Method of Test for
DETERMINATION OF OPTIMUM ASPHALT CEMENT CONTENT FOR AN ASPHALTIC CONCRETE MIXTURE
DOTD Designation: TR 303M/303-96

METHOD A - PLANT DETERMINATION

I. Scope

A. This method of test is designed to determine the optimum asphalt cement content for a specific combination of aggregate, asphalt cement, and additives established in accordance with DOTD mix design procedures.

B. Reference Documents:
1. DOTD TR 304 - Determination of Specific Gravity and Density Characteristics of Compressed Asphaltic Mixtures.
2. DOTD TR 305 - The Stability and Flow of Asphaltic Concrete Mixtures - Marshall Method.
3. DOTD TR 317 - Water Susceptibility of Asphaltic Concrete Materials.
4. DOTD TR 320 - Determination of Asphalt Absorption Factor of Aggregate and Effective Asphalt Content for Asphaltic Mixtures.
5. DOTD TR 322 - Determining the Effect of Moisture on Asphaltic Concrete Paving Mixtures.
6. DOTD TR 403 - Determination of Moisture Content.
7. DOTD S 203 - Sampling Asphaltic Mixtures.
8. *Application of Quality Assurance Specifications for Asphaltic Concrete Mixtures - LA DOTD Mix Design Procedures Manual.*

II. Apparatus

A. **Operating asphaltic concrete plant.**

B. **Sample container with shovel or scoop** - a minimum 20 L (5 gal) insulated container with a heavy cloth cover.

C. **Balance** - with a minimum capacity of 2 kg and readable to 0.1 g.

D. **Dial thermometer** - readable to 1°C (1°F).

E. **Engineering curve.**

F. **Personal protective equipment** - thermal gloves, eye protection, apron, tongs and other tools for handling hot materials.

G. **Constant temperature forced air electric oven** - capable of maintaining temperatures within the range of 40 ± 3°C to 200 ± 3°C (100 ± 5°F to 400 ± 5°F).

H. **Asphaltic Concrete Job Mix Formula** - DOTD Form No. 03-22-0730.

I. **Asphaltic Concrete Mix Design Worksheet** - DOTD Form No. 03-22-0731 (Figure A - 1).

J. **Optimum Asphalt Cement Content - Summary of Test Properties** - DOTD Form No. 03-22-6000 (Figure A-2).

K. **Optimum Mixing & Compaction Temperature Curves.**

III. Sample

The sample shall be a sufficient amount of asphaltic concrete from a truck to prepare a minimum of 3 briquettes. The sample must be a minimum of 20 L (5 gal) to ensure that the temperature remains within the optimum compaction temperature range.

Note A-1: *After each adjustment made in the percent asphalt cement in drum-mixer plants, allow sufficient time for the plant to produce the adjusted mix before obtaining additional samples.*

IV. Health Precautions

Proper precautions are to be taken whenever hot materials or equipment must be handled. Use container holder or thermal gloves while handling hot containers. Wear

eye protection while stirring and weighing heated materials due to possible shattering of particles. Dry contaminated materials under a vent to prevent exposure to fumes.

V. Procedure

A. Produce trial mixtures that conform to the composite gradation established on the Asphaltic Concrete Mix Design Worksheet.
   1. Set all cold feed controls to produce the established composite gradation.
   2. Set the asphalt cement meter or scales to discharge the correct quantity of asphalt cement at the estimated optimum asphalt cement content.
   3. Set the anti-strip metering device to discharge 0.1% greater than the minimum quantity of anti-strip additive established by DOTD TR 317.

Note A-2: *Additional anti-strip additive or hydrated lime may be needed to meet the requirements of DOTD TR 322.*

   4. Set any other plant controls to discharge the established anti-strip additive content.
   5. Begin plant operation and allow the plant adequate time to produce a uniform mixture at the optimum mixing temperature.

