STONE MASTIC ASPHALT - Item No.

Special Provision No. 313S45

October 2006


Material and Construction Requirements for Stone Mastic Asphalt

313.01 SCOPE

Section 313.01 of OPSS 313, March 1993 is amended by the addition of the following:

This specification also covers the design and construction requirements for Stone Mastic Asphalt (SMA).

313.05 MATERIALS

313.05.01 Asphaltic Concrete

Subsection 313.05.01 of OPSS 313, March 1993 is amended by the deletion of the first two paragraphs and their replacement with the following:

Asphaltic concrete shall conform to OPSS 1149, March 1993 and the amendments as specified elsewhere in the contract.

1149.02 REFERENCES

Section 1149.02 of OPSS 1149, March 1993 is amended by the addition of the following under:

Ministry of Transportation Publications:

  LS-306 Method of Test For Bulk Relative Density of Compacted Bituminous Mixtures Using Paraffin Coated Specimens
  LS-603 Method of Test for Resistance to Degradation of Coarse Aggregate by Abrasion and Impact in the Los Angeles Abrasion Machine

American Society for Testing and Materials (ASTM):

  C 612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation

Section 1149.02 of OPSS 1149, March 1993 is amended by the addition of the following:

American Association of State Highways and Transportation Officials (AASHTO):

  M320 Specification for Performance Graded Asphalt Binder
  PP41 Standard Practice for Designing Stone Matrix Asphalt (SMA)
  R28 Practice for Accelerated Aging of Asphalt Binder Using Pressurized Aging Vessel (PAV)
  T19/T19M Bulk Density (“Unit Weight”) and Voids in Aggregate
Asphalt Binder means asphalt cement, modified or unmodified

Stone Mastic Asphalt (SMA) means HMA consisting of a coarse aggregate skeleton and an asphalt binder rich mortar. The mixture has a gap graded aggregate skeleton with coarse aggregate stone-on-stone contact.

Stone Mastic Asphalt (SMA) Mortar means a mixture of asphalt cement and any additives, hydrated lime, fibres, and filler, including all material passing the 0.075 mm sieve, fines returned to the mix, and any commercial filler blended by volume to the proportions required by the JMF.

Superpave means the method for specifying material components and asphalt mixture design using the Superpave gyratory compactor (SGC).

Voids in Coarse Aggregate (VCA) means the volume in between the coarse aggregate particles, which includes filler, hydrated lime, fine aggregate, fines returned to the mix, air voids, asphalt cement, and fibre if used. For SMA, the coarse aggregate particles refer to that portion retained on the 4.75 mm sieve.

Substitution and Design Requirements

Clause 1149.04.04.01 of OPSS 1149, March 1993 is amended by the deletion of paragraphs two, three and four and their replacement with the following:

All mix designs shall be performed by a laboratory certified by the Canadian Council of Independent Laboratories (CCIL) as a Type “A” laboratory or equivalent to conduct bituminous mix designs, designate mix proportions and prepare job-mix formulae for SMA and all other mixes included in the contract. The
laboratory shall also be equipped with a Superpave Gyratory Compactor and staffed with personnel who have been trained in its use.

The SMA shall be designed using the Superpave Gyratory Compactor in accordance with the guidelines given in AASHTO PP41 and NAPA QIP 122, and shall comply with the design criteria specified in Tables A, B and C.

<table>
<thead>
<tr>
<th>Mix Type</th>
<th>Percentage Passing by Volume (See Note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
</tr>
<tr>
<td></td>
<td>26.5 19.0 12.5 9.5 4.75 2.36 1.18 600 300 150 75</td>
</tr>
<tr>
<td>SMA 12.5</td>
<td>100 90-100 50-80 20-35 16-24 - - - 8-11</td>
</tr>
<tr>
<td>SMA 9.5</td>
<td>100 70-95 30-50 20-30 8-21 8-18 8-15 8-12</td>
</tr>
</tbody>
</table>

Notes: 1) When the bulk specific gravities of the different stockpiles to be used in the mixture vary by more than 0.020, then the mix gradation shall be based on volumetric percentages.
### Table B

