May 17, 2002

Mr. John C. Horsley
Executive Director
AASHTO
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Suite 225
Washington, DC  20001

Ms. Mary Peters, Administrator
Federal Highway Administration
U.S. Dept. of Transportation
400 Seventh Street, S.W.
Room 4218
Washington, DC  20590

Dear Mr. Horsley and Ms. Peters:

This is the eighth letter report of the Transportation Research Board’s Superpave Committee. The Superpave® system of asphalt paving materials selection and mixture design was initially an outcome of the Strategic Highway Research Program (SHRP). The American Association of State Highway and Transportation Officials and the Federal Highway Administration are engaged in a joint effort to further develop and deploy the Superpave system among transportation agencies. Throughout its existence, the SHRP was guided by a tripartite arrangement among the FHWA, AASHTO, and the National Research Council (NRC). By mutual agreement of the three parties, the NRC, through its TRB Superpave Committee, continues to provide advice and assistance on the conduct of the Superpave deployment and development program.

The eighth meeting of our committee was held on February 25, 2002. The agenda for this meeting featured increased attention to planning for technology transfer activities. This is in keeping with the final goal of our long-range plan. The committee also continued discussion on several items reported in my letter of November 29, 2001. These discussions and related committee recommendations are summarized below. I have enclosed a committee roster (Appendix 1) that indicates those members in attendance at this meeting. You will note from this roster that I was not present at the meeting. Committee member Douglas Rose, Chief Engineer of the Maryland State Highway Administration, took the chair in my stead. The recommendations included in this letter report were developed in a closed session held at the conclusion of the meeting. I have reviewed and concur with these recommendations.

2001 ANNUAL REPORT

I am transmitting with this letter the 2001 annual report of the committee. The committee completed review of this report at our meeting. The annual report conveys accomplishments of FHWA, AASHTO and TRB in meeting the four long-range goals for Superpave development and deployment. The report also details outstanding technical and administrative issues that are
being or should be addressed. Copies of the annual report will be forwarded to members of the AASHTO Highway Subcommittee on Materials (HSOM) for their information.

SUPERPAVE SOFTWARE

At our meeting, two distinct but interconnected discussions of future software development related to Superpave took place. These discussions are summarized below.

If asphalt pavement designs are to achieve predicted performance, key information about the design predictions, conditions of service, and materials properties must be transmitted from each stage in the design and construction process to the next. It is a goal of the Superpave long-range plan to create just such practical linkages among the Superpave system, the asphalt pavement components of the new pavement design guide being developed under the National Cooperative Highway Research Program (NCHRP) Project 1-37a, and the performance-related specifications for hot-mix asphalt construction emerging from NCHRP Project 9-22. As the findings of each of the research efforts will probably be manifested in the form of computer software, it is logical to expect a growing demand for these software programs to be unified or at least work in tandem.

NCHRP projects 1-37a and 9-22 are approaching completion. It seems prudent to the committee that a scoping study be undertaken by FHWA and/or AASHTO to determine the feasibility of linking the various software packages of these efforts with the AASHTO Superpave Software. We further believe that professional software developers should conduct this study rather than pavement researchers -- whose advice, however, should be solicited. The checkered history of the Superpave software, beginning with SHRP, amply demonstrates the pitfalls that can attend software development.

The licensing, technical support, and product maintenance of the AASHTO Superpave software was suspended as of June 30, 2001. This step was taken because license sales were not providing sufficient revenue to meet costs. At that time, AASHTO also instituted a “Superpave Sunset Policy” that preserved the right of access to the program source code by legitimate licensees but otherwise restricted distribution pending thorough consideration of issues related to further development or disposition of the software. Of particular concern to the committee was that premature public access to the software source code might limit future integration of the Superpave software with other emerging hot-mix asphalt pavement design and construction packages being developed as part of the NCHRP research noted above. Public distribution might also confound efforts of the National Academy of Sciences to protect the Superpave trademark from deceptive usage.

When the agenda for our meeting was publicly posted, Dr. Riaz Ahmad, a member of the team that developed the AASHTO Superpave Software, asked to address the committee in public session on the issue of Superpave-related software. He did so as a member of the public and not as a representative of AASHTO. Dr. Ahmad contended that the current AASHTO Superpave software package and with certain changes in functionality, a tool of significant utility to transportation agencies and their asphalt paving contractors and materials suppliers can yet be developed. He proposed that he or other software developers working under license to AASHTO could make these changes and serve highway agencies and the hot-mix asphalt industry as
private entrepreneurs. The committee has no opinion regarding the merits of the specific changes recommended by Dr. Ahmad. After discussion, however, we did conclude that if the current software does have residual value, AASHTO might want to consider licensing third parties to undertake independent development and marketing with certain restrictions. AASHTO should reserve the right to use any modification made by a licensee in future software development such as that described in the discussion above. Also, in marketing the software, licensees should not imply that AASHTO, the FHWA or the National Academy of Sciences has officially endorsed the product.

These suggestions are offered as a way to benefit from the value of investments already made in the development of the Superpave software and to encourage expanded use of the system. We recognize that AASHTO must view this as a business decision with economic consequences and act accordingly.

POTENTIAL AMENDMENTS TO AASHTO SUPERPAVE STANDARDS

The letter report of November 29, 2001, conveyed the committee’s concurrence with the principal finding of the NCHRP-initiated Project 9-14, Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification. This investigation concluded that the restricted zone is redundant if the asphalt aggregate mix design strictly meets all other aggregate angularity and volumetric mixture design requirements included in the AASHTO Superpave specifications. We further recommended that this finding be brought to the attention of the HSOM for consideration as an amendment to the current specification. At the time, we noted that many state departments of transportation specify coarse-graded or fine-graded mixes for different purposes and define coarse or fine gradation through a relationship to the restricted zone. If the restricted zone is removed from the specifications, these definitions will be lost. To remedy this situation, we have enclosed suggested language for redefining fine- and coarse-graded hot-mix asphalt mixtures found in AASHTO specification MP-2 (Appendix 2). We recommend this suggested language, developed by our Expert Task Group on Mixtures and Aggregates, be forwarded to the HSOM for its consideration.

