to produce a viscosity of 170 ± 20 centistokes kinematics and 280 ± 30 centistokes kinematics shall be established as the mixing temperature and compaction temperature respectively. **When Performance Grade (PG) asphalt is used, the manufacturer shall provide the mixing and compaction temperatures.**

(d) *Preparation of Mold and Hammer* - Thoroughly clean the specimen mold assembly and face of the compaction hammer and heat them in a boiling water bath or on the hot plate to a temperature between 200^{o} F (95^{o} C) and 300^{o} F (150^{o} C). Place a piece of waxed paper cut to size in the bottom of the mold before the mixture is placed in the mold.

(e) *Preparation of Mixture*-Weigh into separate pans for each test specimen the amount of each size fraction required to produce a batch that will result in a compacted specimen 2.5 ± 0.05 in. (63.5 ± 1.3 mm.) in height. This will normally be about 1.2 Kg (27 lbs)

Place the pans in the oven or on the hot plate and heat to a temperature of approximately 50^{o} F (28^{o} C) above the mixing temperature specified in (c) above. If a hot plate is used, provision should be made for dead space, baffle plate, or sand bath beneath the pan and the hot plate to prevent local overheating. Charge the mixing bowl with the heated aggregates and dry mix thoroughly. Form a crater in the dry blended aggregate and weigh the required amount of asphalt cement into the mixture in accordance with the accumulative batch weights. At this point the temperature of the asphalt aggregate must be within the limits of the mixing temperature established in (c) above. Asphalt should not be held at the mixing temperature for more than one hour before using, and shall be kept covered. Mix the asphalt and aggregate, preferably with a mechanical mixer or by hand with a trowel, as quickly and thoroughly as possible to yield a mixture having a uniform distribution of asphalt throughout.

(f) *Compaction of specimen* - Place the mixture in the mold, spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Remove the collar and smooth the surface to a slightly rounded shape. The temperature of the mixture immediately prior to compaction shall be within the limits of compaction temperature established in paragraph (c); otherwise, it shall be discarded. In no case shall the mixture be re-heated.

Replace the collar, place the mold assembly on the compaction pedestal in the mold holder. Apply either 50 or 75 blows, as indicated in the contract specifications, with the compaction hammer using a free fall of 18 in. (457 mm.). For manual compaction, hold the axis of the hammer as nearly perpendicular as possible. Remove the base plate and collar, and reverse and reassemble the mold. Apply the same number of compaction blows to the face of the reversed specimen.

NOTE: The type of compaction hammer used (manual or mechanical) shall be included with the data submitted. See Appendix A, page 5 as an example. Since the production testing must use the same type of hammer as used in the JMF, the laboratory shall ensure that the same type hammer is available at the plant laboratory.

After compaction, remove the base plate and allow the specimen to cool in air until no deformation will result when removing it from the mold. When more rapid cooling is desired table fans may be used, but not water unless the specimen is placed in a plastic bag.

Remove the specimen from the mold by means of an extrusion jack or other compression device and place on a smooth, level surface until ready for testing.

2.5 Test Procedure

2.5.1 General: In the Marshall method each compacted test specimen shall be subjected to the following tests and analysis in the order listed:

(a) Bulk Specific Gravity

(b) Stability and Flow

(c) Density and Voids Analysis

2.5.2 Equipment- The equipment for the testing of the specimens is as follows:

(a) *Balance*, 2 Kg. minimum capacity, sensitive to 0.1 gm. to enable bulk specific gravities of the specimens to be calculated to at least four significant figures, i.e., to at least three decimal places. It shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen in water while suspended from the center of the scale pan of the balance. The balance shall be properly calibrated.

(b) *Water bucket*, suitable for weighing compacted specimens in water.

(c) *Marshall Testing Machine,* electrically powered (110 volt). Designed to apply loads to test specimens through semi-circular testing heads at a constant rate of 2 in. (51 mm.) per minute. It is equipped with a calibrated proving ring for determining the applied load, a stability testing head for use in testing the specimens, and a flow meter for determining the amount of deformation at the maximum load. The machine may be equipped with an automatic readout to record the load/deformation diagram. The testing machine shall be properly calibrated.

(d) *Water Bath,* at least 6 inches deep and thermostatically controlled to 140° ± 1.8° F (60° ± 1.0° C). The tank shall have a perforated false bottom or be equipped with a shelf for suspending the specimens at least 2 inches above the bottom of the bath.

(e) *Thermometers*, for water bath with a range of 134° to 144° F (57° to 62° C), sensitive to 0.4° F (0.2° C), thermometer to verify 77° F (25° C), in water used for bulk specific gravity. The thermometers shall be properly calibrated.

2.6 <u>Bulk Specific Gravity Determination</u> - The bulk specific gravity test may be performed as soon as the freshly compacted specimens have cooled to room temperature.

This test shall be performed according to ASTM D 2726, Bulk Specific Gravity of Bituminous Mixture Using Saturated Surface- Dry Specimens. *Procedure 9.3 of ASTM D 2726 for Thoroughly Dry Specimens shall be followed*.

2.7 <u>Stability and Flow Test</u> - After the bulk specific gravity of the test specimens have been determined, the stability and flow test shall be performed as follow:

(a) Adjust the flow meter to zero by inserting a 4.0 in. (101.6 mm) diameter metal cylinder in the testing head, placing the flow meter over the guide rod and adjusting the flow meter to read zero.

(b) Immerse the specimens in water bath at 140° ± 1.8° F (60° ± 1.0° C) for 30 to 40 minutes before test.

(c) Thoroughly clean inside surfaces of testing head. Temperature of head shall be maintained at from 70° to 100°F (21° to 37.8° C) using a water bath when required. Lubricate guide rods with a thin film of oil so that the upper test head will slide freely without binding. When a proving ring is used to measure applied load, check that the dial indicator is firmly fixed and zeroed for the "no-load" position.

(d) With testing apparatus in readiness, remove test specimen from water bath and carefully dry surface. Place specimen in lower testing head and center; then fit upper testing head into position and center complete assembly in loading device. Place flow meter, adjusted to zero, over guide rod.

(e) Apply testing load to specimen at constant rate of deformation, 2 in. (51 mm.) per minute, until failure occurs. The point of failure is defined by the maximum load reading obtained. The total number of pounds required to produce failure of the specimen at 140^{o} F (60^{o} C) shall be recorded as its measured Marshall stability value. If necessary, a conversion shall be made on the basis of measured volume as per Paragraph 2.10 (a) of this Section. When using the automatic readout, should more than one peak of the load-deformation curve is obtained, the first peak obtained shall be used for the stability and flow value.

(f) While the stability test is in the progress, hold the flow meter firmly in position over the guide rod and remove when the load begins to decrease; record reading. The reading in the flow value for the specimen, expressed in units of 1/100 inches, i.e., if the specimen deformed 0.15 in. the flow value is 15. This reading is recorded as a whole number.

NOTE: The entire procedure, both stability and flow tests, Starting with the removal of the specimen from the water bath, shall be completed within a period of 30 seconds.

2.8 Tensile Strength Ratio- If the tensile strength ratio of the specimen of composite mixture, as determined by ASTM D 4867 is less than 75 percent, the aggregates shall be rejected or the asphalt shall be treated with approved anti-stripping agent. The amount of anti-stripping agent added to the asphalt shall be sufficient to produce a Tensile Strength Ration of not less than 75 percent.

NOTE: The Tensile Strength Ratio shall be determined only for the specimens at the proposed job mix formula asphalt content.

2.9 Density and Voids Analysis- A density and void analysis shall be made for each series of specimens as follow:

(a) Average the bulk specific gravity values for all test specimens of a given asphalt content; values obviously in error shall not be included in the average.

(b) Determine unit weight for each asphalt content by multiplying the average bulk specific gravity value by 62.4 lb./ft^3 (1.0 Mg/m^3)

(c) Calculate Percent Air Voids in Compacted Mixture by the following formula:

$$P_a = 100 - 100(G_{mb}/G_{mm})$$

where:

P_a = Air voids in compacted mixture, percent of total volume

G_{mb} = Bulk specific gravity of compacted mixture

G_{mm} = Maximum specific gravity as determined from ASTM D 2041

Example

G_{mb} = 2.334

G_{mm} = 2.416

P_a = 100 -100(2.334/2.416)

P_a = 100 -100(.9661)

P_a = 100-96.61 = 3.39

(d) Calculate the Percentage of Voids in Mineral Aggregate by the following formula:

(1) If mix composition is determined as percent by weight of total mixture:

$$VMA = 100 - (G_{mb} \times P_s) \div G_{sb}$$

where:

VMA = voids in mineral aggregate (percent of bulk volume)

G_{sb} = bulk specific gravity of aggregate (ASTM C 127 and ASTM C 128)

G_{mb} = bulk specific gravity of compacted mixture (ASTM D 2726)

P_s = aggregate, percent by total weight of mixture

(2) If mix composition is determined as percent by weight of aggregate

$$VMA = 100 - (G_{mb} \div G_{sb}) \times (100 \div (100 + P_b)) \times 100$$

where:

P_b = asphalt, by weight of aggregate

<u>Example:</u>

G_{mb} = 2.344

P_s = 93.04

G_{sb} = 2.651

P_b = 7.48

(1) By total weight of mix:

VMA = 100 - (2.344 x 93.04) ÷ 2.651 = 17.73

(2) By total weight of aggregate:

VMA = 100 - (2.344 ÷ 2.651) x (100 ÷ (100 + 7.48)) x 100

VMA = 17.73

2.10 Interpretation of Test Data - The stability and flow values and voids data shall be prepared as follows:

(a) Measured stability values for specimens that depart from the standard 2-1/2 in. (63.5 mm.) thickness shall be converted to an equivalent 2-1/2 in. (63.5 mm.) value by means of a conversion factor as shown in Table 1. The conversion shall be made on the basis of measured volume only, use Appendix A, Page 5, column F of the standard form. Specimens below 2 1n., and over 3 in., in thickness shall be discarded.

(b) Average the values for each parameter for all specimens of a given asphalt content. Values that are obviously in error shall not be included in the averages. Flow average should be carried up to the decimal.

(c) Prepare a separate graphical plot for the following values as illustrated in Appendix B:

Stability vs. Asphalt content

Flow vs. Asphalt content

Unit Weight vs. Asphalt content

Percent Air Voids vs. Asphalt content

Percent Voids in Mineral Aggregates vs. Asphalt content

In each graphical plot connect the plotted values with a smooth curve that best fits all the values.

2.11 Determination of Optimum Asphalt Content- The optimum asphalt content of the paving mix shall be determined at approximately the mid value of the Percent Air voids specification. See example in Appendix B.

When the Optimum Asphalt Content as determined at the mid value of the Percent Air Voids specification does not result in a JMF that meets the specification parameters, or results in a JMF which marginally meets the design parameter or results in a mix which may be difficult to produce or compact in the field then the aggregate blend must be revised or a new source of aggregates secured, and a new set of JMF data developed.

Note: Since the acceptance by the Engineer will be based on Marshall characteristics of Plant-Produced material and field density, it is imperative that the Job Mix Formula be developed in a way that can be readily produced and compactable in the field

2.12 Verification of Job Mix Formula - Where the asphalt content for the proposed job mix formula does not coincide with an asphalt content used in the trial specimens, an additional set of specimens shall be prepared at the proposed job mix formula asphalt content to verify that actual results duplicate those anticipated from the curves. Two separate determinations of the Maximum Theoretical Specific Gravity shall be made, by means of ASTM D 2041, Type C, or D container using a minimum sample size of 2,000 gms. The average of the two values shall be used in the void analyses.

2.13 Use of Standard Forms - All data and computations used in developing the job mix formula shall be entered on the standard forms shown in Appendix A.

NOTES:

1. The addition of natural sand to a mix containing coarse and fine aggregates of excessive angularity and harshness will normally increase its workability. It may be necessary to keep natural sand below 20 percent to obtain optimum pavement properties, as the addition of natural sand tends to decrease the stability of the pavement. However, blending natural sand (low specific gravity) with manufactured sand (high specific gravity) may affect the calculation of percent of Air Voids.

2. Mixes designed with stability greater than 2,500 pounds (1,125 Kg.) may result in a mixture difficult to compact to the required density.

3. USE OF DRYER DRUM PLANT. It is recommended that when a dryer drum plant is to be used, the contractor proofs the proposed Job Mix Formula by conducting a production run and verify that the material actually produced by the plant meets the production criteria at the Job Mix Formula asphalt content. The data will be developed in accordance with the procedure contained in this section and presented to the engineer with the job mix formula for approval.

