Chapter 2A

Design and Control of Hot-Mix Asphalt (HMA) Mixtures Using the Superpave Asphalt Mixture Design and Analysis System

1. General Scope

The Department has established procedures for the design and control of hot-mix asphalt (HMA) based on the Superpave Asphalt Mixture Design and Analysis System. Superpave (Superior Performing Asphalt Pavements) is the end result of the Strategic Highway Research Program’s (SHRP) $50 million investment in asphalt-related research. Unlike the empirical Marshall mix design system, Superpave is a comprehensive method, based on performance characterizations tailored specifically to project traffic, environment, and structural section. Since Superpave considers the interaction of traffic, climate, and pavement structure within the paving mix, the mix design and structural design are truly better integrated into a single system. There are three main components to the system; the performance graded asphalt binder specification, the Superpave volumetric mix design procedures, and the additional mix testing and analysis. The purpose of these procedures is to provide uniform guidance in the use of a more complex and currently incomplete, performance-related design system for Department work.

Currently, the Superpave asphalt binder specification and the Superpave volumetric mix design procedures are available and will be used by the Department. The additional mix testing and analysis is currently not ready for Department use. Nationally, the additional mix testing and analysis is still undergoing research refinements, validation work, and the development of performance models. Once completed, the additional mix testing and analysis will provide performance predictions of mixture designs. These predictions can then be used to enable the Department to specify hot-mix asphalt pavements with greater confidence that the mix will perform well for defined traffic and climate conditions over realistic and planned life cycles.

The Department will follow the Superpave mix design procedure and Superpave specifications contained in the Standard Practice for Superpave Volumetric Design for HMA (AASHTO R 35) and Standard Specification for Superpave Volumetric Mix Design (AASHTO M 323) except as revised herein. All AASHTO standard practices, specifications and test procedures are implied to reference the most current approved and published version available at the time of project bid letting.

2. Department Revisions to AASHTO R 35 - Standard Practice for Superpave Volumetric Design for HMA

AASHTO R 35, Section 3. Terminology

*Revise Section 3 by adding new Subsections as follows:*

3.13 Durability - a measure of resistance to disintegration by weather or traffic conditions. The most important factor with respect to durability is the amount of binder. An HMA mixture is resistant to action of air and water in direct proportion to the degree that they are kept out of the mix. It is desirable that the mix should contain
as high a binder content as is consistent with balanced strength, strain, and voids for the expected life cycle of traffic load and environmental factors. This can be achieved with high voids in the mineral aggregate (VMA). This will give the pavement maximum durability and prevent raveling because of a deficiency of asphalt binder. This binder content is referred to as the optimum.

3.14 Flexibility - the ability of the HMA mixture to bend repeatedly without cracking and to conform to changes in the base course. To have flexibility, a mix must contain the proper amount of binder. Open-graded mixtures are more flexible than dense-graded mixtures. Also, a mixture consisting of a softer binder grade is more flexible than the same mixture made with a harder binder grade.

3.15 Workability - the property that enables the efficient placement without segregation, and compaction of the mixture. Harsh or stiff mixtures can result from an excess of coarse aggregate, low VMA, low binder content, or an excess of minus 75 μm (No. 200) sieve fraction.

3.16 Friction Number - a measure of the sliding force exerted on a tire when a vehicle’s brakes are locked. HMA wearing courses must have the highest possible friction number obtainable with the combination of aggregates available in the area. The type of coarse aggregate has the greatest effect on friction number. Aggregates which polish rapidly and repeatedly produce low friction numbers before the normal service life is complete should not be used. An excessive binder content can produce a flushed surface resulting in low friction number.

3.17 Superpave Gyratory Compactor (SGC) - a mechanical compaction device used to mold and compact 150 mm (6 inch) diameter mixture specimens. It compacts the specimens using a loading ram which applies a loading pressure of 600 kPa to the specimen. The mold is held at an angle during compaction. The SGC gyrates the specimen during compaction at a constant speed of 30 revolutions per minute. The complete test procedure is found in AASHTO T 312.

3.18 Initial number of gyrations ($N_{ini}$) - the number of gyrations applied by the SGC to the mixture specimens early in the compaction process and is generally considered useful in identifying tender or poorly graded mixtures which may compact too readily or mixtures that are too harsh and require excessive compactive effort in the field.

3.19 Design number of gyrations ($N_{des}$) - the number of gyrations, which when applied to the design mixture specimens, results in 4.0 percent air voids and determines the design asphalt content if $N_{ini}$ and $N_{max}$ requirements are satisfied. This compaction level is generally considered to represent the pavements expected air void content several years after construction, assuming the correct traffic level and climate are accounted for in design. It is also used to select the design asphalt content.

3.20 Maximum number of gyrations ($N_{max}$) - the maximum number of gyrations applied during the SGC compaction cycle and represents the maximum level the mix is expected to compact to in the pavement assuming the correct traffic level and climate are accounted for in design. The maximum density requirement at $N_{max}$ insures that the
mix will not compact excessively under the design traffic, become plastic, and produce permanent deformation. The air voids content must be 2.0 percent or greater.

AASHTO R 35, Section 4. Summary of the Practice

Revise Subsection 4.1 by adding the following to Note 3:

When using RAP or manufacturer waste Recycled Asphalt Shingles (RAS), the Department’s modified design procedures (See Appendix H) shall be followed exclusively.