Superpave was originally conceived as a materials selection and mixture design system suitable for application on mainline highways. In consequence, the typical aggregates described in AASHTO specifications had relatively large nominal maximum aggregate sizes. Increasingly, agencies have seen a need to develop “Superpave” mixes suitable for use as leveling courses or thin surface courses for lower volume roadways. In response, we asked our ETG on Mixtures and Aggregates to investigate a mixture specification with a nominal maximum aggregate size of 4.75 millimeters to meet this need. The ETG has completed this task and we forward Appendix 3 for consideration by the HSOM. For the convenience of the HSOM, Appendix 3 contains a version of AASHTO Standard Specification MP2 (Superpave volumetric Mix Design) with suggested amendments highlighted. The Appendix also includes the Expert Task Group discussion of these proposed amendments.

CALIBRATION AND COMPARISON OF GYRATORY COMPACTORS

The committee’s letter report of August 10, 2001 stated:
The widespread availability and use of Superpave gyratory compaction devices is a mark of the success of Superpave deployment. Increasingly these devices are being used for quality control and quality assurance purposes in asphalt pavement construction. Occasionally a dispute arises between an agency and a construction contractor as to whose device is “right” if the bulk specific gravity of specimens prepared with different devices varies unacceptably. Often the difference is attributed to mechanical problems with one of the devices or to incorrect calibration of the internal angle of gyration. At the request of FHWA, we have investigated this issue with the aid of our Expert Task Group on Mixtures and Aggregates.

We find that currently there is no standard calibration procedure that permits unequivocal comparison of devices in such circumstances. If devices of different manufacturers are involved, the issue is more complex as each manufacturer uses unique calibration procedures.

In the same letter we also reported that FHWA researchers were developing a device, known as the dynamic angle validation kit, that might provide a foundation for a satisfactory calibration and comparison procedure for Superpave gyratory compactors. We encouraged FHWA to continue this research. The need to develop an adequate procedure for calibration and comparison of gyratory compactors is growing rapidly. Unresolved discrepancies between agency and contractor devices can lead to large economic penalties for the contractor or poorly performing pavements for the agency.

We are pleased to report that through the NCHRP-supported project 90-01, this FHWA research has been completed. Several early production devices were made available to members of our ETG on Mixtures and Aggregates. These ETG members engaged in a rigorous round-robin experiment to test the merits of the new device in the calibration and comparison of compactors. We have asked the chairman of the ETG to make the information acquired in this round robin testing available for consideration by the HSOM.

INCREASED FOCUS ON TECHNOLOGY TRANSFER

As I indicated earlier, a substantial portion of this meeting was devoted to technology transfer activities. Included were discussions of the Asphalt Pavement Conference: Superpave 2003. This conference will be held in Nashville, Tennessee, in March 2003. The conference, jointly sponsored by the FHWA and the Asphalt Pavement Alliance, is another example of the mutual cooperation of government and industry in the deployment of the Superpave system.

In June 2003, our committee will sponsor a workshop on the application of Superpave to low volume roads as part of the 8th International Conference on Low-Volume Roads in Reno, Nevada. We are looking forward to developing this workshop in cooperation with your organizations.

Finding or developing effective mechanisms for the transfer of technology to the very large but fragmented workforce of the highway industry has always been a challenge. No matter how
useful the Superpave system may be, if it is not clearly and uniformly understood by the agency and industry construction workforce, its capacity to improve asphalt pavement quality will be constrained. In recent months our Expert Task Group on Communications and Training has been considering technology transfer mechanisms. At our meeting, ETG members informed us about the newly formed Transportation Curriculum Coordination Council (TCCC). The TCCC, formed in the summer of 2000, has dedicated itself to improving training opportunities for transportation workers. The Council's goals include: (1) developing a national core training curriculum that can be used by any agency and (2) building partnerships among state highway agencies and industry associations to save time and costs in developing training materials. The TCCC members include representatives from state highway agencies, the Federal Highway Administration and its National Highway Institute, and industry associations. While the TCCC ultimately hopes to address all aspects of highway construction, hot-mix asphalt construction is an early priority. This would seem to make the TCCC a natural ally in the Superpave deployment effort. We have encouraged the ETG to investigate such an alliance in the coming months. We will inform you of the outcome of this investigation in our next report.

Sincerely,

Joseph A. Mickes, Chairman
TRB Superpave Committee

Appendices:
Appendix 1 – Committee Roster
Appendix 2 – Redefining Fine- and Coarse Hot-Mix Asphalt Mixtures
Appendix 3 – Amended AASHTO Standard Specification MP-2

Enclosure
2001 Annual Report
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Superpave Mixture and Aggregates Expert Task Group  

Suggested Language for Re-Defining Fine- and Coarse-Graded Hot-Mix Asphalt Mixtures

The Expert Task Group suggests the following changes to AASHTO specification MP2 to re-define fine- and coarse-graded mixtures without reference to the “restricted zone” guideline, if that guideline is removed from the AASHTO specifications for Superpave. This suggested wording was accepted by consensus at the ETG meeting on August 28, 2001. All citations shown refer to AASHTO MP-2.

Add the following text:

3.10 – Primary Control Sieve (PCS): The sieve defining the break point between fine- and coarse-graded mixtures for each nominal maximum aggregate size.