TABLE 1 – STABILITY CORRELATION RATIO

Volume of Specimen	APPROXIMATE THICKNESS OF SPECIMENS		CORRELATION FACTOR
	mm	inches	
200 TO 213	25.4	1	5.56
214 TO 225	27.0	1 1/16	5.00
226 TO 237	28.6	1 1/8	4.55
238 TO 250	30.2	1 3/16	4.17
251 TO 264	31.8	1 1/4	3.85
265 TO 276	33.3	1 5/16	3.57
277 TO 289	34.9	1 3/8	3.33
290 TO 301	36.5	1 7/16	3.03
302 TO 316	38.1	1 1/2	2.78
317 TO 328	39.7	1 9/16	2.50
329 TO 340	41.3	1 5/8	2.27
341 TO 353	42.9	1 11/16	2.08
354 TO 367	44.4	1 3/4	1.92
368 TO 379	46.0	1 13/16	1.79
380 TO 392	47.6	1 7/8	1.67
393 TO 405	49.2	1 15/16	1.56
406 TO 420	50.8	2	1.47
421 TO 431	52.4	2 1/16	1.39
432 TO 443	54.0	2 1/8	1.32
444 TO 456	55.6	2 3/16	1.25
457 TO 470	57.2	2 1/4	1.19
471 TO 482	58.7	2 5/16	1.14
483 TO 495	60.3	2 3/8	1.09
496 TO 508	61.9	2 7/16	1.04
509 TO 522	63.5	2 1/2	1.00
523 TO 535	64.0	2 9/16	0.96
536 TO 546	65.1	2 5/8	0.93
547 TO 559	66.7	2 11/16	0.89
560 TO 573	68.3	2 3/4	0.86
574 TO 585	71.4	2 13/16	0.83
586 TO 598	73.0	2 7/8	0.81
599 TO 610	74.6	2 15/16	0.78
611 TO 625	76.2	3	0.76

NOTES:

1. The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the cortrected stability for a 63.5 mm (2 1/2 - in) specimen.
2. Volume thickness relationship is based on a specimen diameter of 101.6 mm (4 in.)

Section 3

Marshall test

3.0 General Procedures.

This test is to be performed in two separate phases as indicated below:

Phase 1- At the option of the Engineer, prior to the start of plant production to verify the JMF

Phase 2- Fixed requirement, during the entire production of the paving mix, including the test strip

3.1 Phase 1

Prior to the start of plant production, if the Engineer wishes to verify the JMF, shall obtain from the contractor samples of aggregates and asphalt used by him to develop the job mix formula.

Using the sample provided by the contractor, the laboratory shall:

(a) Ascertain that the materials proposed for use meet the project specifications. See Appendix A, page 1a. The engineer has the option to accept material certification in lieu of performing actual tests on aggregates.

(b) Prepare and test at least three (four recommended) compacted specimens at the JMF optimum AC content; and independently determine the maximum specific gravity of the mixture, all in accordance with procedures followed by the contractor in Section 2 of this manual.

3.2 Phase 2

During the production of the paving mix, including the test strip, the engineer or acceptance testing laboratory shall, on a daily basis, determine the following characteristic of the mixture:

(a) Stability, compacted mixture, lbs.

(b) Flow, compacted mixture, 0.01 in.

(c) Unit Weight, compacted mixture, percent

(d) Air Voids, compacted mixture, percent

The procedure to be followed for the Phase 2 evaluation shall be performed as described bellow.

3.3 Preparation of Test Specimens

3.3.1 General- To provide data, three test specimens shall be prepared for each evaluation. Material for the specimens shall be obtained from the plant in accordance with procedures outlined in Section 6, Random Sampling Procedures, Method of Sampling Plant Produced Material and place it in a covered and insulated container or approved substitute, until ready for use.

3.3.2 Equipment - The equipment required for the preparation of the test specimens is as follow:

(a) Compaction Mold, consisting of a base plate, forming mold, and collar extension. The forming mold has an inside diameter of 4 in. (101.6 mm.) and a height approximately 3 in. (76 mm.); the base and collar extension are designed to be interchangeable with either end of the forming mold.

(b) Compaction Pedestal, consisting of an 8 x 8 x 18 in. (200 x 200 x 460 mm.) wooden post capped with a 12 x 12 x 1 in. (305 x 305 x 25 mm.) steel plate. The wooden post shall be oak, yellow pine, or other wood having a dry weight of 42 to 48 lbs./ft^3 (673 to 769 kg/m^3). The wooden post shall be secured by four angle brackets to a solid concrete slab. The steel cap shall be firmly fastened to the post. The pedestal shall be installed so that the post is plumb, the cap level, and the entire assembly free from movement during compaction.

(c) Compaction Hammer, consisting of a flat circular tamping face 3-7/8 in. (98.4 mm.) diameter equipped with a 10 lb. (6.5 kg.) weight constructed to obtain a specified 18 in. (457 mm.) height of drop.

Note: A mechanical compactor using the equivalent compaction hammer as described above may be used for compacting specimens. <u>The same type compactor used for developing the job mix formula, i.e.,,manual or mechanical, must be used in preparing the test specimens.</u>

(d) Mold Holder, consisting of a spring tension device to hold the compaction mold in place on the compaction pedestal.

(e) Extrusion Jack or Press, for extruding specimens from mold

(f) Pans or Containers, for material samples.

(g) Oven and Hot Plates, for heating specimen molds, compaction hammer, and other equipment as required.

(h) Balance, 2 Kg. minimum capacity, sensitive to 0.1 gm. for weighing specimens. The balance shall be properly calibrated.

(i) Thermometers, armored or dial type with metal stem, 50^{o} to 400^{o} F (10^{o} to 204^{o} C) with sensitivity of 5.0^{o} F (2.8^{o} C), or less, for determining temperature of asphalt mixtures. The thermometers shall be properly calibrated.

(j) Mixing Spoon, large, or trowel, for placing mixtures in specimen molds.

(k) Spatula, for spreading mixture.

(l) Gloves, insulated, for handling hot equipment.

(m) Marking Crayons, for identifying the specimens.

3.4 Test Specimens- The actual preparation of the test specimens shall be as follows:

(a) Preparation of the mold and hammer - clean the specimen mold assembly and face of the compaction hammer and heat them to a temperature between 200^{o} F (93^{o} C) and 300^{o} F (149^{o} C) in a oven or on a hot plate. Place a piece of filter paper, or paper toweling cut to size, in the bottom of the mold before the mixture is placed in the mold.

(b) From the insulated container, or approved substitute, holding the sample mixture as described in Paragraph 3.3.1 above, weigh into a pan the amount of material required to produce a compacted specimen 2.5 $\pm$ 0.05 in. (63.5 $\pm$ 1.3 mm.) in height. This will normally be about 1.2 Kg.

(c) Compaction of Specimens - Place the mixture in the mold, spade the mixture with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Remove the collar and smooth the surface to slightly rounded shape.

NOTE: The temperature of the mixture immediately prior to compaction shall be within the limits of the compaction temperatures established in paragraph 2.4(c). If the temperature of the mixture falls below the lower limit of the compaction temperature, the mixture may be reheated provided that the container is covered to prevent oxidation and the temperature has not fallen below 200^{o} F (93^{o} C).

Replace the collar, place the mold assembly on the compaction pedestal in the mold holder. Apply either 50 or 75 blows, as indicated in the contract specifications, with the compaction hammer using a free fall of 18 in. (457 mm). For manual compactor, hold the axis of the hammer as nearly perpendicular to the base of the mold assembly as possible during compaction. Remove the base plate and collar, and reverse and reassemble the mold. Apply the same number of compaction blows to the face of the reversed specimen. After compaction, remove the base plate and allow the specimen to cool in air until no deformation will result when removing it from the mold. When more rapid cooling is desired, table fans may be used, but not water unless specimen is placed in a plastic bag. Remove the specimen from the mold by means of an extrusion jack or other compression device and place on a smooth level surface until ready for testing.

3.5 Test Procedure

3.5.1 General- Each compacted test specimen shall be subjected to the following tests and analysis in the order listed:

(a) Bulk specific gravity

(b) Stability and flow

(c) Density and voids analysis

3.5.2 Equipment - The equipment required for the testing of the specimens is as follows:

(a) Balance, 2 kg. minimum capacity, sensitive to 0.1 gm. To enable bulk specific gravities of the specimens to be calculated to at least four significant figures, i.e., to at least three decimal places. It shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen in water while suspended from the center of the scale pan of the balance. The balance shall be properly calibrated.

(b) Water bucket, suitable for weighing compacted specimens in water.

(c) Marshall Testing Machine, electrically powered (110 volt.) designed to apply loads to test specimens through semi-circular testing heads at a constant rate of 2 in. (51 mm.) per minute. It is equipped with a calibrated proving ring for determining the applied load, a stability testing head for use in testing the specimens, and a flow meter for determining the amount of deformation at the maximum load. The machine may be equipped with an automatic readout to record the load/deformation diagram. The testing machine shall be properly calibrated.

(d) Water Bath, at least 6 in. deep and thermostatically controlled to $140^{o} \pm 1.8^{o}$ F ($60^{o} \pm 1.0^{o}$ C). The tank shall have a perforated false bottom or be equipped with a shelf for suspending the specimens at least 2 in. above the bottom of the bath.

(e) Thermometers, for water bath with a range of 134^{o} to 144^{o} F (57^{o} to 62^{o} C), sensitive to 0.4^{o} F (0.2^{o} C), thermometers to verify 77^{o} F(25^{o} C) in water used for bulk specific gravity. The thermometers shall be properly calibrated.

3.6 <u>Bulk Specific Gravity Determination</u>- The bulk specific gravity test may be performed as soon as the freshly compacted specimens have cooled to room temperature.

This test shall be performed according to ASTM D 2726, Bulk Specific Gravity of Compacted Bituminous Mixtures using Saturated Surface - Dry specimens. <u>Procedure 9.3 of ASTM D 2726 for thoroughly Dry Specimens, shall be followed.</u>

3.7 Stability and Flow Test- After the bulk specific gravities of the test specimens have been determined, the stability and flow tests shall be performed as follows:

(a) Adjust the flow meter to zero.

(b) Immerse the specimens in water bath at $140^{o} \pm 1.8^{o}$ F ($60^{o} \pm 1.0^{o}$ C) for 30 to 40 minutes before test.

(c) Thoroughly clean inside surface of testing head. Temperature of head shall be maintained at from 100^{o} to 140^{o} F (38^{o} to 60^{o} C) using a water bath when necessary. Lubricate guide rods with a thin film of oil so that the upper test head will slide freely without binding. When a proving ring is used to measure applied load, check that the dial indicator is firmly fixed and zeroed for no-load position.

(d) With testing apparatus in readiness, remove test specimen from water bath and carefully dry surface. Place specimen in lower testing head and center; then fit upper testing head into position and center complete assembly in loading device. Place flow meter, adjusted to zero, over guide rod.

(e) Apply testing load to specimen at constant rate of deformation, 2 in. (51 mm.) per minute, until failure occurs. The point of failure is defined by the maximum load reading obtained. The total number of pounds required to produce failure of the specimen at 140^{o} F (60^{o} C) shall be recorded as its measured Marshall stability value. If necessary, a conversion to the 2 – 1/2″ standard thickness shall be made on the basis of measured volume as per Table 2

(f) While the stability test is in progress, hold the flow meter firmly is position over the guide rod and remove when the load begins to decrease; record the reading. This reading is the flow value for the specimen, expressed in units of 1/100 in., i.e., if the specimen deformed 0.15 in. the flow value is 15.

NOTE: The entire procedure, both stability and flow test, starting with the removal of the specimen from the water bath, shall be completed within a period of 30 seconds.

3.8 Density and Voids Analysis - After completion of the stability and flow tests, a density and voids analysis shall be made for each series of test specimens as follows:

(a) Average the bulk specific gravity values for all test specimens. Values obviously in error shall not be included in the average. However, a written justification shall be included in the data when a sample is discarded.

(b) Determine the average unit weight by multiplying the average bulk specific gravity value by 62.4 $lb./ft^3$ (1.0 Mg/m^3).

(c) In voids calculations determine the maximum specific gravity of the mixture in accordance with ASTM D 2041, Type C, D or E container for each sublot of material. The voids calculation for each sublot must use the maximum specific gravity corresponding to the specific sublot. A minimum sample size of 2,000 gm shall be used.

(d) Calculate Percent Air Voids in Compacted Mixture by the following formula:

$P_a = 100 - 100(G_{mb}/G_{mm})$

where:

P_a = Air voids in compacted mixture, percent of total volume

G_{mb} = Bulk specific gravity of compacted mixture

G_{mm} = Maximum specific gravity of mixture from ASTM D 2041 Type C or D Container.

