

2005 Stone Matrix Asphalt (SMA)

Replace 2360.1 DESCRIPTION with:

This work consists of the construction of a Stone Matrix Asphalt Wearing Course Mixture (SMA). The work shall be in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans or established by the Engineer.

Modify 2360.2E Gradation Requirement as follows:

**Table 2360.2-E
Aggregate Gradation Broad Bands
(% passing of total washed gradation)**

| Sieve Size (mm /inch) | A or 4* | B or 3* | C or 2* | 5* | E (SMA) |
|----------------------------------|----------------|----------------|----------------|-----------|--------------------|
| 25.0 (1") | | - | - | | |
| 19.0 (¾") | | - | - | | 100 |
| 12.5 (½") | - | - | - | | 90-97 |
| 9.5 (3/8") | - | - | - | - | 60-85 |
| 4.75 (#4) | - | - | - | - | 25-35 |
| 2.36 (#8) | - | - | - | - | 15-25 |
| 0.075 (#200) | - | - | - | - | 8.0-12.0 |

Delete: 2360.2 A2h, 2360.2 A2i, and 2360.2 A3. Recycled material is not allowed.

Replace 2360.2F Additives, 2360.2F1 Mineral Filler, 2360.2F2 Hydrated Lime with:

An additive is any material added to an asphalt mixture or material, such as mineral filler, asphalt additives, anti-strip, stabilizers, and similar products that do not have a specific pay item. When a Contract requires additives, compensation is included with the pay items for the appropriate mixture. If the Engineer directs the Contractor to incorporate additives, the compensation will be as Extra Work, at the unit price specified in the proposal. The Department will not compensate the Contractor for additives incorporated at the Contractor's option.

Additives shall not be incorporated into the mixture without approval of the Department Bituminous Engineer. Anti-foaming agents shall be added to asphalt cement at the manufacturer's recommended dosage rate. The Engineer will approve or disapprove methods for addition of additives.

B1 Mineral Filler AASHTO M17

B1a Composition

Mineral filler shall consist of carbonate dust, Portland cement, hydrated lime, crushed rock screening, or rotary limekiln dust, subject to approval of the Engineer.

Crushed rock screenings to be used as mineral filler shall be of such composition and quality that the bituminous mixture containing the rock screenings will have stability and durability equivalent to those of the comparable mixture containing one of the other acceptable filler materials. The rock screenings shall be free from clay and shale.

Mineral filler prepared from rock dust , slag dust, and similar materials shall be free from organic impurities and have a plasticity index not greater than 4 (AASHTO T 90).

B1a1 Hydrated Lime

Hydrated lime used in asphalt mixtures shall meet the requirements of ASTM C977 and have a maximum of eight percent unhydrated oxides (as received basis). The method of introducing and mixing the hydrated lime and aggregate shall be subject to approval by the Engineer prior to beginning mixture production.

B1b Gradation

Mineral filler shall be graded within the following limits:

| | |
|--|--------|
| Percent finer than 0.600mm (#30)..... | 100 |
| Percent finer than 0.300mm (#50)..... | 95-100 |
| Percent finer than 0.075mm (#200)..... | 70-100 |

B1c Condition

Mineral filler that is to be added directly to the dried aggregate for the bituminous mixture shall be thoroughly dry and free from lumps consisting of aggregations of fine particles.

Crushed rock screenings used as mineral filler shall be of uniform gradation and shall be processed and handled un such a manner as will prevent segregation. The rock screenings shall be dried by passing through the dryer.

B1d Sampling and Testing

- 1) Sampling.....MnDOT Bituminous Manual
- 2) Fineness
 - Sieve Analysis.....AASHTO T 27
 - Hydrometer Analysis.....AASHTO T 88

(A) This procedure is modified to permit the use of Gum Arabic as a dispersing agent if flocculation occurs.

- 3) Plasticity Index.....AASHTO T 89 & 90
- 4) Specific Gravity.....AASHTO T100

Insert: 2360.2 F5

F5 SMA Asphalt Stabilizer.....AASHTO MP8-02

An asphalt stabilizer additive shall be used to control drain-down. The stabilizer additive shall be either a cellulose fiber conforming to AASHTO MP8-02.