Remove the existing Section 6.1.3

Add the following:

6.1.3 – Gradation Classification – The combined aggregate gradation shall be classified as coarse-graded when it passes below the Primary Control Sieve (PCS) control point as defined in Table 4. All other gradations shall be classified as fine-graded.

Remove the existing Table 4

Add:

Table 4 – Gradation Classification

<table>
<thead>
<tr>
<th>PCS Control Point for Mixture Nominal Maximum Aggregate Size (％ Passing)</th>
<th>37.5 mm</th>
<th>25.0 mm</th>
<th>19.0 mm</th>
<th>12.5 mm</th>
<th>9.5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Maximum Aggregate Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Control Sieve</td>
<td>9.5 mm</td>
<td>4.75 mm</td>
<td>4.75 mm</td>
<td>2.36 mm</td>
<td>2.36 mm</td>
</tr>
<tr>
<td>PCS Control Point</td>
<td>47</td>
<td>40</td>
<td>47</td>
<td>39</td>
<td>47</td>
</tr>
</tbody>
</table>
Appendix 3

Standard Specification for
Superpave Volumetric Mix Design

AASHTO Designation: MP2-02¹,²

1. Scope

1.1 This specification for Superpave volumetric mix design uses aggregate and mixture properties to produce a hot-mix asphalt (HMA) job-mix formula.

1.2 This standard specifies minimum quality requirements for binder, aggregate, and HMA for Superpave volumetric mix designs.

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 AASHTO Standards:

- T11 Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
- T27 Sieve Analysis of Fine and Coarse Aggregates
- T170 Recovery of Asphalt from Solution by Abson Method
- T176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- T283 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- T304 Uncompacted Void Content of Fine Aggregate
- T312 Preparing and Determining the Density of Hot-Mix Asphalt Specimens by Means of the Superpave Gyratory Compactor
- MP1 Performance Graded Asphalt Binder
- PP28 Superpave Volumetric Design for Hot-Mix Asphalt (HMA)

¹This standard is based on SHRP Product M001.
²Approved in December 1995, this provisional standard was first published in June 1996. The 2001-02 publications include major changes primarily resulting from NCHRP 9-12 Project.
2.2 ASTM Standards:

D4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
D5821 Determining the Percentage of Fractured Particles in Coarse Aggregate

2.3 Other References:


The Asphalt Institute Manual MS-2, “Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.”

3. Terminology

3.1 HMA - Hot-Mix Asphalt

3.2 Design ESALs - Design equivalent (80kN) single-axle loads.

Discussion - Design ESALs are the anticipated project traffic level expected on the design lane over a 20-year period. For pavements designed for more or less than 20 years, determine the design ESALs for 20 years when using this standard.

3.3 Air voids ($V_a$) - The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture (Note 1).

3.4 Voids in the Mineral Aggregate (VMA) - The volume of the intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective binder content, expressed as a percent of the total volume of the specimen (Note 1).

3.5 Voids Filled With Asphalt (VFA) - The percentage of the VMA filled with binder (the effective binder volume divided by the VMA).

3.6 Dust-to-Binder Ratio ($P_{0.075}/P_{be}$) - By mass, the ratio between the percent of aggregate passing the 0.075 mm (#200) sieve ($P_{0.075}$) and the effective binder content ($P_{be}$).

3.7 Nominal Maximum Aggregate Size - One size larger than the first sieve that retains more than 10 percent aggregate (Note 2).

3.8 Maximum Aggregate Size - One size larger than the nominal maximum aggregate size (Note 2).

Note 2 - The definitions given in Subsections 3.7 and 3.8 apply to Superpave mixes only and differ from the definitions published in other AASHTO standards.

3.9 Reclaimed Asphalt Pavement (RAP) - removed and/or processed pavement materials containing asphalt binder and aggregate.

4. Significance and Use - This standard may be used to select and evaluate
5. Binder Requirements

5.1 The binder shall be a performance-graded (PG) binder, meeting the requirements of MP1, which is appropriate for the climate and traffic-loading conditions at the site of the paving project or as specified by the contract documents.

5.1.1 Determine the mean and the standard deviation of the yearly, 7-day-average, maximum pavement temperature, measured 20 mm below the pavement surface, and the mean and the standard deviation of the yearly, 1-day-minimum pavement temperature, measured at the pavement surface, at the site of the paving project. These temperatures can be determined by use of the LTPPBind software or be supplied by the specifying agency. If the LTPPBind software is used, the LTPP high and low temperature models should be selected in the software when determining the binder grade. Often, actual site data is not available, and representative data from the nearest weather station will have to be used.

5.1.2 Select the design reliability for the high and low temperature performance desired. The design reliability required is established by agency policy.

Note 3 - The selection of design reliability may be influenced by the initial cost of the materials and the subsequent maintenance costs.

5.1.3 Using the pavement temperature data determined, select the minimum required PG binder that satisfies the required design reliability.

5.2 If traffic speed or the design ESALs warrant, increase the high temperature grade by the number of grade equivalents indicated in Table 1 to account for the anticipated traffic conditions at the project site.

5.3 If RAP is to be used in the mixture, adjust the binder grade selected in 5.1.3 and 5.2 according to Table 2 to account for the RAP binder stiffness and amount. Procedures for developing a blending chart are included in the Appendix.

6. Combined Aggregate Requirements

6.1 Size Requirements

6.1.1 Nominal Maximum Size - The combined aggregate shall have a nominal maximum aggregate size of 4.75 to 19.0 mm for HMA surface course and no larger than 37.5 mm for HMA subsurface courses.

Note 4 – Additional guidance on selection of the appropriate nominal maximum size mixture can be found in the National Asphalt Pavement Association’s Information Series 128, “HMA Pavement Mix Type Selection Guide.”

6.1.2 Gradation Control Points - The combined aggregate shall conform to the gradation requirements specified in Table 3 when tested according to T11 and T27.