Revise Subsection 4.2 by adding the following to Note 4:

Also, other recognized procedures may be used to select trial blends or recommend a design aggregate structure. One such method is the “Baily Method for Gradation Selection in Hot-Mix Asphalt Mixture Design,” by W.R. Vavrik, G. Huber, W.S. Pine, S.H. Carpenter and R. Baily. Transportation Research Circular E-C044, October 2002. Copies may be obtained by contacting National Research Council, Business Office, 500 Fifth Street, N.W. Washington D.C. 20001. Tel: (202) 334-3213 or email TRBsales@nas.edu. This publication is also available on the Internet at http://www.trb.org and following the links for “Online Documents” and “E-Circulars” and then locating E-Circular 44.

Revise Subsection 4.4 as follows:

In the first sentence, change the reference for how the mixture is conditioned from “mixture conditioning for the volumetric mixture design procedure in R 30” to “the revised mixture conditioning for volumetric mixture design and production quality control testing time (Appendix I herein) plus an additional 2 hours”

Also, add the following to the end:

If visual stripping of the asphalt film is observed from the T 283 specimens and estimated to be 5% or greater of the specimen face area, further evaluate moisture susceptibility by performing test procedure ASTM D 3625 (Boiling Water Test). (Uncoated areas due to fractured aggregate should not be recorded as stripped). When asphalt binder coating is less than 95%, as determined by ASTM D 3625, retest the mixture in accordance with Section 11. All collected specimens and test data should be carefully reviewed prior to determining acceptability. If there is any doubt concerning the mixtures susceptibility, the recommended approach is to consider the mix moisture susceptible.

Revise Section 4 by adding a new Subsection as follows:

4.5 Review of Job-Mix Formula (JMF) - The contractor will be solely responsible to design a mix that meets all Department requirements. The contractor will submit the required test results, the composition of the mixtures and the combined aggregate gradation curves proposed for use in the production of base, binder, and wearing courses, to the District Materials Manager/Materials Engineer (DMM/DME) for review
at least three weeks prior to the scheduled start of work. Submit mix designs to the DME/DMM for review following the procedures outlined in Appendix J. The acceptability of the bituminous concrete produced from any mix design is determined as specified in Publication 408, Section 409 in addition to the criteria specified herein.

Whenever the Contractor’s gradations and calculations do not check, the DMM/DME shall request the Contractor to do additional testing and/or recalculate and submit the correct mathematical solutions. The DMM/DME may request, at his option, to observe testing of the trial mix. He may also request that materials be submitted to the Materials and Testing Division (MTD) for evaluation of the mix. The Department reserves the right to review any design through plant production, prior to using for Department work, at no additional cost to the Department. See Department Revisions to AASHTO R 35, Section 12 (page 2A-9) for Evaluating Mix Characteristics. Also, see Department Revisions to AASHTO M 323 Section 7 (page 2A-14) for a recommended procedure for the statistical evaluation of a JMF through plant production.

**AASHTO R 35, Section 6. Preparing Aggregate Trial Blend Gradations**

*Revise Subsection 6.1 completely as follows:*

6.1 Select Performance Graded Binders (PG-Binders) as specified in the project Contract, meeting the requirements of AASHTO M 320, except as revised in the applicable sections of Department Publication No. 37 (Bulletin 25). Obtain material from currently approved producers and sources listed in Department Publication No. 35 (Bulletin 15). If 16% or more RAP is included in the mixture or, if 5% or more RAP and 5% RAS is included in the mixture, adjust the PG-Binder grade if necessary in accordance with the requirements of Appendix H and only as recommended by the MTD.

If two or more mixtures are specified in one project Contract with all things being equal (nominal maximum aggregate size of mixture, ESALs, SRL) except the specified grade of PG-Binder, it is permitted to fully design one of the specified mixtures with one of the specified PG-Binders and then make three specimens in accordance with T 312 at the same JMF asphalt content for the other PG-Binder(s). If the average volumetric properties of the three specimens, such as, air voids at $N_{ini}$, $N_{des}$ and $N_{max}$, VMA, and VFA meet the specified Superpave volumetric properties, use the same asphalt content for the other PG-Binder(s). However, evaluate the mixtures using the different grades of PG-Binders for moisture susceptibility in accordance with AASHTO R 35, Section 11 and as modified herein. If the average volumetric properties of the three specimens do not meet the specified Superpave volumetric criteria, proceed to the following paragraph.

If two or more mixtures are specified in one project contract with all things being equal (nominal maximum aggregate size of mixture, ESALs, SRL) except the specified grade of PG-Binder and the average volumetric properties do not meet the specified Superpave volumetric properties as determined by the procedure in the preceding paragraph, optimum asphalt content must be determined for each grade of PG-Binder.
Using the same combined gradation of the aggregate, follow the procedure outlined in AASHTO R 35 Section 10.

**Revise Subsection 6.4 and 6.5 as follows:**

Change reference of T 27 to PTM No. 616 and reference of T 11 to PTM No. 100.

**Revise Subsection 6.6 by adding the following to the end:**

Determine the Apparent Specific Gravity of mineral filler, if added separately (T 133). At least three determinations should be made and the average value used.

**Revise Subsection 6.8 by adding the following to the end:**

See Note 4 and Department Revisions to Note 4 concerning trial blends. The DME/DMM may, at their discretion, eliminate the need for three trial blends based on a Producer’s previous Superpave mix design work with specific aggregate blends. When preparing trial blends, vary the primary control sieve (PCS) on each trial blend by 4 to 5%.