**SMA Mixture Design Volumetric Criteria**

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Design Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Number of gyrations</td>
<td>100 (see Note 2)</td>
</tr>
<tr>
<td>b. Percent Air Voids</td>
<td>4.0</td>
</tr>
<tr>
<td>c. Percent voids in mineral aggregate (VMA)</td>
<td>17 minimum</td>
</tr>
<tr>
<td>d. VCA\textsubscript{MIX}, % (see Note 3)</td>
<td>Less than VCA\textsubscript{DRC} (see Note 4)</td>
</tr>
<tr>
<td>e. Tensile Strength Ratio (AASHTO T 283), %</td>
<td>70 minimum</td>
</tr>
<tr>
<td>f. Draindown at Production Temperature, % (AASHTO T305)</td>
<td>0.3 maximum</td>
</tr>
</tbody>
</table>

Notes:

2) When aggregates have a Los Angeles Abrasion (LS-603) value greater than 30 percent, the number of SGC design gyrations shall be 75.

3) Voids in Coarse Aggregate of the compacted mixture (AASHTO PP 41).

4) Voids in Coarse Aggregate in the dry rodded condition (AASHTO PP 41).
Table C
Minimum Asphalt Content Requirements For SMA Based on Aggregate Bulk Specific Gravities

<table>
<thead>
<tr>
<th>Combined Aggregate Bulk Specific Gravity</th>
<th>Minimum Asphalt Content Based on Mass, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.40</td>
<td>6.8</td>
</tr>
<tr>
<td>2.45</td>
<td>6.7</td>
</tr>
<tr>
<td>2.50</td>
<td>6.6</td>
</tr>
<tr>
<td>2.55</td>
<td>6.5</td>
</tr>
<tr>
<td>2.60</td>
<td>6.3</td>
</tr>
<tr>
<td>2.65</td>
<td>6.2</td>
</tr>
<tr>
<td>2.70</td>
<td>6.1</td>
</tr>
<tr>
<td>2.75</td>
<td>6.0</td>
</tr>
<tr>
<td>2.80</td>
<td>5.9</td>
</tr>
<tr>
<td>2.85</td>
<td>5.8</td>
</tr>
<tr>
<td>2.90</td>
<td>5.7</td>
</tr>
<tr>
<td>2.95</td>
<td>5.6</td>
</tr>
<tr>
<td>3.00</td>
<td>5.5</td>
</tr>
</tbody>
</table>

1149.04.04.03 Samples for Monitoring Purposes

Clause 1149.04.04.03 of OPSS 1149, March 1993 is amended by the addition of the following:

The Contractor shall provide two representative 1 kg samples of the mineral filler being proposed and data showing conformance of the mineral filler with the requirements of the Contract.

Performance-Graded Asphalt Cement and all aggregates shall be sampled and tested in accordance with the requirements specified elsewhere in the Contract.

If applicable, a minimum 0.5 litre sample of liquid anti-stripping additive or 5 kg sample of dry anti-stripping additive shall be provided to the Contract Administrator.

All samples shall accompany the mix design submissions.

1149.04.04.04 Documents

Clause 1149.04.04.04 of OPSS 1149, March 1993 is amended by deleting paragraphs “c”, “j”, “k” "n" and “s” and replacing with the following:

c. All material proportions and sources for aggregates (including the Supplier’s Mineral Aggregate Inventory Numbers), asphalt cement, mineral fillers, fibres, asphalt cement modifiers or any other additives used, the name of each product, its manufacturer and the manufacturer’s data sheet.

j. The percent air voids, voids in mineral aggregate and voids in coarse aggregate of the selected mix design compared with the requirements for air voids, voids in mineral aggregate and voids in coarse
aggregate in the dry rodded condition as shown in Table B. Voids in coarse aggregate of the mix (VCA) shall be calculated as follows:

\[ P_{sy} = P_s \times PA_{bp} \]
\[ VCA = 100 - \left( \frac{G_{ca}}{G_{mb}} \times P_{sy} \right) \]

where: \( P_{sy} \) is the percent aggregate by total mixture mass retained on the breakpoint sieve (4.75 mm)
\( P_s \) is the percent of aggregate in the mix
\( PA_{bp} \) is the percent aggregate by total aggregate mass retained on the breakpoint sieve (4.75 mm)
\( G_{ca} \) is the combined bulk relative density of the coarse aggregate (AASHTO T85), and
\( G_{mb} \) is the bulk relative density of the compacted specimens (AASHTO T166)