6.1.3 Gradation Restricted Zones - It is recommended that the selected combined aggregate gradation does not pass through the restricted zones specified in Table 4. See Figure 1 for an example of a graph showing the gradation control points and the restricted zone.

6.2 Coarse Aggregate Angularity Requirements - The aggregate shall meet the percentage of fractured faces
requirements, specified in Table 5, measured according to D5821.

6.3 Fine Aggregate Angularity Requirements - The aggregate shall meet the uncompacted void content of fine aggregate requirements, specified in Table 5, measured according to T304, Method A.

6.4 Sand Equivalent Requirements - The aggregate shall meet the sand equivalent (clay content) requirements, specified in Table 5, measured according to T176.

6.5 Flat-and-Elongated Requirements - The aggregate shall meet the flat-and-elongated requirements, specified in Table 5, measured according to D4791, with the exception that the material passing the 9.5 mm sieve and retained on the 4.75 mm sieve shall be included. The aggregate shall be measured using the ratio of 5:1, comparing the length (longest dimension) to the thickness (smallest dimension) of the aggregate particles.

6.6 When RAP is used in the mixture, the RAP aggregate shall be extracted from the RAP using a solvent extraction or ignition oven as specified by the Agency. The RAP aggregate shall be included in determinations of gradation, fractured faces, fine aggregate angularity and flat-and-elongated particles. The sand equivalent requirements shall be waived for the RAP aggregate but shall apply to the remainder of the aggregate blend.

Note 5 – Grading of the RAP and the final mix may be different, therefore, some processing of the RAP (i.e., crushing and/or screening) may be required. RAP particles should be no larger than one sieve size larger than the maximum sieve size.

7. HMA Design Requirements

7.1 The binder and aggregate in the HMA shall conform to the requirements of Sections 5 and 6.

7.2 The HMA design, when compacted in accordance with T312, shall meet the relative density (corresponding design air void value, $V_d$), VMA, VFA, and dust-to-binder ratio requirements specified in Table 6. The initial, design, and maximum number of gyrations are specified in PP28.

7.3 The HMA design, when compacted according to T312 at $7.0 \pm 1.0$ percent air voids and tested in accordance with T283 shall have a tensile strength ratio of at least 0.80.
### Table 1 - Binder Selection on the Basis of Traffic Speed and Traffic Level

<table>
<thead>
<tr>
<th>Design ESALs$^1$ (million)</th>
<th>Traffic Load Rate</th>
<th>Adjustment to the High Temperature Grade of the Binder$^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standing$^2$</td>
<td>Slow$^3$</td>
</tr>
<tr>
<td>&lt; 0.3</td>
<td>-6</td>
<td>-</td>
</tr>
<tr>
<td>0.3 to &lt; 3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 to &lt; 10</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>≥ 30</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

1. The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.
2. Standing traffic - where the average traffic speed is less than 20 km/h.
3. Slow traffic - where the average traffic speed ranges from 20 to 70 km/h.
4. Standard traffic - where the average traffic speed is greater than 70 km/h.
5. Increase the high temperature grade by the number of grade equivalents indicated (one grade is equivalent to 6°C). Use the low temperature grade as determined in Section 5.
6. Consideration should be given to increasing the high temperature grade by one grade equivalent.

**Note 6** - Practically, PG binders stiffer than PG 82-XX should be avoided. In cases where the required adjustment to the high temperature binder grade would result in a grade higher than a PG 82, consideration should be given to specifying a PG 82-XX and increasing the design ESALs by one level (e.g., 10 to < 30 million increased to ≥ 30 million).

### Table 2 - Binder Selection Guidelines for RAP Mixtures

<table>
<thead>
<tr>
<th>Recommended Virgin Asphalt Binder Grade</th>
<th>RAP Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No change in binder selection</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Select virgin binder one grade softer than normal (e.g., select a PG 58-28 if a PG 64-22 would normally be used.)</td>
<td>15 - 25</td>
</tr>
<tr>
<td>Follow recommendations from blending charts</td>
<td>&gt;25</td>
</tr>
</tbody>
</table>

**Note 7** - Research conducted as part of NCHRP Project 9-12 indicated that the high stiffness RAP (PG 88-4 after recovery) used in the study had a greater effect on the low temperature properties of the blended asphalt binder than the medium and low stiffness RAP (PG 82-16 and PG 82-22, respectively). This data suggests that the limiting RAP values in the Table may be modified depending on the low temperature stiffness of the recovered RAP binder. Refer to the NCHRP Project 9-12 final report for more details.
### Table 3 - Aggregate Gradation Control Points

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Nominal Maximum Aggregate Size - Control Point (Percent Passing)</th>
<th>37.5 mm</th>
<th>25.0 mm</th>
<th>19.0 mm</th>
<th>12.5 mm</th>
<th>9.5 mm</th>
<th>4.75 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0</td>
<td>100</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<td>--</td>
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<tr>
<td>37.5</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>--</td>
<td>--</td>
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<tr>
<td>25.0</td>
<td>--</td>
<td>90</td>
<td>90</td>
<td>100</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>19.0</td>
<td>--</td>
<td>--</td>
<td>90</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>12.5</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>90</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>9.5</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>4.75</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2.36</td>
<td>15</td>
<td>41</td>
<td>19</td>
<td>45</td>
<td>23</td>
<td>49</td>
<td>28</td>
</tr>
<tr>
<td>1.18</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
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<td>0</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>8</td>
<td>2</td>
</tr>
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</table>