**Note 5A** - M 323, Table 3 is incorrect and the Department revised the table by changing “Max. 90" for the first sieve size smaller than the nominal maximum aggregate size for each gradation to “Max. 89". This change is more consistent with the definition as stated in Subsection 3.10. (See Department Revisions to AASHTO M 323, Section 6.1.2 Table 3). Also see Note 4.

**Revise Subsection 6.9 by adding the following to the end:**

Source property of Toughness (Abrasion) has been added to aggregate requirements (See Department Revisions to AASHTO M 323, Section 6 - Combined Aggregate Requirements).

**Revise Note 6 by adding the following to the end:**

It is recommended to perform the fine aggregate quality tests on the combined aggregate trial blend and not estimate the fine aggregate quality tests mathematically from quality tests on each fine aggregate stockpile.

**AASHTO R 35, Section 7. Determining an Initial Trial Binder Content for Each Trial Aggregate Gradation**

**Replace Note 7 with the following:**

When using RAP, RAS or a combination of RAP and RAS, the Department’s modified design procedures (see Appendix H) shall be followed exclusively.
AASHTO R 35, Section 8. Compacting Specimens of Each Trial Gradation

Revise the Section 8, Table 1 Row for Design ESALs ≥30 Million and Columns for Compaction Parameters as follows:

Table 1 – Superpave Gyratory Compaction Effort

<table>
<thead>
<tr>
<th>Design ESALs (Millions)</th>
<th>Compaction Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N_{\text{initial}}$</td>
</tr>
<tr>
<td>≥30</td>
<td>8</td>
</tr>
</tbody>
</table>

Replace Subsection 8.2 with the following:

Condition the mixtures according to Bulletin 27, Appendix I, and compact the specimens to $N_{\text{design}}$ gyrations in accordance with T 312. Record the specimen height to the nearest 0.1 mm after each revolution.

Replace reference to AASHTO T 166 with PTM No. 715, typical throughout.

Replace reference to AASHTO T 275 with PTM No. 716, typical throughout.

Revise Subsection 8.3 by adding the following to the end:

In the event a discrepancy occurs between lab test data, PTM No. 715, Method A will be the referee method. Notes 9 and 10 in reference to Table 1 apply.

AASHTO R 35, Section 10. Selecting the Design Binder Content

Revise Subsection 10.1 by adding the following:

When a design using less than 16% RAP or a design using 5% RAS with no RAP is developed based on a previously approved virgin aggregate design of similar composition (gradation, aggregate source, binder content), only specimens with estimated design binder content may be necessary, as directed in the Department’s modified design procedure. (see Appendix H)

Replace Subsection 10.2 with the following:

Condition the mixtures according to Bulletin 27, Appendix I, and compact the specimens to $N_{\text{design}}$ gyrations in accordance with T 312. Record the specimen height to the nearest 0.1 mm after each revolution.

Replace Subsection 10.7.1 with the following:

Condition the mixtures according to Bulletin 27, Appendix I, and compact the specimens according to T 312 to the maximum number of gyrations, $N_{\text{max}}$, from Table 1.
Revise Section 10 by adding the following Subsections:

10.7.3 Prepare replicate (Note 8) specimens composed of the design aggregate structure at the design binder content to confirm that $\%G_{\text{mm, design}}$ satisfies the design requirements in M 323.

10.7.4 Condition the mixtures according to Appendix I, and compact the specimens according to T 312 to the design number of gyrations, $N_{\text{design}}$, from Table 1.

10.7.5 Determine the average specimen relative density at $N_{\text{design}}$, $\%G_{\text{mm, design}}$, by using Equation 15A, and confirm that $\%G_{\text{mm, design}}$ satisfies the volumetric requirement in M 323.

$$\%G_{\text{mm, design}} = 100 \frac{G_{\text{mb}}}{G_{\text{mm}}} \quad (15A)$$

Where:
$\%G_{\text{mm, design}} =$ relative density at $N_{\text{design}}$ gyrations at the design binder content.

10.7.6 Place each replicate specimen gyrated to $N_{\text{design}}$ on a separate pan and place each pan in an oven set at the midpoint of the minimum and maximum mixture temperature range for the PG Binder Grade. Heat each specimen until it is sufficiently soft to separate with a spatula or trowel. Warm the asphalt mixture until it can be handled or mixed. Determine the asphalt content and gradation of each specimen according to PTM No. 757 or PTM No. 702 and PTM No. 739. Compare the gradation of each specimen to the original gradation of the prepared specimens and the JMF. If the gradation of the specimen is not within the single and multiple sample tolerances of Pub. 408, Section 409, Table A, when compared to the JMF, either the specimens were not prepared with enough precision to properly represent the JMF or, significant breakdown of the aggregate has occurred during laboratory compaction if a finer gradation is determined.

If it is determined that the sample preparation was not precise, repeat Section 10 starting at Section 10.7.3 until precision is obtained with each specimen meeting the multiple sample tolerances in Pub. 408, Section 409, Table A. If it is determined that the sample preparation was not precise, review laboratory procedures to ensure specimen preparation is precise and repeat any work where precision was not maintained.