Note A-3: *When using a drum mixer plant, determine the moisture content of the composited aggregate from the cold feed belt in accordance with DOTD TR 403. Incorporate this moisture content into the plant controls.*

B. Obtain, in accordance with DOTD S203, a sample of the mixture. Place the sample in the insulated container. Cover the container to maintain the temperature of the mixture. Age the sample of loose mixture for 30 ± 5 min to allow the asphalt to absorb into the aggregate. After the aging time has elapsed, remove the cover and remix the sample.
   1. Place, tamp and shape the mixture in the Marshall mold in accordance with DOTD TR 305.
   2. Repeat step 1 until there are 3 molds with material. For mixtures with nonabsorptive aggregates, place the molds with material into the oven for 30 ± 5 min at the optimum compaction temperature. For mixtures with absorptive aggregates, place the molds with material into the oven for 60 ± 5 min at the optimum compaction temperature.

Note A-4: *If the optimum compaction temperature of the mixture is not known, set the oven at 150°C (300°F).*

Note A-5: *When absorptive aggregate is used, an increase in the oven time is necessary to ensure an adequate, uniform asphalt coating after absorption has occurred.*

C. Remove one mold with material from the oven and immediately compact and test the briquette in accordance with DOTD TR 304 and TR 305. Repeat for each mold with material. Calculate and record the individual test results on the Asphaltic Concrete Mix Design Worksheet. When absorptive aggregates are used, determine the %VFA using the effective asphalt content determined in accordance with DOTD TR 320. Record the specific gravity of the briquettes to the nearest 0.001.

Note A-6: *Do not allow the time elapsing from the removal of the mixture from the*

oven to the first blow of the hammer to exceed one minute.

D. Average the test values for the 3 briquettes and record on the Asphaltic Concrete Mix Design Worksheet. If any individual specific gravity result varies more than 0.020 from the average, all test results for that briquette shall be discarded. If more than one briquette exhibits erratic results, obtain a new sample and test.

E. Alter the asphalt content of the composited mixture. Obtain a new sample of mixture produced within ±6°C (±10°F) of the initial sample. Repeat steps V.A-D at a minimum of two altered asphalt cement contents. To achieve a valid determination of optimum asphalt cement content, produce one mixture at an asphalt cement content at 0.5% above the estimated optimum and produce the other mixture at an asphalt cement content at 0.5% below the estimated optimum. If one of the asphalt cement contents chosen is less than ±0.3% of optimum and is the only point on the high or low side of optimum, produce additional mixtures at other altered asphalt cement contents.

F. Plot the averaged test values for each design parameter shown on the Optimum Asphalt Cement Content - Summary of Test Properties.

G. Using an engineering curve, connect each series of plotted points for each property on the Optimum Asphalt Cement Content Summary of Test Properties.

H. Determine and mark the percent optimum asphalt cement to the nearest 0.1% for the percent air voids at the midpoint of specification range for the type of the mixture. Optimum asphalt content for the mixture is the asphalt content corresponding to the air voids at the midpoint of the specification range.

I. Determine and mark the following test properties at the optimum asphalt content:
   1. %VMA - must be above specification minimum.
   2. Percent voids filled with asphalt - must be in specification range.
   3. Stability - must be above specification minimum.
   4. Flow - must be within specification range.

   When %VMA, %VFA, stability or flow do not meet specification requirements at optimum asphalt content, a new composite aggregate gradation shall be used with a new optimum asphalt content.

VI. Report

Record the optimum asphalt cement content to the nearest 0.1% on the Optimum Asphalt Cement Content Summary of Test Properties and on the proposed Asphaltic Concrete Job Mix Formula.