### Table 4 - Boundaries of Aggregate Restricted Zone

<table>
<thead>
<tr>
<th>Sieve Size Within Restricted Zone (mm)</th>
<th>Minimum and Maximum Boundaries by Sieve Size for Nominal Maximum Aggregate Size (Percent Passing)</th>
<th>37.5 mm</th>
<th>25.0 mm</th>
<th>19.0 mm</th>
<th>12.5 mm</th>
<th>9.5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.300</td>
<td>10.0</td>
<td>10.0</td>
<td>11.4</td>
<td>11.4</td>
<td>13.7</td>
<td>13.7</td>
</tr>
<tr>
<td>0.600</td>
<td>11.7</td>
<td>15.7</td>
<td>13.6</td>
<td>17.6</td>
<td>16.7</td>
<td>20.7</td>
</tr>
<tr>
<td>1.18</td>
<td>15.5</td>
<td>21.5</td>
<td>18.1</td>
<td>24.1</td>
<td>22.3</td>
<td>28.3</td>
</tr>
<tr>
<td>2.36</td>
<td>23.3</td>
<td>27.3</td>
<td>26.8</td>
<td>30.8</td>
<td>34.6</td>
<td>34.6</td>
</tr>
<tr>
<td>4.75</td>
<td>34.7</td>
<td>34.7</td>
<td>39.5</td>
<td>39.5</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

### Table 5 - Superpave Aggregate Consensus Property Requirements

<table>
<thead>
<tr>
<th>Design ESALS(^1) (million)</th>
<th>Fractured Faces Coarse Aggregate(^3) (Percent), minimum</th>
<th>Uncompacted Void Content of Fine Aggregate (Percent), minimum</th>
<th>Sand Equivalent (Percent), minimum</th>
<th>Flat and Elongated(^3) (Percent), maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 100 mm</td>
<td>&gt; 100 mm</td>
<td>≤ 100 mm</td>
<td>&gt; 100 mm</td>
</tr>
<tr>
<td>&lt; 0.3</td>
<td>55/-</td>
<td>-/-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.3 to &lt; 3</td>
<td>75/-</td>
<td>50/-</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>3 to &lt; 10</td>
<td>85/80(^2)</td>
<td>60/-</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>95/90</td>
<td>80/75</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>≥ 30</td>
<td>100/100</td>
<td>100/100</td>
<td>45</td>
<td>45</td>
</tr>
</tbody>
</table>

1. The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALS for 20 years.
2. 85/80 denotes that 85 percent of the coarse aggregate has one fractured face and 80 percent has two or more fractured faces.
3. This criterion does not apply to 4.75-mm mixtures.
**Appendix 3**

**Note 8** - If less than 25 percent of a construction lift is within 100 mm of the surface, the lift may be considered to be below 100 mm for mixture design purposes.

Table 6 - Superpave HMA Design Requirements

<table>
<thead>
<tr>
<th>Design ESALs(^{(1)}) (million)</th>
<th>Required Relative Density (Percent of Theoretical Maximum Specific Gravity)</th>
<th>Voids in the Mineral Aggregate (VMA) (Percent), minimum</th>
<th>Nominal Maximum Aggregate Size, mm</th>
<th>Voids Filled With Asphalt (VFA)(^{(4)}) Range (Percent)</th>
<th>Dust-to-Binder Ratio Range(^{(6)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.3</td>
<td></td>
<td>37.5</td>
<td>25.0</td>
<td>19.0</td>
<td>12.5</td>
</tr>
<tr>
<td>0.3 to &lt; 3</td>
<td>≤ 91.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 to &lt; 10</td>
<td>≤ 90.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 30</td>
<td>≤ 89.0</td>
<td>96.0(^{(5)})</td>
<td>≤ 98.0</td>
<td>11.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>

(1) Design ESALs are the anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

(2) For design traffic levels > 3 million ESAL’s, the specified VFA range for 9.5-mm nominal maximum size mixtures shall be 73 to 76 percent and for 4.75-mm nominal maximum size mixtures shall be 75 to 78 percent.

(3) For 25.0-mm nominal maximum size mixtures, the specified lower limit of the VFA shall be 67 percent for design traffic levels < 0.3 million ESALs.

(4) For 37.5-mm nominal maximum size mixtures, the specified lower limit of the VFA shall be 64 percent for all design traffic levels.

(5) Corresponds to an Air Void Content (V_a) of 4.0%.

(6) For 4.75-mm nominal maximum size mixtures the dust-to-binder ratio shall be 0.9 to 2.0.

**Note 9** - If the aggregate gradation passes beneath the boundaries of the aggregate restricted zone specified in Table 4, the dust-to-binder ratio range may be increased from 0.6 - 1.2 to 0.8 - 1.6 at the agency’s discretion.

**Note 10** - Mixtures with VMA exceeding the minimum value by more than 2% may be prone to flushing and rutting. Unless satisfactory experience with high VMA mixtures is available, mixtures with VMA greater than two percent above the minimum should be avoided. For further guidance on mix design and criteria refer to the Superpave Mixture Design Guide - WesTrack Forensic Team report, FHWA -RD-01-052.
Figure 1: Superpave Gradation Control Points and Restricted Zone for a 12.5 mm Nominal Maximum Size Aggregate Gradation
Blending of RAP binders can be accomplished by knowing the desired final grade (critical temperature) of the blended binder, the physical properties (and critical temperatures) of the recovered RAP binder and either the physical properties (and critical temperatures) of the virgin asphalt binder or the desired percentage of RAP in the mixture.

X1 Determine the physical properties and critical temperatures of the RAP binder.

X1.1 Recover the RAP binder using TP2 method (Note 1-X1) with an appropriate solvent. At least 50 g of recovered RAP binder are needed for testing. Perform binder classification testing using the tests in MP1. Rotational viscosity, flash point and mass loss tests are not required.

Note 1-X1: While TP2 is the preferred method, at the discretion of the agency, T170 may be used. Research conducted under NCHRP 9-12 indicated that T-170 may affect binder properties.