Voids in the coarse aggregate in the dry-rodded condition (VCA\textsubscript{DRC}) shall be calculated as follows:

\[ VCA_{DRC} = \frac{G_{ca} \gamma_s - \gamma_w}{G_{ca} \gamma_s} \times 100 \]

where: \( G_{ca} \) = combined bulk relative density of the coarse aggregate
\( \gamma_s \) = unit weight of the coarse aggregate fraction in the dry-rodded condition (kg/m\(^3\)) (AASHTO T19/T19M)
\( \gamma_w \) = unit weight of water (998 kg/m\(^3\))

k. Using a four-point mix design, graphs of air voids, voids in mineral aggregate (VMA) and voids in coarse aggregate of the mixture (VCA) plotted against asphalt cement content at the design number of gyrations.

n. Calculations for the % absorption by volume in accordance with AASHTO T166 and the mix bulk relative density using AASHTO T166 or, if the percent absorption by volume is more than 2%, either LS-306 or ASTM D 6752. The method used shall be clearly identified in the submission.

s. The job mix formula. The target values for percent passing each designated sieve for the design aggregate structure shall be shown against the SMA gradation requirements.

And add the following additional paragraphs:

v. Table of the Fine Mortar Properties for the selected asphalt cement content (test temperature, result and requirement) compared with the values shown in Table D.
w. Moisture susceptibility Test Results [Average Dry Strength in kPa, Average Wet Strength in kPa and TSR (%)] for specimens compacted to an average air void content of 6±1%.

x. Draindown sensitivity Test Results (Average Draindown in % for at least the anticipated plant production temperature and 15° C above it).

1149.05 MATERIALS

1149.05.01 Material Requirements

1149.05.01.02 Aggregates

Clause 1149.05.01.02 of OPSS 1149, March 1993 is amended by the addition of the following clause:

1149.05.01.02.07 Stone Mastic Asphalt

The aggregates for SMA shall conform to the physical property requirements specified elsewhere in the Contract.

Both the coarse and fine aggregates used for SMA shall be crushed from the same source. The aggregate source used shall be listed in the Owner's Designated Sources of Materials List as an approved source for Dense Friction Course Mix.

Freshly crushed coarse and fine aggregates less than 30 days old shall not be incorporated into the mix, unless hydrated lime [Ca(OH)₂] is added to the mix and the resultant mix has been reviewed and verified by the Contract Administrator as specified elsewhere in the Contract.

Subsection 1149.05.01 of OPSS 1149, March 1993 is amended by the addition of the following clauses:

1149.05.01.04 Stone Mastic Asphalt Mortar

As part of the mix design, the SMA mortar shall be tested in accordance with the procedures specified herein and meet the requirements stated in Table D.

The asphalt cement, which is used in this testing shall be both RTFO-aged in accordance with AASHTO T240 and PAV-aged in accordance with AASHTO R28 prior to blending with fillers.

The SMA mortar shall be blended and tested in accordance with AASHTO draft test method “Standard Practice for Testing of HMA Mortars – AASHTO Format” (NCAT Report 9-8/4).

Mortar, which includes both unaged and RTFO-aged asphalt cement (AASHTO T240), shall be tested using the Dynamic Shear Rheometer (AASHTO T315) at the average 7-day maximum pavement design temperature of the appropriate asphalt cement grade in accordance with AASHTO M320.

Mortar consisting of PAV-aged asphalt cement (AASHTO R28) shall be tested using the Bending Beam Rheometer (AASHTO T313) at the minimum pavement design temperature of the appropriate asphalt cement grade in accordance with AASHTO M320.
### Table D
**Properties of SMA Mortar**

<table>
<thead>
<tr>
<th>Test</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaged Dynamic Shear Rheometer, G*/Sinθ</td>
<td>5 (kPa) minimum</td>
</tr>
<tr>
<td>RTFO Aged Dynamic Shear Rheometer, G*/Sinθ</td>
<td>11 (kPa) minimum</td>
</tr>
<tr>
<td>PAV Aged Bending Beam Rheometer, Stiffness</td>
<td>1500 (MPa) maximum</td>
</tr>
</tbody>
</table>

1149.05.01.05  **Stabilizing Additives**

Due to the high asphalt contents in SMA, a stabilizing additive shall be used to help bind the asphalt cement to the coarse aggregate during hauling and placement. In order to prevent unacceptable draindown, either cellulose or mineral fibres can be added to the binder. Regardless of the form of stabilization, the Contractor shall follow the manufacturer’s recommendations for any product used.

Cellulose or mineral fibres may be used as a stabilizing additive in dosage rates of 0.3% or 0.4%, respectively, by mass of the total mixture. Cellulose and mineral fibres shall meet the properties shown in Tables E and F, respectively.