<u>Example</u>

G_{mb}= 2.334

G_{mm} = 2.416

P_a = 100 - 100(2.334/2.416)

P_a = 100 - 100(.9661) =100 - 96.91

P_a = 3.39

Standard worksheets for the above data and calculations are included in Appendix D

TABLE 2 – STABILITY CORRELATION RATIO

Volume of Specimen	APPROXIMATE THICKNESS OF SPECIMENS		CORRELATION FACTOR
	mm	inches	
200 TO 213	25.4	1	5.56
214 TO 225	27.0	1 1/16	5.00
226 TO 237	28.6	1 1/8	4.55
238 TO 250	30.2	1 3/16	4.17
251 TO 264	31.8	1 1/4	3.85
265 TO 276	33.3	1 5/16	3.57
277 TO 289	34.9	1 3/8	3.33
290 TO 301	36.5	1 7/16	3.03
302 TO 316	38.1	1 1/2	2.78
317 TO 328	39.7	1 9/16	2.50
329 TO 340	41.3	1 5/8	2.27
341 TO 353	42.9	1 11/16	2.08
354 TO 367	44.4	1 3/4	1.92
368 TO 379	46.0	1 13/16	1.79
380 TO 392	47.6	1 7/8	1.67
393 TO 405	49.2	1 15/16	1.56
406 TO 420	50.8	2	1.47
421 TO 431	52.4	2 1/16	1.39
432 TO 443	54.0	2 1/8	1.32
444 TO 456	55.6	2 3/16	1.25
457 TO 470	57.2	2 1/4	1.19
471 TO 482	58.7	2 5/16	1.14
483 TO 495	60.3	2 3/8	1.09
496 TO 508	61.9	2 7/16	1.04
509 TO 522	63.5	2 1/2	1.00
523 TO 535	64.0	2 9/16	0.96
536 TO 546	65.1	2 5/8	0.93
547 TO 559	66.7	2 11/16	0.89
560 TO 573	68.3	2 3/4	0.86
574 TO 585	71.4	2 13/16	0.83
586 TO 598	73.0	2 7/8	0.81
599 TO 610	74.6	2 15/16	0.78
611 TO 625	76.2	3	0.76

NOTES:

1. The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the cortrected stability for a 63.5 mm (2 1/2 - in) specimen.
2. Volume thickness relationship is based on a specimen diameter of 101.6 mm (4 in.)

Section 4

Pavement Density, Percent Compaction:

4.1 General Information: This method covers the procedure for determining the field density and percent compaction of the finished bituminous pavement by means of cored samples. Field density refers to the density expressed in pounds per cubic foot of the compacted material in place at the site and the percent compaction is defined as the density of the compacted material expressed as a percentage of the density of laboratory prepared specimens.

4.2 Sampling

4.2.1 Equipment - The equipment required for obtaining the finished bituminous pavement samples is as follows:

(a) Core drill, equipped to core and retrieve specimens.

(b) Drill bits; diamond, water cooled. Bit size shall be such as to provide a minimum core diameter of 4 ± 1/4 in. (102 ± 6 mm.).

(c) A rigid plate or suitable container large enough to hold the samples without distortion after removal from the pavement.

(d) Marking crayons.

4.2.2 Sampling Procedures - The procedures for obtaining the pavement samples shall be as follows:

(a) Select the area to be cored in accordance with the sampling procedures described in Section 6 of this manual.

(b) Core the samples and remove all loose particles and foreign matter. All broken or damaged edges of samples shall be carefully trimmed. The samples shall consist only of the material for which the test data are desired, i.e., when the material has been placed in more than one lift and only the top lift is to be evaluated, other material shall be separated and removed in such a manner as not to disturb the desired sample. The cores shall be cut perpendicular to the lift surface and taken in the presence of the Engineer.

(c) Identify the samples with the marking crayon and place in a container. Store in safe, cool place until ready for test.

4.3 Testing

4.3.1 Equipment - The equipment required for determining the pavement density and percent compaction shall be as follows:

(a) Balance, 2 kg. minimum capacity, sensitive to 0.1 gm. to enable bulk specific gravities of specimens to be calculated to at least four significant figures, i.e., to at least three decimal places. It shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimens in water while suspended from the center of the scale pan of the balance. The balance shall be properly calibrated.

(b) Water bucket, suitable for weighing compacted specimens in water, and thermometer to measure water temperature at 77^{o} F (25^{o} C).

4.3.2 Testing Procedures - Each cored pavement sample shall be subjected to the following test and analysis in the order listed:

(a) Bulk Specific Gravity

(b) Pavement Density

(c) Percent Compaction

4.4 Bulk Specific Gravity Determination - This test shall be performed according to ASTM D 2726, Bulk Specific Gravity of Compacted Bituminous Mixture Using Saturated Surface-Dry Specimens. Procedure 9.1 of ASTM D 2726 for Specimens that Contain Moisture shall be followed.

4.5 Pavement Density - Core densities shall be determined as follows:

Determine the density of the individual core in pounds per cubic foot by multiplying the bulk specific gravity value by 62.4 $lbs./ft^3$ (1.0 Mg/m^3).

4.6 Percent compaction - Calculate the percent compaction by the following formula:

Percent Compaction = $(G_{mbf} \div G_{mbf}) \times 100$

where:

G_{mbf} = Bulk Specific Gravity of core as obtained from paragraph 4.4

G_{mbl} = Average bulk specific gravity of all laboratory prepared specimens for the lot

Example:

G_{mbf} = 2.355

G_{mbl} = 2.380

Percent Compaction = (2.355 ÷ 2.380) x 100 = 98.9%

Standard worksheets for the above data and calculations are included in Appendix E

Section 5

Laboratory Equipment

5.0 The equipment required for the development of the job mix formula is listed in this manual as follows:

(a)	Equipment required for the preparation of test specimens	Section 2, par. 2.3 pages 6-8
(b)	Equipment required for the testing of the specimens	Section 2, par. 2.5.2 page 11

5.1 The equipment required for the Marshall Test is listed in this manual as follows:

(a)	Equipment required for the preparation of test specimens	Section 3, par. 3.3.2 pages 21-23
(b)	Equipment required for the testing of the specimens	Section 3, par. 3.5.2 pages 24-25

5.2 The equipment required for the determining field density of the finished bituminous pavement by core method is listed in this manual as follows:

(a)	Equipment required for obtaining the finished pavement samples	Section 4, par. 4.2.1 page 29
(b)	Equipment required for determining the pavement density	Section 4, par. 4.3.1 page 30

5.3 The equipment required for hot bins gradation analyses (by contractor) ASTM C 136

5.4 The equipment required for the extraction test (by contractor):

(a) Moisture content ASTM D 1461

(b) Weight of ash & bitumen content ASTM D 2172

(c) Aggregate gradation ASTM D 136

5.5 The equipment required for ASTM D 2041 the Type C, D or E Container Test

NOTE: The testing laboratory must ensure that the required equipment is available in the laboratory. If the contract specifications indicate that the required equipment is the contractor's responsibility and the equipment is not available, the testing laboratory shall immediately inform the engineer of the missing items. If the contract specifications indicate that the required equipment is the testing laboratory's responsibility, the testing laboratory shall furnish the equipment.

Section 6

Random Sampling Procedures - Method of Sampling Bituminous Material

6.0 Random Sampling Procedure for Sampling Plant Produced Material - Random sampling for plant produced material shall be done as follows:

(a) From the expected amount of material (lot) to be delivered to the site, determine sublots size by dividing the lot into four (4). This can be done using time (number of hour of operation) or a selected tonnage.

(b) Determine the number of increments per sublot to be used in the random sampling procedure, e.g., 10 minutes increments for time or 20 tons increments for tonnage.

(c) Place consecutively numbered one-inch square pieces of cardboard, equal to the number of increments to be used, into a container (such as a bowl). Mix them thoroughly and draw out 1 piece. The number on the square drawn represents the increment to be sampled for that sublot.

(d) Replace the drawn piece into the container and repeat the process for subsequent sublots.

Example:

1. Sublot size 2-1/2 hours (Plant on 10-hour day)

2. Time increment - 10 minutes. The number of increment is, therefore 150 min. divided by 10 = 15

3. From 15 consecutively numbered pieces of cardboard thoroughly mixed is drawn the number 2

4. The sample is to be taken from the truck being filled 10 minutes X 2 = 20 minutes after the sublot time frame starts.

NOTES:

1) When silos are being used, the increments shall be based on tonnage.

2) For procedures to be used to sample the bituminous mixture at the plant see paragraph 6.2 in this Section.

6.1 Random Sampling Procedures for Sampling Field Compacted Material - The random sampling of field compacted material shall be done as follows:

(a) Determine the sublots size by dividing the lot size by four (n = 4). The number of sublot is independent of the number of sublot on the plant produced material.

(b) Using the sublot size as determined in (a), determine the width and length of each sublot along the paving lanes.

(c) Select a column of random numbers in Table 1 on this Section by placing 28 one-inch square pieces of cardboard numbered 1 through 28 into a container (such as a bowl), shaking them till they are thoroughly mixed and drawing out one.

(d) Go to the column of random numbers identified with the number drawn from the container. In sub-column A locate all numbers equal to and less than the number of sublot, i.e., 01, 02, 03, 04.

(e) Multiply the total length of the paving lane in the sublot by the decimal value obtained in sub-column B found opposite the number used from sub-column A. This is the longitudinal station of the sampling point from the beginning of the sublot. Round to the nearest foot.

(f) Multiply the total width of the individual paving lanes by the decimal value in sub-column C opposite the number used from sub-column A. This will be the sampling offset for the associated longitudinal station measured from the reference edge of the paving lane. Round to the nearest foot.

(g) When steps (e) or (f) indicate that a core will be taken less than 1 foot from a joint or pavement edge, the test shall be taken at 1 foot from the joint or pavement edge.

(h) Go completely through a column before using the same number over. If, for example, the plan calls for four core sample increments per lot, the first time a column is used, the first four location would correspond to numbers 01-04 in sub column A; the second time that column is used, numbers 05-08 would be used; and so forth.

Example

A 12-1/2 feet paver places a 1600 feet lot of material in three adjacent lanes (see figure 1). The contract specification requires four core measurements per lot (one per sublot).

1. The number 12 is drawn from the container.

2. Divide the lot into four equal sublot. 1600 - 4 = 400. The sampling location are as follows:

3. The random numbers selected from column 12 in Table 3 for a four sample sublot are as follows:

A	B	C
04	.153	.163
01	.320	.212
02	.489	.827
03	.542	.352

NOTE: The numbers shown in column A are in the order found in Table 3, Column 12.

Sublot	Longitudinal Station From the Beginning of the Sublot	Offset*
4	400' x .153 = 61'	12.5 x .163 = 2'
1	400' x .320 = 128'	12.5 x .212 = 3'
2	400' x .489 = 196'	12.5 x .827 = 10'
3	400' x .542 = 217'	12.5 x .352 = 4'

* Station offset referenced from left side of lanes.

Referring to Figure 1, sample increment #1 would be taken 128 feet from the start of sublot 1; #2 would be taken 196 feet from the start of sublot 2, #3 would be taken 217 feet from the start of sublot 3, and #4 would be taken 61 from the start of sublot 4.

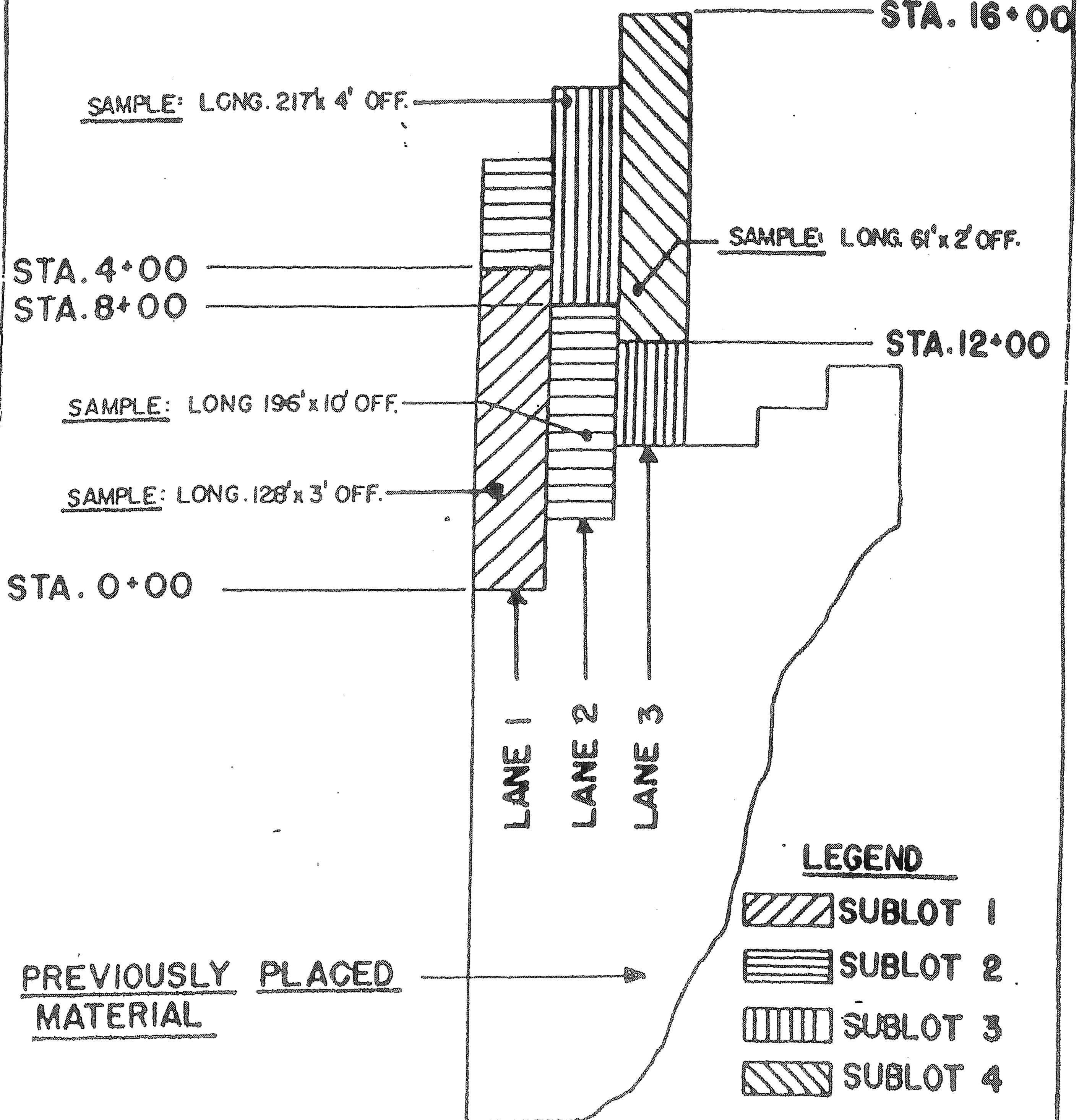


FIGURE 1

MAT DENSITY SAMPLING

N.T.S.