The stabilizer supply system shall be a separate system that proportions the required amount of stabilizer in uniform distribution. The system shall include low level and no-flow indicators and a printout of status of feed rate in lbs/min. The stabilizer supply line shall include a section of transparent pipe for observing consistency of flow or feed. Stabilizer dosage rate shall be within 0.2-0.4 percent by weight of the total mix.

2360.3 MIXTURE DESIGN

A Mixture Design General

Include: It shall be the Contractor's responsibility to design the SMA asphalt mixture such that it meets the requirements of this specification and is in accordance with AASHTO PP41-02 Standard Practice for Designing Stone Matrix Asphalt (SMA). Additional information can be found in Appendix B of NAPA's Designing and Constructing SMA Mixtures-State-of-the-Practice, Quality Improvement Series 122. Mixture bulk specific gravity shall be determined by ASTM D6752 Mn/DOT modified (Corelok).

Insert:

B1a Desired Aggregate Blend

At least 7 working days prior to the start of asphalt production, the Contractor shall submit at least 150 lbs. of the coarse aggregate fraction from the selected design aggregate structure. This sample will be tested for the voids in coarse aggregate fraction (VCA_{drc}).

Modify Table 2360.3-B2a as follows :

**Table 2360.3-B2a
Mixture Aggregate Requirements**

| Aggregate Blend Property | Traffic Level 2& LV | Traffic Level 3 & MV | Traffic Level 4 | Traffic Level 5 | SMA T. Level 6 |
|--|--|--|------------------------|------------------------|---|
| 20 year Design ESAL's | <1 million | 1 - 3 million | 3 - 10 million | 10 - 30 million | |
| Coarse Aggregate Angularity (ASTM D5821) (one face / two face), %- Wear (one face / two face), %- NonWear | 30/- 30/- | 55 / - 55 / - | 85 / 80 60/ - | 95 / 90 80 / 75 | 100/90 N/A |
| Coarse Aggregate Absorption, % AASHTO T85, Mn/DOT modified | | | | | ≤ 2 |
| Void In Coarse Aggregate (VCA_{drc}) AASHTO PP41-02 & AASHTO T19 | | | | | VCA _{mix} < VCA _{drc} |
| Fine Aggregate Angularity (FAA) (AASHTO T304, Method A) %- Wear %-Non-Wear | 40 ⁽²⁾ 40 ⁽²⁾ | 42 ⁽¹⁾ 40 ⁽¹⁾ | 44 40 | 45 40 | -* - |
| Flat and Elongated Particles, max⁽²⁾ % by weight, (ASTM D 4791) | - | 10 (3:1 ratio) | 10 (3:1 ratio) | 10 (3:1 ratio) | 10 (3:1 ratio) |
| Clay Content⁽²⁾ (AASHTO T 176) | - | - | 45 | 45 | 45 |
| Total Spall in fraction retained on the 4.75mm (#4) sieve | 5.0 | 2.5 | 1.0 | 1.0 | 1.0 |
| Maximum Spall Content in Total Sample | 5.0 | 5.0 | 1.0 | 1.0 | 1.0 |
| Maximum Percent Lumps in fraction retained on the 4.75mm (#4) sieve | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Class B Carbonate Restrictions | | | | | |
| Maximum% -4.75mm (-#4) Final Lift/All other Lifts | 100/100 | 100/100 | 80/80 | 50/80 | 50/- |
| Maximum% +4.75mm (#4) Final Lift/All other Lifts | 100/100 | 100/100 | 50/100 | 0/100 | 0/- |
| Gyratory Max. allowable RAP percentage Wear /Non Wear | 30/40 | 30 | 30 | 30 | 0 |

* No FAA requirement, however, fine aggregate shall be 100% crushed.