X1.2 Perform original DSR testing on the recovered RAP binder to determine the critical high temperature, $T_c(\text{High})$, based on original DSR values where $G*/\sin \delta = 1.00$ kPa. Calculate the critical high temperature as follows.

where:
\[ G_1 = \text{the } G*/\sin \delta \text{ value at a specific temperature } T_1 \]
\[ a = \text{the slope as described in X1.2.1} \]

Note 2-X1: Although any temperature ($T_1$) and the corresponding stiffness ($G_1$) can be selected, it is advisable to use the $G*/\sin \delta$ value closest to the criterion (1.00 kPa) to minimize extrapolation errors.

X1.3 Perform RTFO aging on the remaining binder.

X1.4 Perform RTFO DSR testing on the RTFO-aged recovered binder to determine the critical high temperature (based on RTFO DSR). Calculate the critical high temperature (RTFO DSR) as follows:

where:
\[ G_1 = \text{the } G*/\sin \delta \text{ value at a specific temperature } T_1 \]
\[ a = \text{the slope as described in X1.4.1} \]

Note 3-X1: Although any temperature ($T_{11}$) and the corresponding stiffness ($G_1$) can be selected, it is advisable to use the $G*/\sin \delta$
Appendix 3

X1.5 Determine the critical high temperature of the recovered RAP binder as the lowest of the original DSR and RTFO DSR critical temperatures. Determine the high temperature performance grade of the recovered RAP binder based on this single critical high temperature.

X1.6 Perform intermediate temperature DSR testing on the RTFO-aged recovered RAP binder to determine the critical intermediate temperature $T_c$(Int), as if the RAP binder were PAV aged.

Note 4-X1: Although any temperature ($T_1$) and the corresponding stiffness ($G_1$) can be selected, it is advisable to use the $G*sin \delta$ value closest to the criterion (5000 kPa) to minimize extrapolation errors.

X1.7 Perform BBR testing on the RTFO-aged recovered RAP binder to determine the critical low temperature, $T_c$(S) or $T_c$(m), based on BBR Stiffness or m-value.

X1.7.1 Determine the slope of the Stiffness-Temperature curve as $\Delta \log(S)/\Delta T$

X1.7.2 Determine $T_c$(S) to the nearest 0.1°C using the following equation:

where:

- $S_1 = \text{the } S\text{-value at a specific temperature } T_1$
- $a = \text{the slope as described in X1.7.1}$

Note 5-X1: Although any temperature ($T_1$) and the corresponding stiffness ($S_1$) can be selected, it is advisable to use the $S$ value closest to the criterion (300 MPa) to minimize extrapolation errors.

X1.7.3 Determine the slope of the m-value-Temperature curve as $\Delta m\text{-value}/\Delta T$

X1.7.4 Determine $T_c$(m) to the nearest 0.1°C using the following equation:

where:

- $m_1 = \text{the } m\text{-value at a specific temperature } T_1$
- $a = \text{the slope as described in X1.7.3}$

Note 6-X1: Although any temperature ($T_1$) and the corresponding m-value ($m_1$) can be selected, it is advisable to use the m-value closest to the criterion (0.300) to minimize extrapolation errors.

X1.7.5 Select the higher of the two low critical temperatures, $T_c$(S) or $T_c$(m), to represent the low critical temperature for the recovered asphalt binder, $T_c$(Low). Determine the low value closest to the criterion (2.20 kPa) to minimize extrapolation errors.

X1.6.1 Determine the slope of the stiffness-temperature curve, $a$, as $a = \Delta \log(G*sin \delta)/\Delta T$.

X1.6.2 Determine $T_c$(Int) to the nearest 0.1°C using the following equation:

where:

- $G_1 = \text{the } G*sin \delta \text{ value at a specific temperature } T_1$
- $a = \text{the slope as described in X1.6.1}$
temperature performance grade of the recovered RAP binder based on this single critical low temperature.

X1.8 Once the physical properties and critical temperatures of the recovered RAP binder are known, proceed with blending at a known RAP percentage or with a known virgin binder grade.

X2. Blending at a Known RAP Percentage

X2.1 If the desired final blended binder grade, the desired percentage of RAP and the recovered RAP binder properties are known, then the required properties of an appropriate virgin binder grade can be determined.

X2.1.1 Determine the critical temperatures of the virgin asphalt binder at high, intermediate and low properties as:

\[ T_{\text{Virgin}} = \text{critical temperature of virgin asphalt binder (high, intermediate or low)} \]
\[ T_{\text{Blend}} = \text{critical temperature of blended asphalt binder (final desired) (high, intermediate or low)} \]
\[ \%\text{RAP} = \text{percentage of RAP expressed as a decimal} \]

Using this equation for the high, intermediate and low critical temperatures respectively, the allowable RAP percentage that will satisfy all temperatures can be determined.

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\[ T_{\text{RAP}} = \text{critical temperature of recovered RAP binder (high, intermediate or low)} \]

Using this equation for the high, intermediate and low critical temperatures respectively, the properties of the virgin asphalt needed can be determined.

X3 Blending with a Known Virgin Binder

X3.1 If the final blended binder grade, virgin asphalt binder grade and recovered RAP properties are known, then the allowable RAP percentage can be determined.

X3.1.1 Determine the allowable RAP percentage as:

\[ \%\text{RAP} = \left( \frac{T_{\text{Blend}} - T_{\text{RAP}}}{T_{\text{Virgin}} - T_{\text{Blend}}} \right) \times 100 \]

where:
\[ T_{\text{Virgin}} = \text{critical temperature of the virgin asphalt binder (high, intermediate or low)} \]
\[ T_{\text{Blend}} = \text{critical temperature of the blended asphalt binder (final desired) (high, intermediate or low)} \]
\[ T_{\text{RAP}} = \text{critical temperature of the recovered RAP binder (high, intermediate or low)} \]
Section 3 Terminology

1. All definitions to remain the same. Of particular note, the definition of ESAL’s will remain the same as other HMA designed by Superpave method.