Col. No. 1			Col. No. 2			Col. No. 3			Col. No. 4			Col. No. 5			Col. No. 6			Col. No. 7		
A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
15	.033	.576	05	.048	.879	21	.013	.220	18	.089	.716	17	.024	.863	30	.030	.901	12	.029	.386
21	.101	.300	17	.074	.156	30	.036	.853	10	.102	.330	24	.060	.032	21	.096	.198	18	.112	.284
23	.129	.916	18	.102	.191	10	.052	.746	14	.111	.925	26	.074	.639	10	.100	.161	20	.114	.848
30	.158	.434	06	.105	.257	25	.061	.954	28	.127	.840	07	.167	.512	29	.133	.388	03	.121	.656
24	.177	.397	28	.179	.447	29	.062	.507	24	.132	.271	28	.194	.776	24	.138	.062	13	.178	.640
11	.202	.271	26	.187	.844	18	.087	.887	19	.285	.899	03	.219	.166	20	.168	.564	22	.209	.421
16	.204	.012	04	.188	.482	24	.105	.849	01	.326	.037	29	.264	.284	22	.232	.953	16	.221	.311
08	.208	.418	02	.208	.577	07	.139	.159	30	.334	.938	11	.282	.262	14	.259	.217	29	.235	.356
19	.211	.798	03	.214	.402	01	.175	.641	22	.405	.295	14	.379	.994	01	.275	.195	28	.264	.941
29	.233	.070	07	.245	.080	23	.196	.873	05	.421	.282	13	.394	.405	06	.277	.475	11	.287	.199
07	.260	.073	15	.248	.831	26	.240	.981	13	.451	.212	06	.410	.157	02	.296	.497	02	.336	.992
17	.262	.308	29	.261	.087	14	.255	.374	02	.461	.023	15	.438	.700	26	.311	.144	15	.393	.488
25	.271	.180	30	.302	.883	06	.310	.043	06	.487	.539	22	.453	.635	05	.351	.141	19	.437	.655
06	.302	.672	21	.318	.088	11	.316	.653	08	.497	.396	21	.472	.824	17	.370	.811	24	.466	.773
01	.409	.406	11	.376	.936	13	.324	.585	25	.503	.893	05	.488	.118	09	.388	.484	14	.531	.014
13	.507	.693	14	.430	.814	12	.351	.275	15	.594	.603	01	.525	.222	04	.410	.073	09	.562	.678
02	.575	.654	27	.438	.676	20	.371	.535	27	.620	.894	12	.561	.980	25	.471	.530	06	.601	.675
18	.591	.318	08	.467	.205	08	.409	.495	21	.629	.841	08	.652	.508	13	.486	.779	10	.612	.859
20	.610	.821	09	.474	.138	16	.445	.740	17	.691	.583	18	.668	.271	15	.515	.867	26	.673	.112
12	.631	.597	10	.492	.474	03	.494	.929	09	.708	.689	30	.736	.634	23	.567	.798	23	.738	.770
27	.651	.281	13	.499	.892	27	.543	.387	07	.709	.012	02	.763	.253	11	.618	.502	21	.753	.614
04	.661	.953	19	.511	.520	17	.625	.171	11	.714	.049	23	.804	.140	28	.636	.148	30	.758	.851
22	.692	.089	23	.591	.770	02	.699	.073	23	.720	.695	25	.828	.425	27	.650	.741	27	.765	.563
05	.779	.346	20	.604	.730	19	.702	.934	03	.748	.413	10	.843	.627	16	.711	.508	07	.780	.534
09	.787	.173	24	.654	.330	22	.816	.802	20	.781	.603	16	.858	.849	19	.778	.812	04	.818	.187
10	.818	.837	12	.728	.523	04	.838	.166	26	.830	.384	04	.903	.327	07	.804	.675	17	.837	.353
14	.895	.631	16	.753	.344	15	.904	.116	04	.843	.002	09	.912	.382	08	.806	.952	05	.854	.818
26	.912	.376	01	.806	.134	28	.969	.742	12	.884	.582	27	.935	.162	18	.841	.414	01	.867	.133
28	.920	.163	22	.878	.884	09	.974	.046	29	.926	.700	20	.970	.582	12	.918	.114	08	.915	.538
03	.945	.140	25	.939	.162	05	.977	.494	16	.951	.601	19	.975	.327	03	.992	.399	25	.975	.584

Col. No. 8			Col. No. 9			Col. No. 10			Col. No. 11			Col. No. 12			Col. No. 13			Col. No. 14		
A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
09	.042	.071	14	.061	.935	26	.038	.023	27	.074	.779	16	.073	.987	03	.033	.091	26	.035	.175
17	.141	.411	02	.065	.097	30	.066	.371	06	.084	.396	23	.078	.056	07	.047	.391	17	.089	.363
02	.143	.221	03	.094	.228	27	.073	.876	24	.098	.524	17	.096	.076	28	.064	.113	10	.149	.681
05	.162	.899	16	.122	.945	09	.095	.568	10	.133	.919	04	.153	.163	12	.066	.360	28	.238	.075
03	.285	.016	18	.158	.430	05	.180	.741	15	.187	.079	10	.254	.834	26	.076	.552	13	.244	.767
28	.291	.034	25	.193	.469	12	.200	.851	17	.227	.767	06	.284	.628	30	.087	.101	24	.262	.366
08	.369	.557	24	.224	.572	13	.259	.327	20	.236	.571	12	.305	.616	02	.127	.187	08	.264	.651
01	.436	.386	10	.225	.223	21	.264	.681	01	.245	.988	25	.319	.901	06	.144	.068	18	.285	.311
20	.450	.289	09	.233	.838	17	.283	.645	04	.317	.291	01	.320	.212	25	.202	.674	02	.340	.131
18	.455	.789	20	.290	.120	23	.363	.063	29	.350	.911	08	.416	.372	01	.247	.025	29	.353	.478
23	.488	.715	01	.297	.242	20	.364	.366	26	.380	.104	13	.432	.556	23	.253	.323	06	.359	.270
14	.496	.276	11	.337	.760	16	.395	.363	28	.425	.864	02	.489	.827	24	.320	.651	20	.387	.248
15	.503	.342	19	.389	.064	02	.423	.540	22	.487	.526	29	.503	.787	10	.328	.365	14	.392	.694
04	.515	.693	13	.411	.474	08	.432	.736	05	.552	.511	15	.518	.717	27	.338	.412	03	.408	.077
16	.532	.112	20	.447	.893	10	.476	.468	14	.564	.357	28	.524	.998	13	.356	.991	27	.440	.280
22	.557	.357	22	.478	.321	03	.508	.774	11	.572	.306	03	.542	.352	16	.401	.792	22	.461	.830
11	.559	.620	29	.481	.993	01	.601	.417	21	.594	.197	19	.585	.462	17	.423	.117	16	.527	.003
12	.650	.216	27	.562	.403	22	.687	.917	09	.607	.524	05	.695	.111	21	.481	.838	30	.531	.486
21	.672	.320	04	.566	.179	29	.697	.862	19	.650	.572	07	.733	.838	08	.560	.401	25	.678	.360
13	.709	.273	08	.603	.758	11	.701	.605	18	.664	.101	11	.744	.948	19	.564	.190	21	.725	.014
07	.745	.687	15	.632	.927	07	.728	.498	25	.674	.428	18	.793	.748	05	.571	.054	05	.797	.595
30	.780	.285	06	.707	.107	14	.745	.679	02	.697	.674	27	.802	.967	18	.587	.584	15	.801	.927
19	.845	.097	28	.737	.161	24	.819	.444	03	.767	.928	21	.826	.487	15	.604	.145	12	.836	.294
26	.846	.366	17	.846	.130	15	.840	.823	16	.809	.529	24	.835	.832	11	.641	.298	04	.854	.982
29	.861	.307	07	.874	.491	25	.863	.568	30	.838	.294	26	.855	.142	22	.672	.156	11	.884	.928
25	.906	.874	05	.880	.828	06	.878	.215	13	.845	.470	14	.861	.462	20	.674	.887	19	.886	.832
24	.919	.809	23	.931	.659	18	.930	.601	08	.855	.524	20	.874	.625	14	.752	.881	07	.929	.932
10	.952	.555	26	.960	.365	04	.954	.827	07	.867	.718	30	.929	.056	09	.774	.560	09	.932	.206
06	.961	.504	21	.978	.194	28	.963	.004	12	.881	.722	09	.935	.582	29	.921	.752	01	.970	.692
27	.969	.811	12	.982	.183	19	.988	.020	23	.937	.872	22	.947	.797	04	.959	.099	23	.973	.082

Col. No. 15			Col. No. 16			Col. No. 17			Col. No. 18			Col. No. 19			Col. No. 20			Col. No. 21		
A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
15	.023	.979	19	.062	.588	13	.045	.004	25	.027	.290	12	.052	.075	20	.030	.881	01	.010	.946
11	.118	.465	25	.080	.218	18	.086	.878	06	.057	.571	30	.075	.493	12	.034	.291	10	.014	.939
07	.134	.172	09	.131	.295	26	.126	.990	26	.059	.026	28	.120	.341	22	.043	.893	09	.032	.346
01	.139	.230	18	.136	.381	12	.128	.661	07	.105	.176	27	.145	.689	28	.143	.073	06	.093	.180
16	.145	.122	05	.147	.864	30	.146	.337	18	.107	.358	02	.209	.957	03	.150	.937	15	.151	.012
20	.165	.520	12	.158	.365	05	.169	.470	22	.128	.827	26	.272	.818	04	.154	.867	16	.185	.455
06	.185	.481	28	.214	.184	21	.244	.433	23	.156	.440	22	.299	.317	19	.158	.359	07	.227	.277
09	.211	.316	14	.215	.757	23	.270	.849	15	.171	.157	18	.306	.475	29	.304	.615	02	.304	.400
14	.248	.348	13	.224	.846	25	.274	.407	08	.220	.097	20	.311	.653	06	.369	.633	30	.316	.074
25	.249	.890	15	.227	.809	10	.290	.925	20	.252	.066	15	.348	.156	18	.390	.536	18	.328	.799
13	.252	.577	11	.280	.898	01	.323	.490	04	.268	.576	16	.381	.710	17	.403	.392	20	.352	.288
30	.273	.088	01	.331	.925	24	.352	.291	14	.275	.302	01	.411	.607	23	.404	.182	26	.371	.216
18	.277	.689	10	.399	.992	15	.361	.155	11	.297	.589	13	.417	.715	01	.415	.457	19	.448	.754
22	.372	.958	30	.417	.787	29	.374	.882	01	.358	.305	21	.472	.484	07	.437	.696	13	.487	.598
10	.461	.075	08	.439	.921	08	.432	.139	09	.412	.089	04	.478	.885	24	.446	.546	12	.546	.640
28	.519	.536	20	.472	.484	04	.467	.266	16	.429	.834	25	.479	.080	26	.485	.768	24	.550	.038
17	.520	.090	24	.498	.712	22	.508	.880	10	.491	.203	11	.566	.104	15	.511	.313	03	.604	.780
03	.523	.519	04	.516	.396	27	.632	.191	28	.542	.306	10	.576	.659	10	.517	.290	22	.621	.930
26	.573	.502	03	.548	.688	16	.661	.836	12	.563	.091	29	.665	.397	30	.556	.853	21	.629	.154
19	.634	.206	23	.597	.508	19	.675	.629	02	.593	.321	19	.739	.298	25	.561	.837	11	.634	.908
24	.635	.810	21	.681	.114	14	.680	.890	30	.692	.198	14	.749	.759	09	.574	.599	05	.696	.459
21	.679	.841	02	.739	.298	28	.714	.508	19	.705	.445	08	.756	.919	13	.613	.762	23	.710	.078
27	.712	.366	29	.792	.038	06	.719	.441	24	.709	.717	07	.798	.183	11	.698	.783	29	.726	.585
05	.780	.497	22	.829	.324	09	.735	.040	13	.820	.739	23	.834	.647	14	.715	.179	17	.749	.916
23	.861	.106	17	.834	.647	17	.741	.906	05	.848	.866	06	.837	.978	16	.770	.128	04	.802	.186
12	.865	.377	16	.909	.608	11	.747	.205	27	.867	.633	03	.849	.964	08	.815	.385	14	.835	.319
29	.882	.635	06	.914	.420	20	.850	.047	03	.883	.333	24	.851	.109	05	.872	.490	08	.870	.546
08	.902	.020	27	.958	.856	02	.859	.356	17	.900	.443	05	.859	.935	21	.885	.999	28	.871	.539
04	.951	.482	26	.981	.976	07	.870	.612	21	.914	.483	17	.863	.220	02	.958	.177	25	.971	.369
02	.977	.172	07	.983	.624	03	.916	.463	29	.950	.753	09	.863	.147	27	.961	.980	27	.984	.252