Modify Table 2360.3-B2b as follows :

**Table 2360.3-B2b
Mixture Requirements**

| | Traffic Level 2 | Traffic Level 3 | Traffic Level 4 | Traffic Level 5 | SMA T. Level 6 |
|---|-------------------|-------------------|-------------------|-------------------|-------------------|
| 20 year Design ESAL's | < 1 million | 1 - 3 million | 3 - 10 million | 10 - 30 million | |
| Gyratory Mixture Requirements | | | | | |
| Gyrations for N _{initial} | 6 | 7 | 8 | 8 | - |
| Gyrations for N _{design} | 40 | 60 | 90 | 100 | 75 |
| Gyrations for N _{maximum} | 60 | 90 | 140 | 160 | - |
| Air Voids, % -- Wear | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Air Voids, % -- Non-Wear | 3.0 | 3.0 | 3.0 | 3.0 | |
| % G _{mm} at N _{initial} – Wear | - | ≤ 91.5 | ≤ 90.5 | ≤ 90.0 | - |
| % G _{mm} at N _{initial} – Non-Wear | - | ≤ 92.5 | ≤ 91.5 | ≤ 91.0 | - |
| % G _{mm} at N _{maximum} – Wear | ≤ 98.0 | ≤ 98.0 | ≤ 98.0 | ≤ 98.0 | - |
| % G _{mm} at N _{maximum} – NonWear | ≤ 99.0 | ≤ 99.0 | ≤ 99.0 | ≤ 99.0 | - |
| Tensile Strength Ratio ⁽¹⁾ , min% | 75 ⁽²⁾ | 75 ⁽²⁾ | 80 ⁽³⁾ | 80 ⁽³⁾ | 70 ⁽⁴⁾ |
| Fines/Effective Asphalt | 0.6 – 1.2 | 0.6 – 1.2 | 0.6 – 1.2 | 0.6 – 1.2 | 1.2-2.0 |
| VFA, % -- Wear | 65 - 78 | 65 - 78 | 65 - 76 | 65 - 76 | 70-80 |
| NonWear | 70 - 83 | 70 - 83 | 70 - 82 | 70 - 82 | - |
| Draindown - based on a 1 hour reading at the anticipated production temperature | | | | | ≤ 0.3 |
| Stabilizer by wt. Of total mix, % | | | | | 0.2-0.4 |
| VMA % | | | | | 17.0 |
| VCA Ratio | | | | | VCA Ratio<1.0 |

(1) See 2360.4 E9. Use 150mm (6-inch) specimens for gyratory.

(4) Mn/DOT Min = 60

Insert: 2360.3 B2d Minimum Asphalt Content

Asphalt content will be established based on the combined aggregate bulk specific gravity Gsb. The guidelines in Table 2360.3-B2d shall be used to determine the minimum asphalt content.

**Table 2360.3-B2d
Minimum Asphalt Content**

| Guide to adjust Minimum Asphalt Content based on Varying Bulk Specific Gravities (Gsb) of Combined Aggregates | |
|--|----------------------------------|
| Combined Aggregate Bulk Specific Gravity | Minimum Asphalt Content, Percent |
| <2.400 | 6.8 |
| 2.401-2.450 | 6.7 |
| 2.451-2.500 | 6.6 |
| 2.501-2.550 | 6.5 |
| 2.551-2.600 | 6.3 |
| 2.601-2.650 | 6.2 |

| | |
|-------------|-----|
| 2.651-2.700 | 6.1 |
| 2.701-2.750 | 6.0 |
| 2.751-2.800 | 5.9 |
| 2.801-2.850 | 5.8 |
| 2.851-2.900 | 5.7 |
| 2.901-2.950 | 5.6 |
| 2.951-3.000 | 5.5 |

Modify Table 2360.3-B3 as follows:

Compacted briquette air void content for gyratory design shall be 5.5 – 6.5%.

Insert under: 2360.3C Documentation, Additional Documentation for Gyratory Design:

(G1a) For each of the three trial blends, determine the Voids in the Coarse Aggregate-Dry Rodded Condition (VCA_{DRC}) according to AASHTO T19. The VCA ratio (VCA_{mix}/VCA_{DRC}) shall be less than 1.0, i.e. $VCA_{mix} < VCA_{DRC}$.

Modify 2360.3 C Documentation, under Additional Documentation for Gyratory Design, subsection (G2) with:

(G2) The design traffic level and the design number of gyrations at N_{design} .