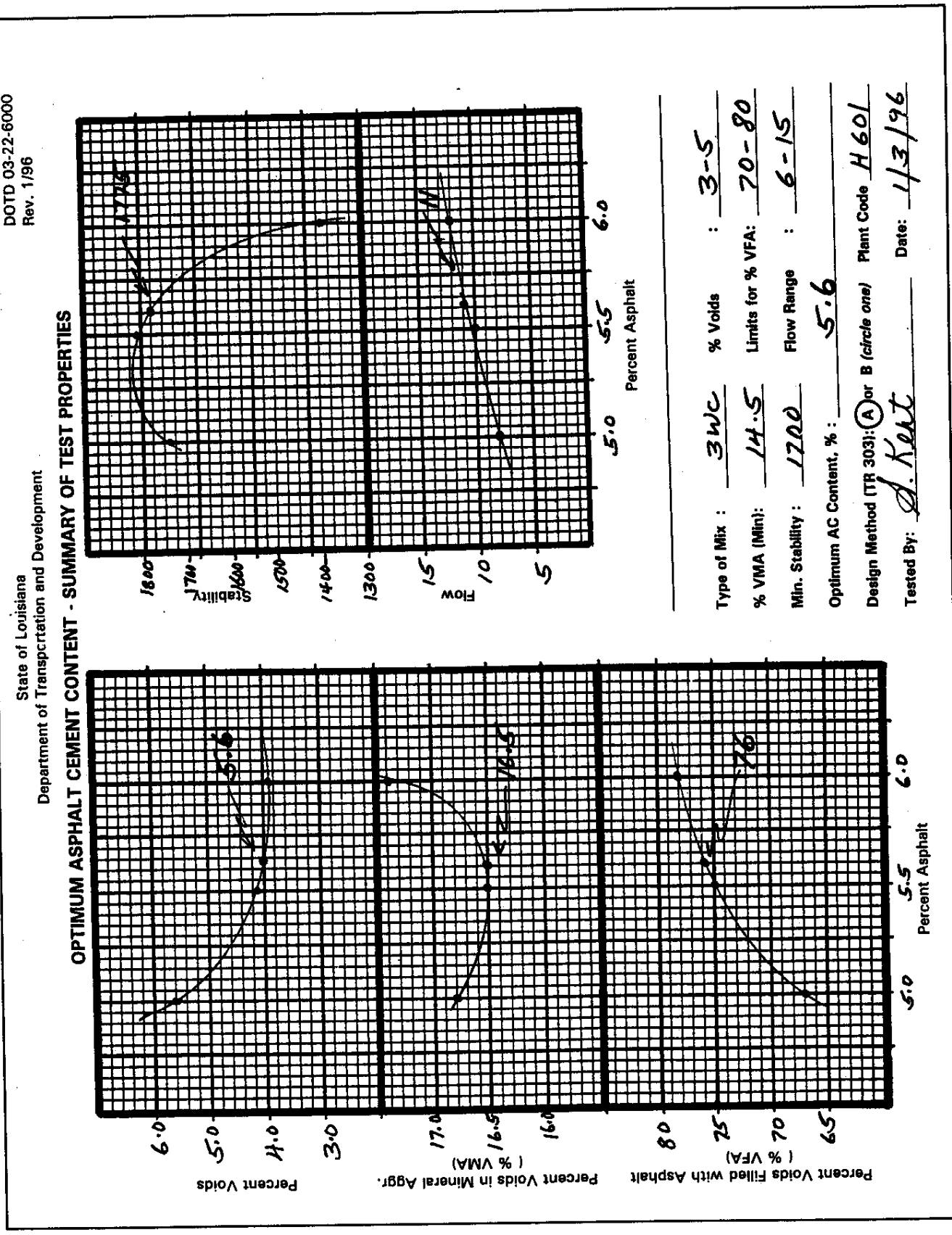
VII. Normal Test Reporting Time

Normal test reporting time is 1 day.