Col. No. 22			Col. No. 23			Col. No. 24			Col. No. 25			Col. No. 26			Col. No. 27			Col. No. 28		
A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
12	.051	.032	26	.051	.187	08	.015	.521	02	.039	.005	16	.026	.102	21	.050	.952	29	.042	.039
11	.068	.980	03	.053	.256	16	.068	.994	16	.061	.599	01	.033	.886	17	.085	.403	07	.105	.293
17	.089	.309	29	.100	.159	11	.118	.400	26	.068	.054	04	.088	.686	10	.141	.624	25	.115	.420
01	.091	.371	13	.102	.465	21	.124	.565	11	.073	.812	22	.090	.602	05	.154	.157	09	.126	.612
10	.100	.709	24	.110	.316	18	.153	.158	07	.123	.649	13	.114	.614	06	.164	.841	10	.205	.144
30	.121	.744	18	.114	.300	17	.190	.159	05	.126	.658	20	.136	.576	07	.197	.013	03	.210	.054
02	.166	.056	11	.123	.208	26	.192	.676	14	.161	.189	05	.138	.228	16	.215	.363	23	.234	.533
23	.179	.529	09	.138	.182	01	.237	.030	18	.166	.040	10	.216	.565	08	.222	.520	13	.266	.799
21	.187	.051	06	.194	.115	12	.283	.077	28	.248	.171	02	.233	.610	13	.269	.477	20	.305	.603
22	.205	.543	22	.234	.480	03	.286	.318	06	.255	.117	07	.278	.357	02	.288	.012	05	.372	.223
28	.230	.688	20	.274	.107	10	.317	.734	15	.261	.928	30	.405	.273	25	.333	.633	26	.385	.111
19	.243	.001	21	.331	.292	05	.337	.844	10	.301	.811	06	.421	.807	28	.348	.710	30	.422	.315
27	.267	.990	08	.346	.085	25	.441	.336	24	.363	.025	12	.426	.583	20	.362	.961	17	.453	.783
15	.283	.440	27	.382	.979	27	.469	.786	22	.378	.792	08	.471	.708	14	.511	.989	02	.460	.916
16	.352	.089	07	.387	.865	24	.473	.237	27	.379	.959	18	.473	.738	26	.540	.903	27	.461	.841
03	.377	.648	28	.411	.776	20	.475	.761	19	.420	.557	19	.510	.207	27	.587	.643	14	.483	.095
06	.397	.769	16	.444	.999	06	.557	.001	21	.467	.943	03	.512	.329	12	.603	.745	12	.507	.375
09	.409	.428	04	.515	.993	07	.610	.238	17	.494	.225	15	.640	.329	29	.619	.895	28	.509	.748
14	.465	.406	17	.518	.827	09	.617	.041	09	.620	.081	09	.665	.354	23	.623	.333	21	.583	.804
13	.499	.651	05	.539	.620	13	.641	.648	30	.623	.106	14	.680	.884	22	.624	.076	22	.587	.993
04	.539	.972	02	.623	.271	22	.664	.291	03	.625	.777	26	.703	.622	18	.670	.904	16	.689	.339
18	.560	.747	30	.637	.374	04	.668	.856	08	.651	.790	29	.739	.394	11	.711	.253	06	.727	.298
26	.575	.892	14	.714	.364	19	.717	.232	12	.715	.599	25	.759	.386	01	.790	.392	04	.731	.814
29	.756	.712	15	.730	.107	02	.776	.504	23	.782	.093	24	.803	.602	04	.813	.611	08	.807	.983
20	.760	.920	19	.771	.552	29	.777	.548	20	.810	.371	27	.842	.491	19	.843	.732	15	.833	.757
05	.847	.925	23	.780	.662	14	.823	.223	01	.841	.726	21	.870	.435	03	.844	.511	19	.896	.464
25	.872	.891	10	.924	.888	23	.848	.264	29	.862	.009	28	.906	.367	30	.858	.299	18	.916	.384
24	.874	.135	12	.929	.204	30	.892	.817	25	.891	.873	23	.948	.367	09	.929	.199	01	.948	.610
08	.911	.215	01	.937	.714	28	.943	.190	04	.917	.264	11	.956	.142	24	.931	.263	11	.976	.799
07	.946	.065	25	.974	.398	15	.975	.962	13	.958	.990	17	.993	.989	15	.939	.947	24	.978	.633

6.2 Method of Sampling Plant Produced Bituminous Material

6.2.1 General - This method of sampling covers procedures used to sample bituminous mixtures at the plant to obtain samples for Marshall Test and laboratory extraction tests.

6.2.2 Apparatus. Scoop to make furrows and to dig material from the furrows in the pile of bituminous mixture.

6.2.3 Procedures.

a) The sample for extraction and stability testing will be taken at the plant, from the truck, by their contractor's or engineer's representative, as required.

b) The following method will be used to obtain samples from the designates truckloads of material:

(1) From two of the conical piles of mixture within the truck, two furrows 3 to 6 inches depth will be dug extending from the top to the bottom of the pile. Each furrow will follow the slope of the pile and be formed as near its center as possible. Sampling in areas between piles will be avoided because of possible segregation.

(2) Three scoops of approximately equal volume of material will be dug from each furrow, representing the top third, center third and bottom third of the pile. The material will then be thoroughly mixed together to form one sample. The amount of material collected should be enough to prepared at least three Marshall plugs.

(3) The material shall be placed in a sealed and insulated container, or approved substitute. When ready for use, very carefully remove the material so as to keep the samples representative and place directly in the molds.

(4) All tools and containers will be kept clean to prevent the build-up of bituminous material.

(5) All samples used for acceptance testing must be identified as to the time, date and truck number from which they were taken.

Section 7

7.0 Contractor Quality Control

7.1 Asphalt Content

7.1.1 General Information - Extraction test shall be performed by the contractor as part of his required quality control testing. The purpose of the test is to determine the bitumen content and aggregate gradation in the pavement mixture.

7.1.2 Sampling Procedure and Frequency - The sampling procedure shall be in accordance with the method described in Section 6 of this manual and a minimum of two extraction tests per lot shall be performed.

7.1.3 Equipment and Test Procedure - Bitumen Content - The equipment required and the test procedure to be followed for the determination of the bitumen content in paving mixture shall be in accordance with ASTM D 2172. Extraction equipment and test procedures approved by State testing agencies shall also be acceptable.

7.1.4 Moisture Content - The determination of the moisture content of the paving mixture shall be determined once per lot and in accordance with ASTM D 1461.

7.1.5 Weight of Ash - The weight of ash portion of the extraction test, as described in ASTM D 2172 shall be determined as part of the first extraction test performed at the beginning of plant production, and as part of every tenth extraction test performed thereafter for the duration of plant production for the project. The last weight of ash value obtained from the extraction test shall be used, where applicable, in the calculation of bitumen content of the mixture.

7.2 Gradation Analyses

7.2.1 General Information - Gradation analyses shall be performed by the contractor as part of his required quality control plan. The purpose of the test is to determine the aggregate gradation of the mixture as produced by the plant. When the asphalt content of the mixture is determined by a method other than the extraction test, the aggregate gradation shall be determined from samples taken from hot bins on batch plants or cold feed on drum mix or continuous plants.

7.2.2 Sample Procedure and Frequency - The sampling procedure shall be in accordance with methods described in Section 6 of this manual and shall be determined a minimum of twice per lot.

7.2.3 Equipment and Test Procedure - The equipment required and the test procedure to be followed for the determination of the particle size distribution of aggregates, extracted from the mixture or sampled from the plant, shall be in accordance with ASTM C 136. Dry sieving only shall be utilized.

7.2.4 Moisture Content of Aggregate - The moisture content of the aggregates shall be determined a minimum of once per lot in accordance with ASTM C 566.

7.3 Temperature

7.3.1 General Information - Temperature measurements shall be made by the contractor as part of his required quality control testing. The purpose of the measurements is to check the temperature of the dryer, the bitumen in the storage tank, the mixture in the trucks at the plant, and the mixture at the spreader at the job site.

7.3.2 Frequency of Measurements - The temperatures shall be checked at least four times per lot

7.3.3 Equipment and Procedure - The thermometers shall be reliable and accurate instruments, appropriate as to type and sensitivity for the particular measurements required. Armored glass, dial-type with metal stem, or remote sensing element with shield and associated indicator are typical examples. They shall be properly calibrated at a minimum by comparative readings with accurate, calibrated thermometers.

7.3.4 Use of Standard Forms - Standard forms for extraction test data and calculations, gradation analyses and calculations and the recording the required temperatures measurement, are included in Appendix C

SECTION 8

8.0 Method of Estimating Percent Within Limits - General:

The quality of an isolated quantity of material, commonly called lot, is determined using the concept called Percent Within Limit (PWL). The PWL for a lot of material is a statistical based evaluation method using the average (X) and standard deviation (S_N) for the specified number (n) of sublots test for the lot, and the specification tolerance limits (L for lower, U for upper). From these values, the respective Quality Index(s) (Q_L for Lower Quality Index and Q_U for Upper Quality Index) are computed and the PWL for the specified (n) is determined using Table 4 in this section.

8.1 - Rounding Rule:

8.1.1: If the digit following the last digit to be kept is 0, 1, 2, 3, or 4, strike out that digit and all the following digits.

Example: for the number 28.69248539, if only three decimal places are being kept the number becomes 28.692.

8.1.2: If the digit following the last digit to be kept is 6, 7, 8, or 9, increase the last digit to be kept by 1 and strike out all the following digits.

Example: for the number 28.69248539, if only one decimal place is being kept the number becomes 28.7.

8.1.3: If the digit following the last digit to be kept is 5 and there are digits other than zero to the right of 5, increase the last digit to be retained by 1 and strike out all following digits.

Example: for the number 28.69248539, if five decimal places are being kept the number becomes 28.69249.

8.1.4: If the digit following the last digit to be kept is 5 and there are no digits other than zero beyond 5, increase the last digit to be retained by 1 if it is odd or leave it unchanged if it is even.
Example: for the number 28.69248500, if five decimal places are being kept the number becomes 28.69248.

8.2 - Calculating Average: Determine the specified test value for each sublot. Calculate the average (X) by the formula:

$$X = (x_1 + x_2 + ...+ x_n)/n$$

Where:

X is the Average of all sublot values within a lot

x_1, x_2,..x_n are the individual sublot values

<u>8.3 - calculating the Standard Deviation.</u>

$S_n = ((d_1^2 + d_2^2 + ...+ d_n^2)/n-1)^{1/2}$

Where

S_N = Standard Deviation

d_1, d_2, ...d_n = deviations of each individual sublot value x_1, x_2,...x_n from the Average value X.

$d_1 = x_1 - X$, $d_2 = x_2 - X$,... $d_n = x_n - X$

n = number of sublots

<u>8.4 Determination of Quality Index</u>

<u>8.4.1 Lower Quality Index:</u> Determine the Lower Quality Index by use of the following formula:

$Q_L = (X - L)/S_N$

Where

L = lower specification tolerance limit

8.4.2 - Upper Quality Index: Determine the Upper Quality Index by use of the following formula:
$Q_U = (U - X)/S_N$

Where

U specification upper tolerance limit

8.5 Determination of Percent Within Limits (PWL)

8.5.1 For one side specification limit (i.e. L or U): With the Quality Index (Q_L or Q_U) enter Table 1 using the column appropriate to the number of sublots (n). If the value of Q_L or Q_U falls between values shown in Table 4, use the higher value.