2. Nominal Maximum Size: There was considerable discussion among the Expert Task Group members regarding whether the definition used for the larger size mixtures should apply to the 4.75 mm mixture. A decision was made that there is no data to indicate a different definition might apply; therefore, the same definition will be used for 4.75 mm mixture.

3. Maximum Size: The definition can remain the same even though decisions were made for gradation that are somewhat different than the other size mixtures. The proposed gradation limits still comply with the definition of maximum size. The changes in gradation will be discussed in Section 6.

Section 5 Binder Requirements

1. The entire section concerning binder requirements was determined to be applicable to the 4.75-mm mixture. This includes the requirements respecting the use of RAP, which may be used according to section 5.3.

Section 6 Combined Aggregate Requirements

1. The size designation of 4.75-mm nominal maximum size mixture will be added to Section 6.1.1.
   - The section will be changed to read:
     
     The combined aggregate shall have a nominal maximum aggregate size of 4.75 to 19.0 mm for HMA surface course and not larger than 37.5 mm for HMA subsurface course.
   
   - The wording allows 4.75-mm nominal maximum size mixture to be used as the layer below the surface when used to correct the cross section prior to applying a new HMA surface.
   
   - A Note was added referencing the National Asphalt Pavement Association’s Information Series 128, “HMA Pavement Mix Type Selection Guide” to provide additional guidance in this area.

2. Table 3 gradation requirements are based on the following considerations
Appendix 3

• Based on the definition of nominal maximum size, percent passing the 4.75-mm sieve is 90 percent minimum and 100 percent maximum.

• Normally, the 9.5 mm sieve, which in this case is the maximum sieve size, should be 100 percent passing. The blend for a 4.75-mm nominal maximum size mixture requires a small sized coarse aggregate, such as an AASHTO 8 or 89 stone. Therefore, the 9.5 mm sieve should be allowed to have some retained material. Hence, the specifications were set at 95 percent minimum and 100 percent maximum. This recommendation allows up to 5 percent to be retained on the 9.5-mm sieve and does not violate the definition of maximum sieve size. The 12.5-mm sieve requirement would be 100 percent.

• The key sieve separating coarse and fine aggregate is the 1.18 mm sieve. This is different than the larger size mixtures which all have a specification for the 2.36-mm sieve. Since the 4.75-mm nominal maximum size mixture is so much smaller, it requires a smaller sieve to be specified. The 1.18-mm sieve is near the median aggregate particle size. For the 1.18-mm sieve, the recommended specification is 30 percent minimum and 60 percent maximum.

• Gradation controls are not required for the 2.36-mm sieve. Specifying limits for both the 2.36-mm sieve as well as the 1.18-mm sieve could create an unnecessary conflict. The option of controlling the 2.36-mm sieve instead of the 1.18 mm sieve provides poor control over design gradation because the typical percent passing the 2.36-mm sieve will be 70 to 80.

Controlling gradation using the 1.18-mm sieve is more reasonable because the percent passing the 1.18-mm sieve will be closer to 50 percent.

• No minimum or maximum is specified for the 0.600-mm, 0.300-mm sieve or the 0.150-mm sieve.

• For the 0.075-mm sieve the maximum percent passing should be quite high to allow a dust to asphalt ratio as high as 2.0 as well as to recognize that the 4.75-mm mixture will include unwashed screenings which have 14 to 20 percent passing the 0.075-mm sieve. A maximum percent passing the 0.075-mm sieve was chosen to be 12.0 percent.

There was considerable discussion of a suitable minimum percent passing the 0.075 mm sieve. Mixtures with low amounts of 0.075-mm material are considered undesirable because the asphalt content will tend to be excessively high. With little stiffening from the minus 0.075-mm material the mixture will be prone to flushing. A minimum of 6.0 percent passing the 0.075-mm sieve was chosen.
Appendix 3

3. Table 4 Restricted zone will not apply to the 4.75-mm nominal maximum size mixture. The entire table is expected to be removed for all mixture sizes in 2002.

4. Section 6.2, 6.4 and 6.5 references to Table 5
   - Coarse Aggregate Angularity requirements will not apply for 4.75 mm mixture. Crushed faces are measured only on the plus 4.75 mm particles. At most a 4.75-mm nominal maximum size mixture will have 10 percent retained on the 4.75-mm sieve. Crushed faces on such a small component was not believed to be important in the overall properties of the mixture. A footnote to Table 5 has been added indicating this criterion does not apply to 4.75-mm mixtures.
   - Fine aggregate angularity requirements would apply as currently listed in Table 5. This will be the main property controlling aggregate angularity and shape.
   - Flat and elongated particles are measured only on the plus 4.75 mm particles. Note that the test method requires flat and elongated particles to be determined only on the material retain on the 9.5-mm sieve. MP2 adds a requirement that particles passing the 9.5-mm sieve but retained on the 4.75-mm sieve shall also be measured.

Since no more than 10 percent of the aggregate blend will be retained on the 4.75-mm sieve, it was felt that this small portion would not significantly effect the properties of the entire mixture. Therefore, the requirement for flat and elongated particles is waived for 4.75-mm nominal maximum size mixtures. A footnote to Table 5 has been added indicating this criterion does not apply to 4.75-mm mixtures.