If it is determined that the laboratory compaction resulted in breakdown of the aggregate and the gradation after compaction no longer meets the single and multiple sample tolerances of Pub. 408, Section 409, Table A, the mixture should be considered suspect. Either the aggregate structure of the mixture results in a “harsh” mixture that is not conducive to compaction or the aggregate quality is poor. Harsh mixtures should be redesigned to make them more workable. Poor quality aggregates should be investigated in cooperation with the District and not used until the investigation is completed.
Revise Section 11 by adding Notes as follows:

Note 17A - It has been shown that the chemical composition of asphalt binders, aggregates and any mixture additives can have a strong influence on the results obtained from these testing procedures. Therefore, it is recommended that the sources of materials (binder and additives) used in the design process be the same as the materials that will be incorporated in the mixture during production. If either of these components change at the time of production, the actual production mixture must be verified by retesting, initially with ASTM D 3625 (Boiling Water Test) as a screening test. Otherwise, the design testing may not be representative.

Note 17B – If multiple mix designs use the same aggregate combination and the same PG binder but differ in optimal asphalt content, the DMM/DME may elect to require moisture susceptibility evaluation of only the mix with the lowest asphalt content. The “same aggregate combination” can be defined as mix designs with gradation targets differing by less than the multiple sample tolerances of Publication 408, Section 409, Table A.

Revise Subsections 11.1 and 11.2 completely as follows:

11.1 Prepare at least six mixture specimens (half to be tested dry and the other half to be tested after partial saturation and freeze-thaw conditioning) composed of the design aggregate structure at the design binder content. Condition the mixtures in accordance with the revised mixture conditioning for volumetric mixture design and production quality control testing time (Appendix I herein) plus an additional 2 hours. After conditioning, compact the specimens to 7 ± 0.5 percent air voids in accordance with T 312.

11.2 Test the specimens within 24 hours of completion of T 312 in accordance with T 283, starting with Section 9.6 of the procedure with the following exceptions:
   (a) Revise T 283, Section 10.3.1 vacuum application time to apply a vacuum of 254 mm (10 in.) mercury partial pressure for 30 minutes to the conditioned specimens, regardless of air voids and percent final saturation (See Note 17C).
   (b) Delete T 283, Sections 10.3.5 and 10.3.6

Note 17C – The following table explains the proper vacuum settings and readings.

<table>
<thead>
<tr>
<th>Vacuum Gauge Type</th>
<th>Measurement Scale</th>
<th>Vacuum Reading with No Vacuum Applied</th>
<th>Vacuum Reading with Proper Vacuum Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial</td>
<td>Inches of Mercury</td>
<td>0 (Zero)</td>
<td>10</td>
</tr>
<tr>
<td>Partial</td>
<td>mm of Mercury</td>
<td>0 (Zero)</td>
<td>254</td>
</tr>
<tr>
<td>Absolute</td>
<td>Inches of Mercury</td>
<td>Approximately 29.9</td>
<td>19.9</td>
</tr>
<tr>
<td>Absolute</td>
<td>mm of Mercury</td>
<td>Approximately 760</td>
<td>506</td>
</tr>
</tbody>
</table>
Calculate the average ($\bar{x}$) and standard deviation ($s$) of tensile strengths for both the dry group of specimens and the freeze-thaw group. Calculate the Coefficient of Variation (C.V.) for each group by dividing the standard deviation by the average:

$$C.V. = \frac{s}{\bar{x}} \%$$

If the C.V. is greater than 12% for the dry group, or 24% for the freeze-thaw group, the test results should be viewed as suspect and a new subset of specimens prepared and tested.

If only one of the results is suspect and analysis according to PTM No. 4 identifies that result as an outlier, a replacement is initially only required for that specimen. If the C.V. considering the replacement specimen in place of the outlier is still greater than the acceptable limit, prepare and test an entire subset of new specimens. Each group of specimens, dry or freeze-thaw, is defined as a subset.

**Revise Subsection 11.3 by adding the following:**

If the average dry strength for mixtures containing PG 64-22 or PG 76-22 is less than 80 psi (552 kPa) or the average dry strength for mixtures containing PG 58-28 is less than 65 psi (448 kPa), the mix is unacceptable. Any mixture containing PG 58-28, PG 64-22 or PG 76-22 with average wet/freeze strength less than 50 psi (345 kPa) is unacceptable.

**AASHTO R 35, Section 12. Adjusting the Mixture to Meet Properties**

**Revise Subsection 12.1 by adding the following to the end:**

See Department Revisions to AASHTO R 35, Subsection 4.2, Note 4. The suggested reference may assist in adjusting the aggregate skeleton.

**Revise Section 12 by adding the following new Subsections:**

12.4 Evaluating Mix Characteristics - Although a mix may satisfy all the Superpave volumetric design criteria at design asphalt binder content, it may be unacceptable because of the following considerations:

12.4.1 Britteness - Mixes with abnormally high values of Tensile Strength and abnormally high binder stiffness values due to thin apparent asphalt film thickness (low binder content) are undesirable because pavements of such mixes tend to be more rigid or brittle and may crack under heavy volumes of traffic. This is particularly true where base and subgrade deflections are such as to permit moderate to relatively high deflections of the pavement. As a guideline to ensure there is sufficient asphalt binder in the mixture, calculate the apparent asphalt film thickness according to the procedure in the reference book entitled Hot Mix Asphalt Materials, Mixture Design and Construction, TB-1, Second Edition, 1996 by Roberts, Kandhal, et al. and available through the National Asphalt Pavement Association (NAPA), as part of the mix design process. As a guideline, mixtures with a calculated apparent asphalt film thickness ranging from 9 to 12 microns
should provide enhanced durability. If the calculated apparent asphalt film thickness is not within the guideline range, the mixture's other properties should be further scrutinized to ensure mixture durability. Apparent asphalt film thickness should not be used as the sole parameter to reject the mixture. Adjustments in the aggregate gradation [particularly the percentages passing the 2.36 mm and 75 μm (No. 8 and No. 200) sieves] should be made to increase the VMA so that more asphalt can be incorporated in the mix. This may be done by deviating further from the maximum density line (Fuller’s curve). If the minus 75μm (No. 200) sieve content is high, a reduction in this fraction will increase the aggregate voids.