8.5.2 For double sided specifications (i.e. L and U): Calculate the percentage of material between the lower (L) and upper (U) tolerance limit by entering Table 1 separately with Q_L and Q_U using the column appropriate for the number of sublots (n) and determining the percent of material above P_L and percent of material below P_U for each tolerance limit. Determine the PWL by using the following formula:

$PWL = (P_U + P_L) - 100$

Where:

P_L = percent above lower specification limit

P_U = percent below upper specification limit.

TABLE 4. TABLE FOR ESTIMATING PERCENT OF LOT WITHIN LIMITS (PWL)

Percent Within Limits (P_L and P_U)	Positive Values of Q (Q_L and Q_U)							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	N=10
99	1.1541	1.4700	1.6714	1.8008	1.8888	1.9520	1.9994	2.0362
98	1.1524	1.4400	1.6016	1.6982	1.7612	1.8053	1.8379	1.8630
97	1.1496	1.4100	1.5427	1.6181	1.6661	1.6993	1.7235	1.7420
96	1.1456	1.3800	1.4897	1.5497	1.5871	1.6127	1.6313	1.6454
95	1.1405	1.3500	1.4407	1.4887	1.5181	1.5381	1.5525	1.5635
94	1.1342	1.3200	1.3946	1.4329	1.4561	1.4717	1.4829	1.4914
93	1.1269	1.2900	1.3508	1.3810	1.3991	1.4112	1.4199	1.4265
92	1.1184	1.2600	1.3088	1.3323	1.3461	1.3554	1.3620	1.3670
91	1.1089	1.2300	1.2683	1.2860	1.2964	1.3032	1.3081	1.3118
90	1.0982	1.2000	1.2290	1.2419	1.2492	1.2541	1.2576	1.2602
89	1.0864	1.1700	1.1909	1.1995	1.2043	1.2075	1.2098	1.2115
88	1.0736	1.1400	1.1537	1.1587	1.1613	1.1630	1.1643	1.1653
87	1.0597	1.1100	1.1173	1.1192	1.1199	1.1204	1.1208	1.1212
86	1.0448	1.0800	1.0817	1.0808	1.0800	1.0794	1.0791	1.0789
85	1.0288	1.0500	1.0467	1.0435	1.0413	1.0399	1.0389	1.0382
84	1.0119	1.0200	1.0124	1.0071	1.0037	1.0015	1.0000	0.9990
83	0.9939	0.9900	0.9785	0.9715	0.9671	0.9643	0.9624	0.9610
82	0.9749	0.9600	0.9452	0.9367	0.9315	0.9281	0.9258	0.9241
81	0.9550	0.9300	0.9123	0.9025	0.8966	0.8928	0.8901	0.8882
80	0.9342	0.9000	0.8799	0.8690	0.8625	0.8583	0.8554	0.8533
79	0.9124	0.8700	0.8478	0.8360	0.8291	0.8245	0.8214	0.8192
78	0.8897	0.8400	0.8160	0.8036	0.7962	0.7915	0.7882	0.7858
77	0.8662	0.8100	0.7846	0.7716	0.7640	0.7590	0.7556	0.7531
76	0.8417	0.7800	0.7535	0.7401	0.7322	0.7271	0.7236	0.7211
75	0.8165	0.7500	0.7226	0.7089	0.7009	0.6958	0.6922	0.6896
74	0.7904	0.7200	0.6921	0.6781	0.6701	0.6649	0.6613	0.6587
73	0.7636	0.6900	0.6617	0.6477	0.6396	0.6344	0.6308	0.6282
72	0.7360	0.6600	0.6316	0.6176	0.6095	0.6044	0.6008	0.5982
71	0.7077	0.6300	0.6016	0.5878	0.5798	0.5747	0.5712	0.5686
70	0.6787	0.6000	0.5719	0.5582	0.5504	0.5454	0.5419	0.5394
69	0.6490	0.5700	0.5423	0.5290	0.5213	0.5164	0.5130	0.5105
68	0.6187	0.5400	0.5129	0.4999	0.4924	0.4877	0.4844	0.4820
67	0.5878	0.5100	0.4836	0.4710	0.4638	0.4592	0.4560	0.4537
66	0.5563	0.4800	0.4545	0.4424	0.4355	0.4310	0.4280	0.4257
65	0.5242	0.4500	0.4255	0.4139	0.4073	0.4030	0.4001	0.3980
64	0.4916	0.4200	0.3967	0.3856	0.3793	0.3753	0.3725	0.3705
63	0.4586	0.3900	0.3679	0.3575	0.3515	0.3477	0.3451	0.3432
62	0.4251	0.3600	0.3392	0.3295	0.3239	0.3203	0.3179	0.3161
61	0.3911	0.3300	0.3107	0.3016	0.2964	0.2931	0.2908	0.2892
60	0.3568	0.3000	0.2822	0.2738	0.2691	0.2660	0.2639	0.2624
59	0.3222	0.2700	0.2537	0.2461	0.2418	0.2391	0.2372	0.2358
58	0.2872	0.2400	0.2254	0.2186	0.2147	0.2122	0.2105	0.2093
57	0.2519	0.2100	0.1971	0.1911	0.1877	0.1855	0.1840	0.1829
56	0.2164	0.1800	0.1688	0.1636	0.1607	0.1588	0.1575	0.1566
55	0.1806	0.1500	0.1406	0.1363	0.1338	0.1322	0.1312	0.1304
54	0.1447	0.1200	0.1125	0.1090	0.1070	0.1057	0.1049	0.1042
53	0.1087	0.0900	0.0843	0.0817	0.0802	0.0793	0.0786	0.0781
52	0.0725	0.0600	0.0562	0.0544	0.0534	0.0528	0.0524	0.0521
51	0.0363	0.0300	0.0281	0.0272	0.0267	0.0264	0.0262	0.0260
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 4. TABLE FOR ESTIMATING PERCENT OF LOT WITHIN LIMITS (PWL)

Percent Within Limits (P_L and P_U)	Negative Values of Q (Q_L and Q_U)							
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
49	-0.0363	-0.0300	-0.0281	-0.0272	-0.0267	-0.0264	-0.0262	-0.0260
48	-0.0725	-0.0600	-0.0562	-0.0544	-0.0534	-0.0528	-0.0524	-0.0521
47	-0.1087	-0.0900	-0.0843	-0.0817	-0.0802	-0.0793	-0.0786	-0.0781
46	-0.1447	-0.1200	-0.1125	-0.1090	-0.1070	-0.1057	-0.1049	-0.1042
45	-0.1806	-0.1500	-0.1406	-0.1363	-0.1338	-0.1322	-0.1312	-0.1304
44	-0.2164	-0.1800	-0.1688	-0.1636	-0.1607	-0.1588	-0.1575	-0.1566
43	-0.2519	-0.2100	-0.1971	-0.1911	-0.1877	-0.1855	-0.1840	-0.1829
42	-0.2872	-0.2400	-0.2254	-0.2186	-0.2147	-0.2122	-0.2105	-0.2093
41	-0.3222	-0.2700	-0.2537	-0.2461	-0.2418	-0.2391	-0.2372	-0.2358
40	-0.3568	-0.3000	-0.2822	-0.2738	-0.2691	-0.2660	-0.2639	-0.2624
39	-0.3911	-0.3300	-0.3107	-0.3016	-0.2964	-0.2931	-0.2908	-0.2892
38	-0.4251	-0.3600	-0.3392	-0.3295	-0.3239	-0.3203	-0.3179	-0.3161
37	-0.4586	-0.3900	-0.3679	-0.3575	-0.3515	-0.3477	-0.3451	-0.3432
36	-0.4916	-0.4200	-0.3967	-0.3856	-0.3793	-0.3753	-0.3725	-0.3705
35	-0.5242	-0.4500	-0.4255	-0.4139	-0.4073	-0.4030	-0.4001	-0.3980
34	-0.5563	-0.4800	-0.4545	-0.4424	-0.4355	-0.4310	-0.4280	-0.4257
33	-0.5878	-0.5100	-0.4836	-0.4710	-0.4638	-0.4592	-0.4560	-0.4537
32	-0.6187	-0.5400	-0.5129	-0.4999	-0.4924	-0.4877	-0.4844	-0.4820
31	-0.6490	-0.5700	-0.5423	-0.5290	-0.5213	-0.5164	-0.5130	-0.5105
30	-0.6787	-0.6000	-0.5719	-0.5582	-0.5504	-0.5454	-0.5419	-0.5394
29	-0.7077	-0.6300	-0.6016	-0.5878	-0.5798	-0.5747	-0.5712	-0.5686
28	-0.7360	-0.6600	-0.6316	-0.6176	-0.6095	-0.6044	-0.6008	-0.5982
27	-0.7636	-0.6900	-0.6617	-0.6477	-0.6396	-0.6344	-0.6308	-0.6282
26	-0.7904	-0.7200	-0.6921	-0.6781	-0.6701	-0.6649	-0.6613	-0.6587
25	-0.8165	-0.7500	-0.7226	-0.7089	-0.7009	-0.6958	-0.6922	-0.6896
24	-0.8417	-0.7800	-0.7535	-0.7401	-0.7322	-0.7271	-0.7236	-0.7211
23	-0.8662	-0.8100	-0.7846	-0.7716	-0.7640	-0.7590	-0.7556	-0.7531
22	-0.8897	-0.8400	-0.8160	-0.8036	-0.7962	-0.7915	-0.7882	-0.7858
21	-0.9124	-0.8700	-0.8478	-0.8360	-0.8291	-0.8245	-0.8214	-0.8192
20	-0.9342	-0.9000	-0.8799	-0.8690	-0.8625	-0.8583	-0.8554	-0.8533
19	-0.9550	-0.9300	-0.9123	-0.9025	-0.8966	-0.8928	-0.8901	-0.8882
18	-0.9749	-0.9600	-0.9452	-0.9367	-0.9315	-0.9281	-0.9258	-0.9241
17	-0.9939	-0.9900	-0.9785	-0.9715	-0.9671	-0.9643	-0.9624	-0.9610
16	-1.0119	-1.0200	-1.0124	-1.0071	-1.0037	-1.0015	-1.0000	-0.9990
15	-1.0288	-1.0500	-1.0467	-1.0435	-1.0413	-1.0399	-1.0389	-1.0382
14	-1.0448	-1.0800	-1.0817	-1.0808	-1.0800	-1.0794	-1.0791	-1.0789
13	-1.0597	-1.1100	-1.1173	-1.1192	-1.1199	-1.1204	-1.1208	-1.1212
12	-1.0736	-1.1400	-1.1537	-1.1587	-1.1613	-1.1630	-1.1643	-1.1653
11	-1.0864	-1.1700	-1.1909	-1.1995	-1.2043	-1.2075	-1.2098	-1.2115
10	-1.0982	-1.2000	-1.2290	-1.2419	-1.2492	-1.2541	-1.2576	-1.2602
9	-1.1089	-1.2300	-1.2683	-1.2860	-1.2964	-1.3032	-1.3081	-1.3118
8	-1.1184	-1.2600	-1.3088	-1.3323	-1.3461	-1.3554	-1.3620	-1.3670
7	-1.1269	-1.2900	-1.3508	-1.3810	-1.3991	-1.4112	-1.4199	-1.4265
6	-1.1342	-1.3200	-1.3946	-1.4329	-1.4561	-1.4717	-1.4829	-1.4914
5	-1.1405	-1.3500	-1.4407	-1.4887	-1.5181	-1.5381	-1.5525	-1.5635
4	-1.1456	-1.3800	-1.4897	-1.5497	-1.5871	-1.6127	-1.6313	-1.6454
3	-1.1496	-1.4100	-1.5427	-1.6181	-1.6661	-1.6993	-1.7235	-1.7420
2	-1.1524	-1.4400	-1.6016	-1.6982	-1.7612	-1.8053	-1.8379	-1.8630
1	-1.1541	-1.4700	-1.6714	-1.8008	-1.8888	-1.9520	-1.9994	-2.0362

JOB MIX FORMULA

DATE	AIP PROJECT NO.
AIRPORT NAME AND LOCATION	
CONTRACTOR NAME AND ADDRESS	

BITUMINOUS PLANT

NAME AND ADDRESS	CAPACITY
SPECIFICATIONS	

PREPARED BY

NAME	ADDRESS

APPENDIX A PAGE 1 of 8

INITIAL MATERIAL ACCEPTANCE TESTING

PROPERTY		TEST	VALUE	SPECIFICCION
Coarse Aggregate WEAR-ABRASION		ASTM C 131		• 40%
SOUNDNESS SODIUM SULFATE MAGNESIUM SULFATE		ASTM C88		LOSS • 10% LOSS • 13%
CRUSHED PIECES AIRCRAFT WEIGHT (POUNDS)	>60,000	N/A		
	• 60,000	N/A		
FLAT ELONGATED PIECES		ASTM D4791		• 8%
SLAG - DENSITY		ASTM C29		• 70 POUND #/FT^3
<u>Fine Aggregate</u> NATURAL SAND				• 15% BY WEIGHT OF TOTAL AGGREGATES
PLASTIC LIMIT		ASTM D 4318		• 6
LIQUID LIMIT		ASTM D 4318		• 25
SAND EQUIVALENT VALUE		ASTM D2419		• 45%
PLASTIC INDEX (FILLER)		ASTM D242		• 4%

NOTE: ALL VALUES SHALL BE LISTED EVEN IF FROM STATE CERTIFICATION

PRODUCER	SPECIFICATION
PROJECT	DATE
SIGNATURE	AFFILLIATION

APPENDIX A PAGES 2 of 8

AGGREGATES PROPERTIES

MATERIALS	SOURCE	PERCENT USED IN FINAL AGGREGATE BLEND	BULK SPECIFIC GRAVITY (G_{sb})

ASPHALT PROPERTIES

GRADE	SOURCE	SPECIFIC GRAVITY

OPTIMUM ASPHALT CONTEN :________%

SIGNATURE	AFFILIATION

APPENDIX A PAGE 3 of 8

MIX FORMULA GRADATION

PRODUCER:__________________________ **PROJECT:** ______________________________ **DATE:** ________________

WERE THE ABOVE REPORTED MATERIALS SAMPLED FROM THE HOT BINS?