The use of fibreglass, rock wool, or asbestos is prohibited.
### Table E

**Physical Requirements for Cellulose Fibres**

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Analysis (Method A or B)</td>
<td></td>
</tr>
<tr>
<td><strong>Method A – Alpine Sieve Analysis – See Note 5)</strong></td>
<td></td>
</tr>
<tr>
<td>Fibre Length</td>
<td>6 mm maximum</td>
</tr>
<tr>
<td>Passing 0.150 mm sieve</td>
<td>70 ± 10%</td>
</tr>
<tr>
<td><strong>Method B - Mesh Screen Analysis – see Note 6)</strong></td>
<td></td>
</tr>
<tr>
<td>Fibre Length</td>
<td>6 mm maximum</td>
</tr>
<tr>
<td>Passing 0.850 mm sieve</td>
<td>85 ± 10%</td>
</tr>
<tr>
<td>0.425 mm sieve</td>
<td>65 ± 10%</td>
</tr>
<tr>
<td>0.106 mm sieve</td>
<td>30 ± 10%</td>
</tr>
<tr>
<td>Ash Content – see Note 7)</td>
<td>18 ± 5% non-volatiles</td>
</tr>
<tr>
<td>PH – see Note 8)</td>
<td>7.5 ± 1.0</td>
</tr>
<tr>
<td>Oil Absorption – see Note 9)</td>
<td>5 ± 1.0 (times fibre mass)</td>
</tr>
<tr>
<td>Moisture Content – see Note 10)</td>
<td>Less than 5% (by mass)</td>
</tr>
</tbody>
</table>

**Notes:**

5) Method A – Alpine Sieve Analysis - This test is performed using an Alpine Air Jet Sieve (Type 200 LS). A representative five gram sample of fibre is sieved for 14 minutes at a controlled vacuum of 75 kPa of water. The portion remaining on the screen is weighed.

6) Method B – Mesh Screen Analysis - This test is performed using standard 0.850, 0.425, 0.250, 0.180, 0.150 and 0.106 mm sieves, nylon brushes, and a shaker. A representative 10 gram sample of fibre is sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve is weighed and the percentage passing calculated.

7) Ash Content. A representative 2-3 gram sample of fibre is placed in a tared crucible and heated between 595 and 650°C for not less than 2 hours. The crucible and ash are cooled in a desiccator and re-weighed.

8) pH test – Five grams of fibre is added to 100 ml of distilled water, stirred and let sit for 30 minutes. The pH is determined with a probe calibrated with pH buffer of 7.0.

9) Absorption Test – Five grams of fibre is accurately weighed and suspended in an excess of mineral spirits for not less than 5 minutes to ensure total saturation. It is then placed in a screen mesh strainer (approximately 0.5 mm² opening size) and shaken on a wrist action shaker for 10 minutes (approximately 32 mm motion at 240 shakes/minute). The shaken mass is then transferred without touching to a tared container and weighed. Results are reported as the amount (number of times its own weight) the fibres are able to absorb.

10) Moisture Content - Ten grams of fibre are weighed and placed in a 121°C forced air oven for two hours. The sample is then re-weighed upon removal from the oven.
### Table F

**Mineral Fibre Quality Requirements**

<table>
<thead>
<tr>
<th>Property</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Analysis</td>
<td></td>
</tr>
<tr>
<td>Fibre Length – see Note 11)</td>
<td>6 mm maximum mean test value</td>
</tr>
<tr>
<td>Thickness – see Note 12)</td>
<td>0.005 mm maximum mean test value</td>
</tr>
<tr>
<td>Shot Content – see Note 13)</td>
<td></td>
</tr>
<tr>
<td>Passing 0.250 mm sieve</td>
<td>90 ± 5%</td>
</tr>
<tr>
<td>Passing 0.063 mm sieve</td>
<td>70 ± 10%</td>
</tr>
</tbody>
</table>

**Notes:**
11) The fibre length is determined according to the Bauer McNett fractionation.
12) The fibre thickness is determined by measuring at least 200 fibres in a phase contrast microscope.
13) Shot content is a measure of non-fibrous material. The shot content is determined on vibrating sieves. Two sieves, 0.250 mm and 0.063 mm are typically utilized. For additional information see ASTM C 612.