12.4.2. Mixture Volumetric Properties Sensitivity to Asphalt Binder Content - Some mixes, such as mixes with aggregate gradation close to the maximum density line (Fuller’s curve), are very sensitive to slight variations in asphalt content. If a +/- 0.5% change in asphalt binder content relative to the estimated design content (see Section 10) results in VMA outside the criteria in AASHTO M 323, Table 6, or voids that are outside of the Department’s production specifications (Publication 408, Section 409) the mix should be considered suspect. If a mix changes from dry to gummy with a 0.5% increase in the asphalt content, the mix should also be considered suspect. Such mixes may be reduced in sensitivity by adjustments to the aggregate gradation, usually by deviating further from the maximum density line.

12.4.3. Tenderness - These mixes tend to pull and shove during the compaction operation resulting in hairline cracking, usually consisting of transverse hairline cracks several inches apart, sometimes accompanied by longitudinal cracking. A poor aggregate gradation often is a leading contributor to tender (slow-setting) or unstable mixes. Tender mixes are frequently typified by the following:

(a) An excess of the middle-size fraction in the material passing the 4.75mm (No. 4) sieve. A hump in the grading curve caused by the excess sand could appear on nearly any sieve below the 4.75 mm (No. 4) sieve and above the 150 μm (No. 100) sieve. This condition is most critical when occurring near the 600 μm (No. 30) sieve. A change in the gradation of the fine aggregate(s) is necessary to remove the hump.

(b) Close proximity of the aggregate gradation to the maximum density line and/or major portion of gradation line relatively straight. These mixes generally have low VMA. Some easily compactable gravel mixes attain the desired maximum density (lowest possible VMA) with one or two passes of the roller, and then start to decompact and deform. A change in the gradation of the mix may be necessary to alleviate this situation.

12.4.4. Poor Handling and/or Constructability Characteristics. Such mixes are difficult to handle from production to field application without segregating and/or difficult to achieve acceptable and uniform compaction. Often these mixes have aggregate gradations that are not uniform or have characteristics as stated previously. Avoiding humps and gaps in gradation typically corrects this condition. Otherwise, aggregate shape and texture characteristics should be investigated. Plant produced materials should be sampled and evaluated relative to design values, if
production material variability is suspected. Evaluate apparent asphalt film thickness as directed in 12.4.1 and compare to design values.

AASHTO R 35, Section 13. Report

Revise Section 13 by adding new Subsections as follows:

13.5 Report the JMF and plot the mixture gradation on the most current Form TR-448A or on a form acceptable to the Department. Provide all design laboratory test results for review by the Department.

13.5.1 As part of the JMF report, the Producer is to provide the ignition furnace correction factors for percent asphalt binder (Cf) and for percent passing the 75 µm (No. 200) sieve (200 Cf) for the JMF. Determine these correction factors according to PTM No. 757 and document the process on the form included in the Electronic State Book (ESB) or on another form provided by the Department. Include this form as part of the JMF documentation submitted to the Department for review. The HMA Producer is responsible for determining the frequency or identifying the criteria that triggers when they determine new or revised ignition furnace correction factors for each JMF. The ignition furnace correction factor documentation submitted as part of the JMF report is to be the HMA Producer’s correction factors that they determined best represent the current raw material components of the JMF and current compositional targets of the JMF.

13.5.2 If ignition furnace correction factors cannot be determined for percent asphalt binder or for percent passing the 75 µm (No. 200) sieve due to potential problematic aggregate conditions in the JMF, the HMA Producer must immediately notify the District Materials Engineer/Manager, and as part of the JMF submission, submit a request to change the test method from PTM No. 757 to PTM No. 702, Modified Method D with comprehensive documentation supporting that problematic aggregates may exist for the JMF. Upon District review of the comprehensive documentation, witnessing the HMA Producer’s attempt to determine ignition furnace correction factors, and concurrence that a potential problematic aggregate condition exists, the District will submit all the comprehensive documentation to the MTD. The MTD will make the final determination if problematic aggregates exist. The MTD, at its discretion, may request samples of the problematic aggregates for testing and verification of the potential problematic aggregate condition.
3. Department Revisions to AASHTO M 323 - Standard Specification for Superpave Volumetric Mix Design

AASHTO M 323, Section 4. Significance and Use

_Revise Section 4 by adding the following to the end:

Under the Department’s Research initiative, currently referred to as Superpave Special Studies or Superpave Validation Studies, and with the approval of the Asphalt Paving Quality Improvement Committee, this standard and specified requirements, in part or whole, may be revised.

AASHTO M 323, Section 5. Binder Requirements

_Revise Section 5 completely as follows:

Delete M 323, Tables 1 and 2. Requirements are as previously specified in the Department Revisions to AASHTO R 35, Subsection 6.1 and Department Publications 242 (Chapter 5.8) and Bulletin 25. Adjustments made for RAP, RAS or a combination of RAP and RAS usage will be in accordance with the Department’s requirements found in Appendix H.