YES_____ NO :______

COLD FEED	

SIDNED________________________ **AFFILIATION**_____________________________

HOT MIX DESIGN DATA
BY THE
MARSHALL METHOD

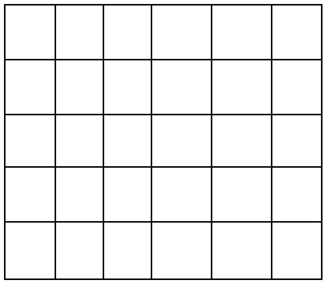
PRODUCER	PROJECT
SPECIFIC GRAVITY AC	LOCATION
AVERAGE BULK SPECIFIC GRAVITY OF TOTAL AGGREGATE	DATE

% AC BY TOT. WEIGHT OF MIX	% AC BY TOT WEIGHT. OF AGG.	SPECIM. HEIGT mm (in)	WEIITHS (grams)			BULK VOL. CC.	SPEC. GRAVITY		AC VOL.	VOIDS Pa	VMA %	UNIT WEIGHT PCF (Mg/m3)	STABILITY (lbs)		FLOW 1/100 .25 mm
			IN AIR	IN WATER	SAT.SURF DRY IN AIR		BULK	MAX. TEOR.					MEASD	ADJUST.	

TYPE OF COMPACTION USED ______ MANUAL ________________MECHANICAL	NUMBER OF BLOW ______50 ________75
SIGNAUTRE	AFFILIATION

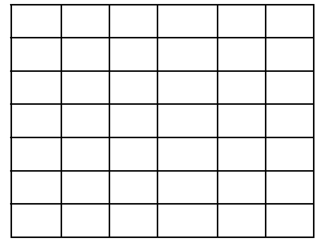
APPENDIX A PAGE 5 OF 8

UNIT
WEIGHT
LB/FT^3



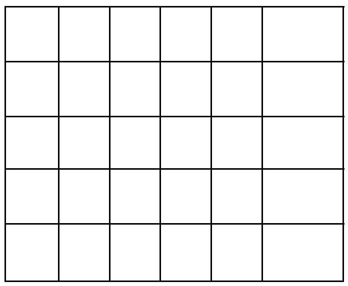
% OF AC

PERCENT VOIDS
TOTAL MIX



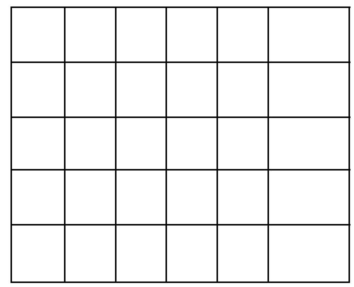
% OF AC

STABILITY



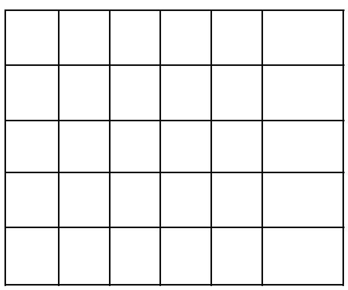
% OF AC

PERCENT V.M.A



5 OF AC

FLOW



% OF AC

PROPJECT NO__________________ Date______________________

Affiliation_________________ SIGNED____________________

JMF TEST PROPERTIES AT APTIMUM ASPHALT CONTENT		
PROPERTY	VALUE	SPECIFICATION
MIXING TEMP. ^{0}F		VISC. 170 ± 20 CS
COMPACTION TEMP ^{0}F		VISC 280 ± 30 CS
NUMBER OF BLOWS		
ASPHALT CONTENT (%)		
MARSHAL STABILITY (LBS)		
FLOW VALUE, 01 IN		
AIR VOIDS, %		
V.M.A, %		
UNIT WEIGHT LBS/FT^3		
MAXIMUM THEORETICAL SPECIFIC GRAVITY LBS/FT^3		
TENSILE STRENGTH RATIO		

PRODUCER	AFFILIATION
PROJECT	SPECIFICATION
NOTES	
SIGNATURE	DATE

APPENDIX A PAGE 7 OF 8

MAXIMUM THEORETICAL SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES

ASTM D 2041 (RICE METHOD)

A = WEIGHT OF DRY SAMPLE IN AIR (GRAMS)
B = WEIGHT OF FLASK FILLED WITH AIR LESS WATER AT 25^{0} C (77^{0} F) (GRAMS)
E = WEIGHT OF FLASK FILLED WITH WATER AND SAMPLE AT 25 ^{0} C (77 ^{0} F) (GRAMS)

TEST NO. 1	TEST NO. 2	TEST NO. 3	TEST NO. 4
A = _______GRAMS D = _______GRAMS E =_________GRAMS G_{mm} =__________ G_{mm} =_____GRAMS	A = _______GRAMS D = _______GRAMS E =_________GRAMS G_{mm} =__________ G_{mm} =_____GRAMS	A = _______GRAMS D = _______GRAMS E =_________GRAMS G_{mm} =__________ G_{mm} =_____GRAMS	A = _______GRAMS D = _______GRAMS E =_________GRAMS G_{mm} =__________ G_{mm} =_____GRAMS
CALCULATED BY		DATE	
AFFILIATION		PROJECT NO.	

DETERMINATION OF OPTIMUM ASPHALT CONTENT - EXAMPLE

JMF DATA

% AC	Unit Weight	Stability	Flow	% Voids	% V.M.A.
5.0	150.0	2,360	10	6.8	15
5.5	152.0	2,720	11	4.2	14.5
6.0	153.7	2,990	12	2.3	14.4
6.5	153.0	2,800	17	1.1	14.8
7.0	151.9	2,590	21	0.5	15.5

Specification

1/2 in. Nominal Maximun Aggregate Size

% AC 5.0-7.5

JMF Requirements*

Stability	2,150 min.
Flow	10-14
% Air Voids	2.8-4.2
% V.M.A	14 min.

Determine the % AC at the midpoint of % Air Voids specification parameter.

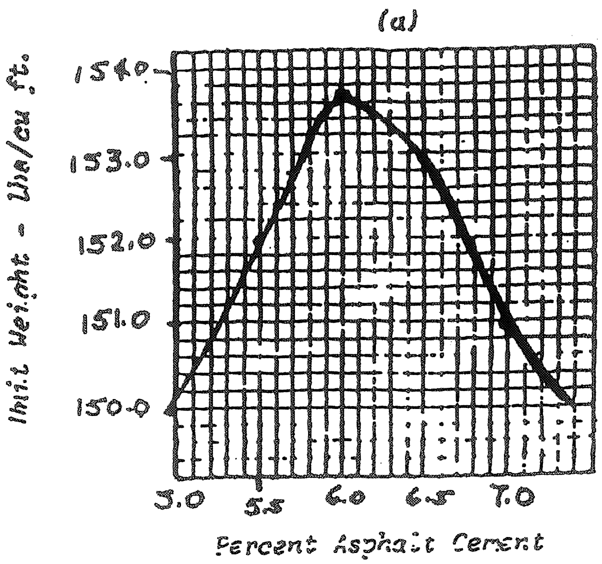
From graph- @ 3.5% Air Voids % AC is 5.6%

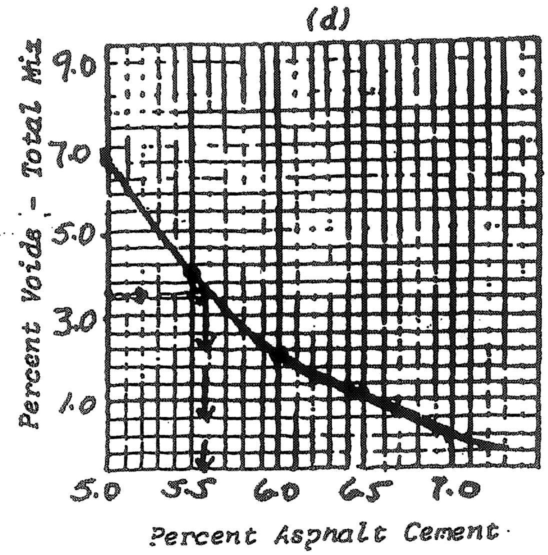
A check of the other specification parameters at this AC content reveals that they are well within the JMF specification limits.

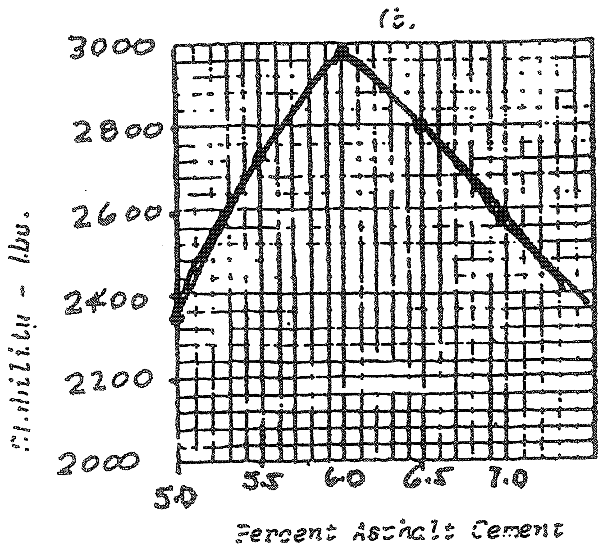
* In this example, it is assumed that the contractor does not have sufficient historical data on his process to revise the JMF contract requirements in accordance with Appendix D, Page 6.

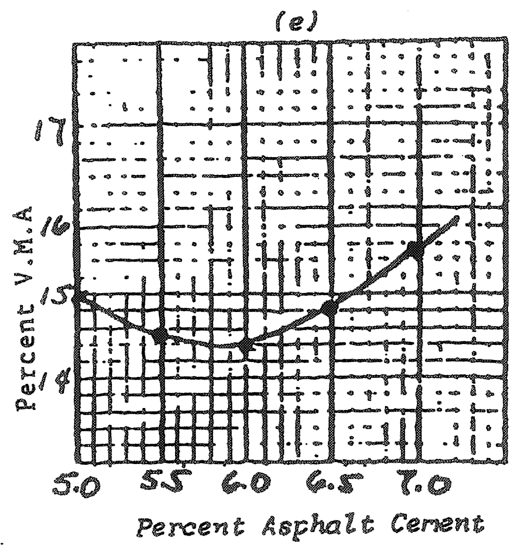
Conclusion - Establish JMF AC content at 5.6% ± 0.5 %

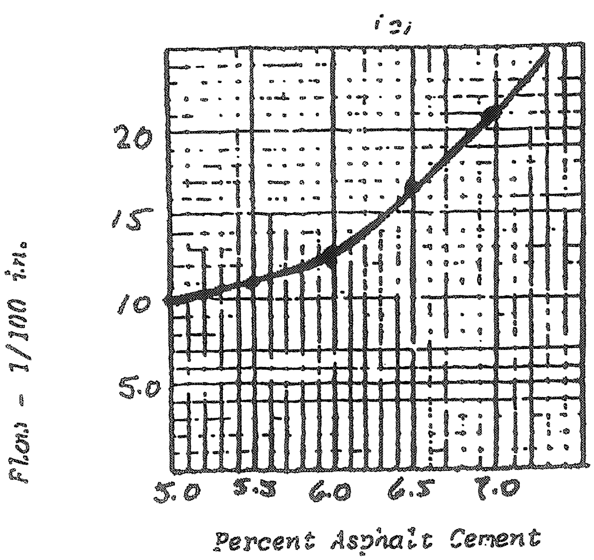
NOTE: Every effort should be made to establish plant production at the 5.6% level. The ± 0.5% tolerance is provided to allow for normal variation in plant production and testing variability. Under no circumstances should the contractor attempt to produce with the AC content at the extremities of the ± 0.5% tolerance limits, since by doing so, his chances of complying with the Marshall acceptance criteria will be greatly reduced.