DOTD TR 304, 305 and 303

ASPHALT CONTENT	5.0 %				5.5 %				6.0 %			
	1	2	3	AVERAGE	4	5	6	AVERAGE	7	8	9	AVERAGE
WEIGHT IN AIR	1208.8	1202.2	1200.1		1199.9	1191.9	1193.8		1200.0	1201.6	1215.8	
WEIGHT IN WATER	685.7	682.0	680.6		688.1	680.2	681.2		686.5	684.1	691.3	
DIFFERENCE	523.1	520.2	519.5		514.8	511.5	512.6		520.1	517.5	524.5	
SP. GRAVITY	2.311	2.311	2.310	2.311	2.331	2.330	2.329	2.330	2.320	2.302	2.318	2.320
THEO. GRAVITY	2448	2.448	2.448		2430	2430	2430		2413	2413	2413	
% THEO. GRAVITY	94.4	94.4	94.4	94.4	95.9	95.9	95.8	95.9	96.1	96.2	96.1	96.1
DENSITY	144.2	144.2	144.1	144.2	145.4	145.4	145.3	145.4	144.8	144.9	144.6	144.8
% VOIDS	5.0	5.6	5.6	5.6	4.1	4.1	4.2	4.1	3.9	3.8	3.9	3.9
% AC BY VOLUME	11.2	11.2	11.2		12.4	12.4	12.4		13.5	13.5	13.5	13.5
% VFA	67	67	67	67	75	75	75	75	78	78	78	78
% VMA	16.8	16.8	16.8	16.8	16.5	16.5	16.6	16.5	17.4	17.3	17.4	17.4
DIAL READING	126	124	120		130	126	124		102	100	93	
STABILITY	1799	1771	1714		1856	1799	1771		1457	1428	1330	
THICKNESS	2 9/16	2 1/2	2 1/2		2 1/2	2 1/2	2 1/2		2 1/2	2 1/2	2 9/16	
CORRECTION FACTOR	1.04	1.00	1.00		1.00	1.00	1.00		1.00	1.00	1.04	
CORRECTED STABILITY	1730	1771	1714	1738	1856	1799	1771	1809	1457	1428	1279	1388
FLOW	8	8	8	8	10	10	11	10	12	12	11	12
TIME SAMPLE TAKEN												
TEMP. OF MIX F												

Portion from the Asphaltic Concrete Mix Design Worksheet
Figure A-1



Optimum Asphalt Cement Content - Summary of Test Properties
Figure A-2

DOTD Designation: TR 303M/303-96

METHOD B - LABORATORY DETERMINATION

I. Scope

A. This method of test is designed to determine the optimum asphalt cement content for a specific combination of aggregate, asphalt cement, and additives established in accordance with LA DOTD mix design procedures.

B. Reference Documents:
1. DOTD TR 304 - Determination of Specific Gravity and Density Characteristics of Compressed Asphaltic Mixtures.
2. DOTD TR 305 - The Stability and Flow of Asphaltic Concrete Mixtures - Marshall Method.
3. DOTD TR 317 - Water Susceptibility of Asphaltic Concrete Materials.
4. DOTD TR 320 - Determination of Asphalt Absorption Factor of Aggregate and Effective Asphalt Content for Asphaltic Mixtures.
5. DOTD TR 403 - Determination of Moisture Content.
6. DOTD S 101 - Sampling Aggregates and Aggregate Mixtures.
7. DOTD S 102 - Sampling Mineral Filler, Portland Cement, Fly Ash and Hydrated Lime.
8. DOTD S 201 - Sampling Asphaltic Materials.
9. DOTD S 601 - Sampling Miscellaneous Materials.
10. *Application of Quality Assurance Specifications for Asphaltic Concrete Mixtures - LA DOTD Mix Design Procedures Manual.*

II. Apparatus

A. **Constant temperature forced air electric oven** - capable of maintaining temperatures within the range of 40 to 200 ± 3°C (100 to 400 ± 5°F).