AASHTO M 323, Section 6. Combined Aggregate Requirements

_Revise Subsection 6.1.2 by revising the referenced Table 3 as follows:

<table>
<thead>
<tr>
<th>Table 3 - Aggregate Gradation Control Points</th>
<th>Nominal Maximum Aggregate Size - Control Point (Percent Passing)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37.5 mm</td>
</tr>
<tr>
<td>50.0 mm</td>
<td>100</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>90</td>
</tr>
<tr>
<td>25.0 mm</td>
<td>--</td>
</tr>
<tr>
<td>19.0 mm</td>
<td>--</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>--</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>--</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>--</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>15</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>0</td>
</tr>
</tbody>
</table>

* The maximum percent passing on these sieves have been revised from the Table 3 in AASHTO M 323 to better conform with the written definition of the nominal maximum aggregate size provided in AASHTO R 35 Section 3.10. (Refer to Department Revisions to AASHTO R 35, Subsection 6.8, Note 5A)
Delete Subsection 6.1.3 completely.

Revise Subsection 6.6 completely as follows:

Refer to the Department’s modified design procedures and requirements (see Appendix H) when RAP, RAS or a combination of RAP and RAS is used in the mixture.

Revise Section 6 by adding a new Subsection as follows:

6.7 Toughness Requirements, Coarse Aggregates - The aggregates shall meet the abrasion requirements specified in Table 5A. The percentage of weight loss will be determined in accordance with AASHTO T 96.

<table>
<thead>
<tr>
<th>Estimated Traffic (million ESALs)</th>
<th>Abrasion (Maximum % Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;3</td>
<td>45</td>
</tr>
<tr>
<td>3 to &lt; 30</td>
<td>40</td>
</tr>
<tr>
<td>≥30</td>
<td>35</td>
</tr>
</tbody>
</table>

Revise the Section 6 Table 5 Row for Design ESALs ≥30 Million and Columns for Fractured Faces, Coarse Aggregate, Percent Minimum as follows:

<table>
<thead>
<tr>
<th>Design ESALs&lt;sup&gt;a&lt;/sup&gt; (Million)</th>
<th>Fractured Faces, Coarse Aggregate, Percent Minimum</th>
<th>Depth from Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥30</td>
<td>≤ 100 mm</td>
<td>95/90</td>
</tr>
<tr>
<td></td>
<td>&gt; 100 mm</td>
<td>95/90</td>
</tr>
</tbody>
</table>

AASHTO M 323, Section 7. HMA Design Requirements

Revise Subsection 7.1 by adding the following to the end:

“and as modified herein.”
Revise the Subsection 7.2, Table 6 Rows for All Design ESALs and Columns for Voids in the Mineral Aggregate (VMA) Percent Minimum and Columns for Voids Filled with Asphalt (VFA) and Revise and Add Table Footnotes as follows:

Table 6 – Superpave HMA Design Requirements

<table>
<thead>
<tr>
<th>Design ESALs&lt;sup&gt;a&lt;/sup&gt; (Million)</th>
<th>Voids in the Mineral Aggregate (VMA), Percent Minimum</th>
<th>Voids Filled with Asphalt (VFA) Range,&lt;sup&gt;b&lt;/sup&gt; Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.3</td>
<td>11.5, 12.5, 13.5, 14.5, 15.5, 16.0</td>
<td>70-78</td>
</tr>
<tr>
<td>0.3 to &lt;3</td>
<td>11.5, 12.5, 13.5, 14.5, 15.5, 16.0</td>
<td>65-78</td>
</tr>
<tr>
<td>3 to &lt;10</td>
<td>11.5, 12.5, 13.5, 14.5, 15.5, 16.0</td>
<td>65-75&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>10 to &lt;30</td>
<td>11.5, 12.5, 13.5, 14.5, 15.5, 16.0</td>
<td>65-75&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>≥30</td>
<td>11.5, 12.5, 13.5, 14.5, 15.5, 16.0</td>
<td>65-75&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> For 37.5-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 64 percent for all design traffic levels. For 25.0-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 66 percent for all design traffic levels. For 19.0-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 69 percent for all design traffic levels. For 12.5-mm nominal maximum aggregate size mixtures, the specified lower limit of the VFA range shall be 71 percent for all design traffic levels.

<sup>b</sup> Delete this footnote.

<sup>c</sup> For design traffic levels > 3 million ESALs, 9.5-mm nominal maximum aggregate size mixtures, the specified VFA range shall be 73 to 76 percent and for 4.75-mm nominal maximum aggregate size mixtures shall be 75 to 78 percent.

Revise Section 7 by adding the following new Subsections to the end:

7.4 Approved Job-Mix Formula - The JMF is developed specifically for the plant from the reviewed laboratory design. This may require small adjustments to fit the plant and thus ensure production within the tolerance limits. The selected laboratory design must be reproducible within the tolerances specified in Publication 408, Section 409. This design, when verified and proven in production by the process described in Publication 408, Section 409.2 can then be considered an approved JMF as long as the mix characteristics are satisfactory during construction and the material sources, aggregate gradations, asphalt content and test values remain within the specifications and design tolerances. If initial JMF verification is unsuccessful, the following process is recommended for statistical evaluation of the JMF:

7.4.1 Statistical Evaluation of JMF Production

(a) The contractor must evaluate the JMF based on a minimum of three (preferably five) random samples taken from a single day’s plant production using PTM No. 1.