EXAMPLE

determination of the Optimum Asphalt Content

Project: *ADAP No.* ______________

SPEC.: ______________

DATE: ______________

SIGNED: ______________

AFFILIATION: ______________

GRADATION ANALYSIS

PRODUCER: ____________________ SPEC: ____________________

PROJECT: AIP No. ____________________ DATE: ____________________

SIEVE SIZE	BIN NO 5 ___%		BIN NO 4 ___%		BIN NO 3 ___%		BIN NO 2 ___%		BIN NO 1 ___%		___%		COMB. GRAD.	PROD. SPEC.		GEN'L SPEC.	
	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch	% Pass	% Batch		MIN.	MAX.	MIN.	MAX.

BLENDED SAND USED: ____________________

JMF SPEC GRAVITY: ____________________

MEASURED SPEC GRAV: ____________________

TEST PERFORMED BY: ____________________

AFFILIATION: ____________________

PRODUCER: ____________________ SPEC: ____________

PROJECT: AIP No. ________________ DATE: ____________

TEST PERFORMED BY: ____________ AFFILIATION: ____________

EXTRACTION TEST

1. WGT. OF SAMPLE: W_1 = ________ gms

2. WGT. OF WATER IN SAMPLE: W_2 = ________ gms

3. WGT. OF EXTRACTED AGGREGATE: W_3 ________ gms

   NOTE: ADD THE INCREASE IN WGT OF FILTER RING TO W_3.

4. WGT. OF ASH IN EXTRACT: W_4 = ________ gms

5. BITUMEN CONTENT OF DRY SAMPLE, %:

$$\% AC = \frac{(W_1 - W_2) - (W_3 + W_4)}{W_1 - W_2} \times 100$$

% AC = ____________ x 100 = ____________ %

6. GRADATION:

SIEVE												
RET. WGT.												
% RET.												
% PASS.												
SPEC.												

PRODUCER: ______________________ SPEC: __________

PROJECT: AIP No. ______________________ DATE: __________

PERFORMED BY: ______________________ AFFILIATION: __________

DAILY TEMPERATURE MEASUREMENTS, °F

LOCATION	No. 1 Time:	No. 2 Time:	No. 3 Time:	No. 4 Time:	No. 5 Time:	No. 6 Time:
BITUMEN IN STORAGE TANK						
MIX IN TRUCKS						
DRYER						
LAYDOWN						

BITUMINOUS CONCRETE TESTING REPORT

PRODUCER	DATE
PROJECT NO.	SPECIFICATION

COMPUTATION OF MARSHALL MIX PROPERTIES

SPECI MEN NO.	ASPHALT CONTENT PERCENT	THICK-NESS INCHES	WEIGHT - GRAMS			VOLUME CC	SPEC. GRAVITY		VOIDS %	UNIT WGT	STABILITY - LB.		FLOW
			IN AIR	IN WATER	SAT SURF DRY		Bulk G_{mb}	THEOR. Gmm	TOTAL MIX	TOT. MIX LB/CU FT	MEAS-URED	CON-VERTED	UNITS OF 1/100 IN
A	B	C	D	E	E'	F	G	H	I	J	K	L	M
						(E-E)	(D) / (F)		(100-100x G) / H)	(Gx62-4)			
SUBLOT NO. ______													
AVG													
SUBLOT NO. ______													
AVG													

NOTES

CALCULATIONS BY	AFFILIATION

SUMMARY SHEET - MARSHALL TESTS

	STABILITY	FLOW	AIR VOIDS
SUBLOT 1			
SPECIMEN NO. 1-1		*	
SPECIMEN NO. 1-2		*	
SPECIMEN NO. 1-3		*	
SAMPLE INCREMENT (AVERAGE)		**	
SUBLOT 2			
SPECIMEN NO. 2-1		*	
SPECIMEN NO. 2-2		*	
SPECIMEN NO. 2-3		*	
SAMPLE INCREMENT (AVERAGE)		**	
SUBLOT 3			
SPECIMEN NO. 3-1		*	
SPECIMEN NO. 3-2		*	
SPECIMEN NO. 3-3		*	
SAMPLE INCREMENT (AVERAGE)		**	
SUBLOT 4			
SPECIMEN NO. 4-1		*	
SPECIMEN NO. 4-2		*	
SPECIMEN NO. 4-3		*	
SAMPLE INCREMENT (AVERAGE)		**	

* TO THE NEAREST WHOLE NUMBER.
** TO THE NEAREST TENTH (ONE DECIMAL PLACE).

CALCULATIONS BY	DATE
AFFILIATION	

AIR VOIDS (VTM) ACCEPTANCE CALCULATION	
(LABORATORY MARSHALL SPECIMENS)	
PERCENT WITHIN LIMIT (PWL)	
SUBLOT 1(AVERAGE) = *	
SUBLOT 2 (AVERAGE) = *	
SUBLOT 3 (AVERAGE) = *	
SUBLOT 4 (AVERAGE) = *	
X (AVERAGE) = *	
S_N(STANDARD DEVIATION) = **	
L (LOWER LIMIT) = 2.0	U (UPPER LIMIT) = 5.0
$Q_L = (X - L)/S_N =$	$Q_U = (U - X)/S_N =$
P_L = (% TABLE 1, SECTION 8) =	P_U=(% TABLE 1, SECTION 8)=
PWL = $(P_L + P_U) - 100$ PWL =	
* TO THE NEAREST TENTH (ONE DECIMAL PLACE) ** TO THE NEAREST HUNDRETH (TWO DECIMAL PLACES)	
CALCULATION BY:	DATE
AFFILIATION	

APPENDIX D, PAGE 3

STABILITY ACCEPTANCE CALCULATION	
(LABORATORY MARSHALL SPECIMENS)	
PERCENT WITHIN LIMITS (PWL)	
SUBLOT 1 (AVERAGE) =	*
SUBLOT 2 (AVERAGE) =	*
SUBLOT 3 (AVERAGE) =	*
SUBLOT 4 (AVERAGE) =	*
X (AVERAGE) =	*
Sn (STANDARD DEVIATION) =	**
L (LOWER LIMIT) =	***
$Q_L = (X - L)/S_n$ =	
$P_L =$ (% TABLE 1, SECTION 8)	
* TO THE NEAREST WHOLE NUMBER ** TO THE NEAREST TENTH (ONE DECIMAL PLACE) *** USE VALUE IN TABLE 5 OF SPECIFICATION	
CALCULATION BY	DATE
AFFILIATION	

APPENDIX D, PAGE 4

FLOW ACCEPTANCE CALCULATION	
(LABORATORY MARSHALL SPECIMENS)	
PERCENT WITHIN LIMIT (PWL)	
SUBLOT 1 (AVERAGE) = *	
SUBLOT 2 (AVERAGE) = *	
SUBLOT 3 (AVERAGE) = *	
SUBLOT 4 (AVERAGE) = *	
X (AVERAGE) = *	
S_N (STANDARD DEVIATION) = **	
L (LOWER LIMIT) = 8	*** U (UPPER LIMIT) =
$Q_L = (X - L)/S_N =$	$Q_U = (U - X)/S_N =$
P_L = (% TABLE 1, SECTION 8) =	P_U = (% TABLE 1, SECTION 8) =
PWL = $(P_L + P_U) - 100$ PWL =	
* TO THE NEAREST TENTH (ONE DECIMAL PLACE) ** TO THE NEAREST HUNDRETH (TWO DECIMAL PLACES) *** USE VALUE IN TABLE 5 OF SPECIFICATION	
CALCULATION BY:	DATE
AFFILIATION	

APPENDIX D, PAGE 5

MAXIMUM THEORETICAL SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES			
ASTM D 2041 (RICE METHOD)			
A = WEIGHT OF DRY SAMPLE IN AIR (GRAMS). D = WEIGHT (GRAMS) OF FLASK FILLED WITH AIR LESS WATER AT 25 C (77 F). E = WEIGHT (GRAMS) OF FLASK FILLED WITH WATER AND SAMPLE AT 25 C (77 F). Gmm = (A)/(A + D - E)			
TEST NO. 1	TEST NO. 2	TEST NO. 3 (OPTIONAL)	TEST NO. 4 (OPTIONAL)
A = ________GRAMS D = ________GRAMS E = ________GRAMS Gmm = ________ Gmm = ________ =	A = ________GRAMS D = ________GRAMS E = ________GRAMS Gmm = ________ Gmm = ________ =	A = ________GRAMS D = ________GRAMS E = ________GRAMS Gmm = ________ Gmm = ________ =	A = ________GRAMS D = ________GRAMS E = ________GRAMS Gmm = ________ Gmm = ________ =
CALCULATION BY:		DATE:	
AFFILIATION		PROJECT NO.	

APPENDIX D, PAGE 6

FORMULAS FOR DEVELOPING JMF DESIGN RANGES

BASED ON CONTRACTORS PROCESS STANDARD DEVIATIONS

1. STABILITY

Lower Limit = 1800 (or 1000) + 1.28 (S_n)

2. FLOW

Lower Limit L = 8 + 1.28 (S_n)

Upper Limit U = 16 (or 20) - 1.28 (S_n)

3. AIR VOIDS (Non-abrasive Aggregates)

Lower Limit L = 2.0 + 1.28 (S_n)

Upper Limit U = 5.0 - 1.28 (S_n)

4. AIR VOIDS (Absorptive Aggregates)

Lower Limit L = 0.5 + 1.28 (S_n)

Upper Limit U = 4.5 - 1.28 (S_n)

ILLUSTRATIVE EXAMPLE:

For air voids (Non-absorptive aggregates) a contractor capable of producing at a standard deviation of 0.3% would be able to design within

Lower Limit L = 2.0 + 1.28 (0.3) = 2.4%
Upper Limit U = 5.0 - 1.28 (0.3) = 4.6%

Whereas a contractor capable of producing at a standards deviation of 0.6% should design within:

Lower Limit L = 2.0 + 1.28 (0.6) = 2.8%
Upper Limit U = 5.0 - 1.28 (0.6) = 4.2%

APPENDIX D, PAGE 7

IN-PLACE DENSITY ACCEPTANCE CALCULATION		
LOCATION OF MAT CORES		
SUBLOT NO.	**PAVEMENT STATION**	**OFFSET**
1		
2		
3		
4		

LOCATION OF JOINT CORES	
SUBLOT	**PAVEMENT STATION**
1	
2	
3	
4	
CALCULATED BY	DATE
AFFILIATION	

APPENDIX E PAGE 1 OF 4

BULK SPECIFIC GRAVITY OF COMPACTED MIXTURE					
ASTM D 2726					
CORE NO.	WEIGTH IN AIR (GRAMS)	WEIGTH IN WATER (GRAMS)	SAT-SURF DRY	VOLUME CU-CM	SPECIFIC GRAVITY G_{mb}
SUBLOT	D	E	E^1	$(E-E^1)$ F	D/F G
1					
2					
3					
4					
CALCULATED BY			DATE		
AFFILIATION					

APPENDIX E PAGE 2 OF 4

CORE PERCENT COMPACTION

SUBLOT NO.	IN-PLACE BULK SPECIFIC GRAVITY (G_{mm}) ASTM D2726 PROCEDURE 9.1 A	AVERAGE BULK SPECIFIC GRAVITY OF LABORATORY SPECIMENS (G_{mbf}) B	(B/A)x100
1			
2			
3			
4			
RESAMPLE 1			
RESAMPLE 2			
RESAMPLE 3			
RESAMPLE 4			
CALCULATED BY:		DATE	
AFILIATION			

APPENDIX E PAGE 3 OF 4

MAT DENSITY - PERCENT COMPACTION	
PERCENT WITHIN LIMITS (PWL)	
SUBLOT 1 (%)	**RESAMPLE 1 (%) ***
SUBLOT 2 (%)	**RESAMPLE 2 (%) ***
SUBLOT 3 (%)	**RESAMPLE 3 (%) ***
SUBLOT 4 (%)	**RESAMPLE 4 (%) ***
X (AVERAGE) *	
S_N (STANDARD DEVIATION) *	
L (LOWER LIMIT) = 96.3	
$Q_L = (X-L)/S_N =$	
PWL (% TABLE 4, SECTION 8)	
*** TO THE NEAREST HUNDRETH (TWO DECIMAL PLACES)**	
CALCULATED BY:	**DATE**
AFILIATION	

APPENDIX E PAGE 4 OF 4