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**313.06 EQUIPMENT**

**313.06.01 Spreading Equipment**

Subsection 313.06.01 of OPSS 313, March 1993 is amended by the deletion of Clause b., Blade Graders.

**313.06.02 Rollers**

Subsection 313.06.02 of OPSS 313, March 1993 is amended by the addition of the following:

Pneumatic-tired rollers shall not be used. Vibratory rollers shall only be used in a high frequency, low-amplitude mode and only if aggregate breakage and/or bleeding can be avoided.

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**313.07 CONSTRUCTION**

**313.07.01.01 Process Control**

Clause 313.07.01.01 of OPSS 313, March 1993 is deleted in its entirety and is replaced with the following:

The Contractor shall carry out minimum quality control activities for SMA as specified elsewhere in the contract.
313.07.01.13  Option to Place a Trial Quantity of Surface Course Hot Mix as Binder Course

Clause 313.07.01.13 of OPSS 313, March 1993 is amended by the replacement of the words “surface course” with “SMA” and the first three paragraphs shall be deleted and replaced by the following:

The Contractor shall inform the Contract Administrator in writing at least two weeks before placement of the trial quantity, if this option is to be used and the intended date(s) of the trial(s). The Contractor shall be allowed to construct up to three trials before placing any SMA as surface course, with each trial being considered as a separate lot for sampling and testing.

Each lot shall consist of three equal sublots, which are sampled and tested in the same manner as SMA that is placed as surface course. For compaction, three sets of cores shall be taken from each sublot. For all attributes, PWL calculations using $n=3$ will be used to determine payment factors and to determine if the mix is rejectable. In addition, at least one set of three 3 kg samples shall also be taken for draindown testing from one of the lots and for each lot where there is a change in the job mix formula. The trials shall constructed at no additional cost to the Owner, using the mix production, lay-down and compaction procedures intended for the entire SMA mix subject to the following:

Clause 313.07.01.13 of OPSS 313, March 1993 is also amended by deleting paragraphs “a.”, “e.”, “f.” and “h.” and replacing them with the following items:

a. The entire combined quantity for all SMA trials shall be a maximum of 1000 tonnes in total, unless the Owner approves of the placement of additional SMA in the trial location(s).

e. Where the thickness of the upper binder course is less than or equal to 50 mm, the trial quantity shall be laid to the same thickness as the upper binder course but, in no circumstances, shall it be less than 40 mm thick.

f. SMA trial(s) shall only be constructed in situations where all binder lifts can be placed with a minimum thickness of 40 mm.

h. When applying the Owner’s acceptance requirements for mix composition and compaction, and the resulting disposition of unacceptable work, the trial quantity of SMA shall be decisioned under the SMA course surface acceptance criteria. However, when applying the Owner’s acceptance requirements for smoothness tolerances and for segregation, the trial quantity of SMA shall be decisioned under regular binder course acceptance criteria.

313.07.01.16  Tolerances

Clause 313.07.01.16 of OPSS 313, March 1993 is deleted in its entirety and is replaced with the following:

Acceptance testing for the surface smoothness of SMA shall be conducted in accordance with the requirements specified elsewhere in the Contract.

313.08  QUALITY ASSURANCE

Section 313.08 of OPSS 313, March 1993 is amended by the addition of the following:
313.08.06 Additional Acceptance Criteria for SMA

Acceptance testing for SMA shall be conducted as specified elsewhere in the Contract.

In addition, for each 10,000 tonnes of SMA produced, all of the fines that are returned to the mix plus the commercial mineral filler used within that 10,000 tonnes shall be considered as one lot. A set of three of aggregate filler samples consisting of at least 1 kg shall be taken from each lot. One sample shall be tested by the Contractor to ensure that the aggregate filler meets the requirements specified elsewhere in the contract and the other two samples will be designated for QA and Referee testing. Samples shall be obtained, packaged appropriately, labelled and delivered by the Contractor as specified elsewhere in the contract.

In addition, for each 10,000 tonnes of SMA produced, testing shall be conducted to ensure the requirements of Table D are met. A set of three samples of the materials required to test for SMA mortar shall be taken by the Contractor from materials used within the 10,000 tonnes of production. One sample shall be tested by the Contractor to ensure that the SMA mortar meets the requirements of Table D and the other two samples will be designated for QA and Referee testing. Samples shall be obtained, packaged appropriately, labelled and delivered by the Contractor as specified elsewhere in the contract. SMA mortar shall be blended by volume to the proportions used in the mix design.