(b) Evaluate the mix composition (gradation and asphalt binder content) for conformance to Publication 408, Section 409.2, Table A. Using the procedure described in Publication 408, Section 106.03, calculate a PWL for asphalt binder content (Pb), percent passing the 2.36 mm (No. 8) sieve,
and percent passing the 75 μm (No. 200) sieve relative to the target values in the JMF. If the resulting PWL for each parameter is 85% or greater, the plant’s process control and blending of mixture components is considered satisfactory. If the resulting PWLs are less than 85%, the mix composition’s reproducibility is inadequate; take corrective action at the plant to obtain the desired mix composition and then re-evaluate the mix.

c) Evaluate the mixture maximum specific gravity (Gmm) and VMA in accordance with Appendix I. Evaluate VFA and the F/A ratio for conformance to AASHTO M 323, Table 6 and voids for conformance to the Department’s production specifications.

d) If the mix composition conforms to the JMF but the volumetric data do not meet the above criteria, perform additional testing of each material component in the mix for change in properties and/or verify all test equipment is in proper working order, calibrated within specifications, and test procedures are performed properly. Provide a summary report which includes findings and recommendations to the DMM/DME for review prior to performing any work with such a design.

7.5 Quality Control Requirements for Mix Designs During Production - Prepare and Submit a QC Plan to the DMM/DME for review and approval as specified in Chapter 1, Section 2.1 and Publication 408, Section 409.2. Perform all tests as required therein at the frequencies specified. Control and documentation of Gmm and volumetric properties during production shall be performed as specified in Appendix I.

7.5.1 Ignition Furnace Correction Factors. As part of the HMA Producer’s QC plan, it is the HMA Producer’s responsibility to regularly monitor and maintain their ignition furnace correction factors to ensure that the correction factors represent the raw material components of the JMF and the JMF compositional targets. The HMA Producer is responsible for determining the frequency of when they monitor, review, or check their ignition furnace correction factors for each JMF or identifying the criteria that trigger the HMA Producer to monitor, review or check their ignition furnace correction factors for each JMF. It is the HMA Producer’s responsibility to request correction factor changes to the appropriate District Materials Engineer/Manager with documentation supporting the correction factor change.

If an ignition furnace correction factor for asphalt content or percent passing the 75 μm (No. 200) sieve has changed, the HMA Producer shall immediately submit a request to change the correction factors with supporting data and justification to the District Materials Engineer/Manager. HMA Producers must submit requests for correction factor changes in a timely manner so as not to jeopardize the accurate testing of pending acceptance samples. The District may request that MTD suspend testing of samples that have arrived at the MTD dock but have not been tested, until the District reviews and makes a decision on the correction factor change request. The District must also keep all other samples of the JMF still located within the District until a decision has been made on the correction factor change request and may also decide to
suspend shipment of this JMF until a decision has been made on the correction factor change request. This will ensure continued bituminous testing efficiency and testing turnaround time at the MTD.

After reviewing the supporting data, the DMM/DME may grant the request to change the current correction factor(s). Correction factor changes will not be allowed to negate or change a failing acceptance sample test result. In addition, revised correction factors cannot be used for retests. All retests will use the correction factors used on the original mixture acceptance samples. It is imperative for the HMA Producer to notify the District immediately of any issues with correction factors for a particular JMF Year and Number. The District will then immediately notify the MTD Bituminous Lab Manager to stop testing on pending samples for the particular JMF Year and Number. MTD will resume testing of the pending samples upon the District’s review and decision of a HMA Producer’s request for change of a correction factor and the District’s notification to the MTD Bituminous Lab Manager.

7.5.2 Change of Test Method Due to Problematic Aggregates. It is the HMA Producer’s responsibility to monitor and maintain their ignition furnace correction factors to ensure that the correction factors represent the raw material components of the JMF and the JMF compositional targets. This monitoring should be included and managed within a HMA Producer’s Quality Control Plan. If during this monitoring or during the volumetric mix design process, the HMA Producer identifies potential problematic aggregates, the HMA Producer must immediately notify the District Materials Engineer/Manager of the affected JMF numbers and submit a request to change the test method from PTM No. 757 to PTM No. 702, Modified Method D with comprehensive documentation supporting that problematic aggregates may exist for the JMF. Problematic aggregates may exist if one or more of the following conditions exist:

- Sample burn times of a specific JMF extend well beyond normal burn times for similar NMAS mixtures.
- Samples burn continuously for the JMF and the weight never stabilizes.
- Exploding aggregate is noted during testing or aggregate breakdown is noted in the gradation results.
- Asphalt content results are significantly (2% or more) higher than expected, based on plant recordation or solvent extraction results.
- The asphalt correction factor is in excess of 1.0.
- Attempts to establish a stable correction factor according to the method in PTM No. 757 are unsuccessful.

Upon being notified of JMF numbers with potential problematic aggregates, the District Materials Engineer/Manager must immediately notify MTD to suspend testing of samples that have arrived at the MTD dock but have not been tested and potentially contain the problematic aggregate. The District must also keep all other samples of this JMF that
are still located within the District and may also decide to suspend shipment of this JMF until the problematic aggregate issue can be investigated. This will ensure continued bituminous testing efficiency and testing turnaround time at the MTD.