B. **Balance** - with a minimum capacity of 2 kg and readable to 0.1 g.

C. **Mechanical mixer or stirrer.**

D. **Electric hot plate.**

E. **Dial thermometer** - readable to 1°C (1°F).

F. **Pots and pans** - a suitable number of each.

G. **Engineering curve.**

H. **Personal protective equipment** - thermal gloves, eye protection, apron, tongs and other tools for handling hot materials.

I. **Stirrer.**

J. **Asphaltic Concrete Job Mix Formula** - DOTD Form No. 03-22-0730.

K. **Asphaltic Concrete Mix Design Worksheet** - DOTD Form No. 03-22-0731 (See Figure A-1).

L. **Optimum Asphalt Cement Content - Summary of Test Properties** - DOTD Form No. 03-22-6000 (See Figure A-2).

M. **Optimum Mixing & Compaction Temperature Curves.**

III. Sample

A. Obtain samples of coarse and fine aggregates, including reclaimed asphaltic pavement (RAP) if used, in accordance with DOTD S 101.

B. Obtain a sample of asphalt cement in accordance with DOTD S 201.

C. If used, obtain a sample of mineral filler in accordance with DOTD S 102.

D. Obtain a sample of liquid anti-strip in accordance with DOTD S 601.

E. If used, obtain a sample of hydrated lime in accordance with DOTD S 102.

IV. Health Precautions

Proper precautions are to be taken whenever hot materials or equipment must

be handled. Use container holder or thermal gloves while handling hot containers. Wear eye protection while stirring and weighing heated materials due to possible shattering of particles. Dry contaminated materials under a vent to prevent exposure to fumes.

V. Procedure

A. Aggregate Composition
   1. Dry aggregate samples, including RAP if used, to a constant weight in accordance with DOTD TR 403.
   2. Composite by weight and thoroughly mix aggregates to manufacture a minimum of nine individual briquettes in accordance with the proposed job mix formula (JMF) composite gradation.

B. Additive Preparation
   1. Anti-strip Additive

Note B-1: *Anti-strip additive and asphalt cement are not to be mixed and heated more than one hour prior to producing the trial mixture. If more than one hour elapses between mixing and using the anti-strip additive and asphalt cement, a fresh anti-strip additive/asphalt cement blend must be prepared.*

   a. Heat a sufficient quantity of asphalt cement for one batch of mixture to 163 ± 3°C (325 ± 5°F) in a loosely covered 2 L (1 qt) can.
   b. Add 0.1% greater than the minimum quantity of anti-strip additive established by DOTD TR 317 and immediately mix for approximately two minutes. Use the stirrer and keep it approximately 25 mm (1in.) from the bottom of the container.

Note B-2: *Additional anti-strip additive or hydrated lime additive may be needed to meet the requirements of DOTD TR 322.*

   c. Place the asphalt cement and anti-strip additive mixture in the oven at a temperature of 163 ± 3°C (325 ± 5 F) and maintain this temperature until the mixture is used.

2. Dry Hydrated Lime Additive
   a. When hydrated lime additive is added dry, place the dry composited aggregate in a mixing bowl.
   b. Add 7% water by weight to the composited aggregate. Mix thoroughly until the aggregate is uniformly wet.
   c. Add the quantity of lime from the proposed JMF to the wet aggregate in the mixing bowl and mix thoroughly until the aggregate is uniformly coated with lime.
   d. Dry the mixture in the oven to a constant weight in accordance with DOTD TR 403.

3. Hydrated Lime Slurry
   a. When hydrated lime is added as a slurry, place the composited aggregate in a mixing bowl.
   b. Form a slurry of hydrated lime and water in the ratio of one part lime to two parts water.
   c. Continually stir the resulting slurry until it is used.
   d. Add the slurry to the composited aggregate, using the quantity of lime from the proposed JMF, in the mixing bowl.
   e. Thoroughly mix the lime slurry and aggregate until the aggregate is uniformly coated with lime.

f. Dry the mixture in the oven to a constant weight in accordance with DOTD TR 403.