5. Section 6.6 discusses the addition of RAP to the mixture.
   - There is no reason to exclude the use of RAP for 4.75-mm mixtures, although there is a concern that the size of RAP particles might be a problem. A note should be added after section 6.6 that would apply to all mixtures containing RAP. The note would be as follows:

   Note 4 Grading of the RAP and the final mix may be different, therefore, some processing, i.e. crushing and/or screening, may be required. RAP particles should be no larger than one sieve size larger than the maximum sieve size.

Section 7 HMA Design Requirements

1. Section 7.2 references to Table 6 air voids and VMA.
   - Three databases of information were used in the discussion.
      - NCAT provided an experimental matrix of mixtures consisting of two aggregates (Georgia granite and Alabama limestone), three gradations (above, below and in middle of the maximum density line), three dust
Appendix 3

Martin Marietta provided a database of historical Georgia mixtures that included twenty-seven mixtures. All of these mixtures are based on Georgia granite.

Martin Marietta provided a database of trial mix designs done on aggregates from 26 states. These aggregates included granite, sandstone, dolomite, limestone and basalt. Aggregates were collected from the states and blended to match the middle gradation used in the NCAT study. Two asphalt contents (6.0 and 6.5 percent) were used. The voids and VMA were measured on each of these mixtures.

- Initially, the discussion focused on how much asphalt is required for good performance.

- The historical mixtures from Georgia have an average of 13.4 percent effective asphalt volume for 6.0 percent design asphalt content. Six percent asphalt binder is a Georgia specification requirement.

- The database of trial mix designs had an effective asphalt volume that ranged from 10 percent for higher absorption aggregates to 14 percent for the very non-absorptive.

- The NCAT mixes had a range of effective asphalt volume from 8.7 to 14.5 percent for the limestone aggregate and 9.6 to 16.8 percent for the granite aggregate.

- After discussion of these mixtures, a minimum effective volume of asphalt was selected to be 12.0 percent.

- There was considerable discussion about design air voids. Discussions included a range of air voids (4.0 to 7.0 percent) or a single air void content (4.0, 5.0 or 6.0 percent).

The Georgia granite mixtures typically have a high VMA. There was concern that these mixtures would have excessively high asphalt contents if the design voids were 4.0 percent. Using the changes in gradation discussed in Section 6 it will be possible to reduce the VMA and obtain a final asphalt content of about 6 percent which is Georgia’s current design content.

The Martin Marietta mixtures from across the country had been graded to Georgia’s existing specification. These mixtures were evaluated to determine the effect of setting the design air voids to 4.0 percent. There is room to adjust the gradation to the proposed 4.75-mm gradation specifications, select the asphalt content at 4.0 percent air voids and obtain a reasonable asphalt content.

Based on all the data available and the proposed gradation specifications, a design air void content of 4.0 percent was considered reasonable. The final recommendation is for design air voids to be 4.0 percent, which requires no change in Table 6.
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- **Design VMA:** Based on a minimum effective asphalt volume of 12.0 percent and a design air void of 4.0 percent, the minimum design VMA content is 16.0.

A maximum VMA was discussed. In the past, a recommendation had been made to limit the VMA of mixtures designed by the Superpave method to 2 percent above the minimum. For the 4.75-mm mixture, this limit is felt to be important to prevent mixtures with high asphalt content that have a tendency to flush and rut. As a result a note is proposed to be added to the specification as an advisory.

*Note 8 – Mixtures with VMA more than two percent higher than the minimum may be prone to flushing and rutting. Unless satisfactory experience with high VMA mixtures is available, mixtures with VMA greater than two percent above the minimum should be avoided.*

2. **Section 7.2 references to Table 6 VFA.**

- Voids filled with asphalt were discussed based on the range of VFA likely to be encountered in mix design. With 16.0 percent VMA and 4.0 percent air voids, the VFA is 75 percent. With 18.0 percent VMA and 4.0 percent air voids, the VFA is 78 percent. The range of VFA for the three higher traffic ranges (3 to <10, 10 to <30 and >30 million ESAL’s) was set at 75 to 78 percent. The ranges as currently published for <0.3 and 0.3 to 3 million ESAL’s do not require changing.

- A change will be made to parenthetical note (2) of Table 6. The note will be changed from:

  (2) For 9.5-mm nominal maximum size mixtures, the specified VFA range shall be 73 to 76 percent for design traffic levels >3 million ESAL’s.

  to

  (2) For design traffic levels >3 million ESAL’s, the specified VFA range for 9.5-mm nominal maximum size mixtures shall be 73 to 76 percent and for 4.75-mm nominal maximum size mixtures shall be 75 to 78 percent.

3. **Section 7.2 references to Table 6 Dust-to-Binder Ratio Range.**

- Dust-to-binder ratio for 4.75-mm nominal maximum size mixtures should be higher than for the larger size mixtures designed with the Superpave system. A lower limit of 0.9 is based on the minimum percent passing the 0.075-mm sieve and a VMA of 18.0. A higher limit of 2.0 is quite a bit higher than the limit for larger mixtures. In fact, it is quite similar to the dust-to-binder ratio that exists in SMA. Based on SMA experience an upper limit of 2.0 is considered reasonable. Therefore, the range chosen for a 4.75-mm nominal maximum size mixture is 0.9 to 2.0.

- A new parenthetical note will be added to Table 6 as follows:

  (5) For 4.75-mm nominal maximum size mixtures the dust-to-binder ratio shall be 0.9 to 2.0

4. **Section 7.3, moisture sensitivity**

- As for other mixtures designed with the Superpave system, a 4.75-mm nominal maximum size mixture should be evaluated for moisture damage resistance. The
Appendix 3

HMA design would be compacted according to T-312 without any differences for the 4.75-mm mixture. Therefore, no changes are required to Section 7.3

- Requirements for stripping resistance should be the same for a 4.75-mm mixture as compared to the other HMA mixtures; therefore, no changes are needed to section 7.3.