The District will conduct an investigation including a review of the supporting documentation provided by the HMA Producer and witnessing the HMA Producer’s testing of each JMF number to verify one or more of the above problematic aggregate conditions exist. Upon completing its investigation and if the District concurs that potential problematic aggregates exist, the District will submit a written request to change the test method from PTM No. 757 to PTM No. 702 Modified Method D for a JMF to the MTD. The request must include all supporting data to justify the request for a change in test method. The MTD will make the final determination if problematic aggregates exist. The MTD, at its discretion, may request samples of the problematic aggregates for verification testing.

As part of the HMA Producer’s quality control plan, it must periodically test problematic aggregate mixtures to verify that the problematic aggregate conditions continue to exist. If the problematic aggregate conditions cease to exist, the HMA Producer must immediately notify the District Materials Engineer/Manager of the affected JMF numbers and submit a request to change the test method from PTM No. 702 Modified Method D to PTM No. 757 with comprehensive documentation supporting that problematic aggregate conditions no longer exist for the JMF.

The District will conduct an investigation including a review of the supporting documentation provided by the HMA Producer and witnessing the HMA Producer’s testing of each JMF number to verify that problematic aggregate conditions cease to exist. Upon completing its investigation and if the District concurs that problematic aggregates cease to exist, the District will submit a written request to change the test method from PTM No. 702 Modified Method D to PTM No. 757 for a JMF to the MTD. The request must include all supporting data to justify the request for a change in test method. The MTD will make the final determination if problematic aggregates cease to exist. The MTD, at its discretion, may request samples of the problematic aggregates for verification testing.

7.6 Quality Control Requirements for P.G. Binder Supply and Handling During Production

7.6.1 Same grade PG-Binders may be commingled in the same hot mix asphalt producer storage tank only when compatible (i.e., the PG-Binders can become homogeneous through agitation or circulation and remain the same grade of PG-Binder). Before commingling same grade PG 76-22 from different suppliers, or any other modified PG-Binders from different suppliers, producers are to obtain written verification of material compatibility from the approved supplier(s).
7.6.2 Different grade PG-Binders may be commingled in the same hot mix asphalt producer storage tank only when the former PG-Binder is compatible (i.e. the PG-Binder can become homogeneous through agitation or circulation with the different grade PG-Binder) and has been drained as low as practical prior to introducing a different grade PG-Binder. Add a minimum of two full tanker loads (three if feasible) of new different grade PG-Binder, and circulate well before using.

7.6.3 If the storage tank is not dedicated to a specific grade, producers of bituminous mixtures are to maintain a log of shipments or notify the respective DMM/DME when receiving and storing a PG-Binder of a different grade or different modifier.

7.6.4 When a supply change occurs during production, evaluate the mixtures using same grade PG-Binders supplied from a different primary supplier (i.e., Citgo vs. Chevron) for moisture susceptibility in accordance with ASTM D 3625 (Boiling Water Test) as a screening test. When asphalt binder coating is less than 95%, as determined by ASTM D 3625, the mixture shall be retested in accordance with AASHTO R 35, Section 11 and as modified herein. Same grade PG-Binders supplied from different storage facilities or terminals of the same primary source (e.g., Citgo) do not require additional testing unless there is evidence of a problem that may relate to a supply change.

Note 9A- Use of ASTM D 3625 as a screening test is intended as a time saving alternative to be used primarily during high volume production at the HMA facility. If an approved mix design was only tested for moisture susceptibility in accordance with Section 11, using a PG Binder supplied from a different primary supplier, a recommend best practice is to conduct testing according to Section 11 as soon as time permits using the new primary PG Binder Supplier.

7.6.5 Provide Department Quality Assurance (QA) teams P.G. Binder samples as required.

Note 9B- When the purpose of the sample is to verify the quality of the binder being incorporated into a production mix, the preferred location for asphalt sampling at an HMA plant is at the asphalt pump. A sample valve located at the HMA plant asphalt pump guarantees the asphalt QC sample represents the asphalt added to the mix. It is important to note that taking samples from this location requires coordination between the HMA plant operator and the QC person to insure the sample is taken while the plant is producing the mix to be tested. Manufacturers typically provide sample port locations on the piping at the pump. Connection of the sample valve to the pump piping with a very short pipe nipple will keep the valve hot and prevent safety concerns during sampling. The short connection between the sample valve and the asphalt line also can help minimize the amount of waste material required to insure a representative sample. A QC asphalt sample from an HMA plant storage tank indicates if the material in that tank meets the required PG asphalt. It does not insure that valves were set correctly and that this asphalt grade was added to the HMA mix.

7.6.6 Prepare and maintain a QC Plan at each production facility for P.G. Binder including all of the following elements:
1. A schematic drawing showing all tanks, pumps, piping, valves, sampling points and heat system components. Each individual item (tank, valve, etc) should be clearly labeled and/or numbered on the drawing and in the field.

2. Specific procedures for movement of asphalt into and out of each storage tank. The procedures should clearly identify all pumps and valves used for the desired flow of asphalt binder and indicate pump direction and valve positions.

3. Specify sampling location and sampling procedure. The sampling procedure should include the need for any Personal Protective Equipment and safe practices when sampling hot asphalt.

4. Establish storage temperatures for each PG asphalt binder to be stored at the HMA plant. Identify heat system controls and settings to obtain the desired temperatures and institute a monitoring procedure to insure proper temperatures are maintained.
[This page intentionally left blank.]