C. Trial Mixtures

1. Approximately three hours prior to planned mixing time, heat the composited aggregate to the proposed JMF optimum mixing temperature.
2. Determine by weight the correct quantity of asphalt cement to be added to one portion of the composite aggregate to yield a mixture at the estimated optimum asphalt content.
3. Form a crater in the composited aggregate, then place the container with the aggregate on a tared scale. Add the quantity of asphalt cement/ anti-strip additive blend, prepared in step A.2, by pouring it into the crater.
4. Mix immediately with either the mechanical mixer or by hand until the asphalt cement uniformly coats the aggregate. Place the mixture in the oven set at optimum compaction temperature for 60 ± 5 min.
5. Remove the mixture from the oven.
6. Remix. Place, tamp and shape the mixture in the Marshall mold in accordance with DOTD TR 305.
   a. For mixtures with nonabsorptive aggregates, place the molds with material into the oven for 30 ± 5 min at the optimum compaction temperature.
   b. For mixtures with absorptive aggregates, place the molds with material into the oven for 60 ± 5 min at the optimum compaction temperature.
7. Repeat steps 2 - 6 until there are at least 3 briquettes per asphalt cement content.

Note B-3: *If the optimum compaction temperature of the mixture is not known, set the oven to 150°C (300°F).*

Note B-4: *When absorptive aggregate is used, an increase in the oven time is necessary to ensure an adequate, uniform asphalt coating after absorption has occurred.*

8. Remove one mold with material from the oven and immediately compact and test each briquette in accordance with DOTD TR 305 and TR 304. Repeat for each mold with material.

Note B-5: *Do not allow the time elapsing from the removal of the mold with material from the oven to the first blow of the compaction hammer to exceed one minute.*

9. Calculate and record the test results on the Asphaltic Concrete Mix Design Worksheet.
10. When absorptive aggregates are used, determine the %VFA using the effective asphalt content determined in accordance with DOTD TR 320. Record the specific gravity of the briquettes to the nearest 0.001.
11. Average the test values for the three briquettes and record on the Asphaltic Concrete Mix Design Worksheet. When the specific gravity of a briquette varies from the average by more than ±0.020, obtain fresh aggregates, asphalt cement, and additives, remold and retest the set of briquettes at that asphalt content.
12. Plot the averaged test values for each design parameter shown on the Optimum Asphalt Cement Content - Summary of Test Properties.
13. Repeat steps V.A-C at a minimum of two other asphalt cement contents.

To achieve a valid determination of optimum asphalt cement content, produce one mixture at an asphalt cement content at 0.5% above the estimated optimum; produce the other mixture at an asphalt cement content at 0.5% below the estimated optimum. Additional mixtures at other altered asphalt cement contents shall be produced when one of the asphalt cement contents chosen is less than ±0.3% of optimum and is the only point on the high or low side of optimum.

14. Using an engineering curve, connect each series of plotted points on the Optimum Asphalt Cement Content - Summary of Test Properties.
15. Determine and mark the percent optimum asphalt cement to the nearest 0.1% for the percent air voids at the midpoint of the specification range for the type of mixture. Optimum asphalt content for the type of mixture is the asphalt content corresponding to the air voids at the midpoint of the specification range.
16. Determine and mark the following test properties at the optimum asphalt content.
    a. %VMA - must be above specification minimum.
    b. Percent voids filled with asphalt - must be in specification range.
    c. Stability - must be above specification minimum.
    d. Flow - must be within specification range.

    When %VMA, %VFA, stability or flow do not meet specification requirements at optimum asphalt content, a new composite aggregate gradation shall be used with a new optimum asphalt content.

VI. Report

Record the optimum asphalt cement content to the nearest 0.1% on the Optimum Asphalt Cement Content-Summary of Test Properties and on the proposed Asphaltic Concrete Job Mix Formula.

VII. Normal Test Reporting Time

Normal test reporting time is 1 day.