Replace 2360.3 C Documentation, under Additional Documentation for Gyratory Design, subsection (G4) with:

(G4) Evidence that the completed mixture will conform to all specified physical requirements as follows: Design air voids (V_a), VMA, VFA, TSR, F/A_e (Fines to effective asphalt ratio), VCA ratio, draindown, minimum asphalt content and densification %G_{mm} at N_{design} .

Insert under: 2360.3 C Documentation, Additional Documentation for Gyratory Design:

(G6) Percent and manufacturer's data for type of stabilizer used.

Replace the 2nd paragraph of 2360.4 D Sampling and Testing as follows:

The tests for mixture properties shall be conducted on representative portions of the mix, quartered from a larger sample of mixture taken from the truck box. The mixture shall be sampled from the truck box at the plant site after the truck has been fully loaded. The procedure for truck box sampling is as follows:

- 1) In at least three random locations in the truck box and at least 1 foot away from the sides take equal increment samples that when combined will form a field sample whose quantity equals or exceeds the minimum required.
- 2) Agency personnel should monitor all samples obtained from the truck box.

Modify Table 2360.4-D as follows :

**Table 2360.4-D
Production Start-Up Testing Rates**

| Production Test | Testing Rates | Test Reference | Spec Section |
|-----------------------------|--|--------------------------------------|---------------------|
| Bulk Specific Gravity | 1 test per 450 metric tons (500 tons) | ASTM D6752 Mn/DOT modified (Corelok) | 2360.4E2a |
| Maximum Specific Gravity | 1 test per 450 metric tons (500 tons) | AASHTO T209 MnDOT modified | 2360.4E3 |
| Air Voids (calculated) | 1 test per 450 metric tons (500 tons) | AASHTO T269, T312 | 2360.4E4 |
| Asphalt Content | 1 test per 450 metric tons (500 tons) | Bit & Lab Manual | 2360.4E1 |
| VMA (Calculated) | 1 test per 450 metric tons (500 tons) | AI MS 2 & SP 2 | 2360.4E5 |
| Gradation | 1 test per 900 metric tons (1000 tons) | AASHTO T11 & T27 | 2360.4E6 |
| Fine Aggregate Angularity* | | | |
| Coarse Aggregate Angularity | 1 test per 900 metric tons (1000 tons) | ASTM D5821 | 2360.4E7 |
| VCA Ratio (calculation) | 1 test per 450 metric tons (500 tons) | AASHTO PP41-02 | 2360.4E14 |
| Draindown | 1 test per 450 metric tons (500 tons) | AASHTO T305 | 2360.3 |

* No FAA requirement, however, fine aggregate shall be 100% crushed.

Insert:

2360.4D1 SMA Test Strip

The Contractor cannot begin full-scale production of the SMA mixture until it is shown, in a test strip, that the mixture can be produced, placed, and compacted to the requirements of this specification. The test strip shall be limited to 500 tons with a minimum requirement of 200 tons placed at the specified thickness and width indicated in the contract. During construction of the test strip the Contractor shall take a minimum of 2 mixture samples to determine mixture properties as shown in Table 2360.4-D. One sample shall be taken within the first 100 tons of mixture produced and the other shall be taken randomly within the remaining mixture produced. After both samples are obtained production of the SMA will cease until mixture properties are tested and evaluated by both the Contractor and the Department. Production will be allowed to resume when:

- 1) The Contractor's and the Department's test results are within the allowable testing tolerances shown in Table 2360.4-M, and
- 2) Each of the Contractor's test results are within the JMF limits as indicated on the Mixture Design Report and Table 2360.4-H, and
- 3) The average of the two Contractor test results meets the requirements of 2360.3-B2b, and

- 4) The average of two cores from the roadway meets the minimum density requirement as specified in this provision. One core shall be taken at random in the area representative of where the first mixture sample was obtained. The other core shall be taken at random in the area representative of the second mixture sample.

If the material in the test strip does not meet the requirements listed above another test strip will be required. With the approval of the Engineer, the test strip may be placed within the project limits.

Modify Table 2360.4-E as follows :

**Table 2360.4-E
Production Sampling and Testing Rates**

| Production Test | Sampling/Testing Rates | Test Reference | Spec Section |
|---|---|--|---------------------|
| Bulk Specific Gravity | Divide the planned production by 1000. Round the number to the next higher whole number. | ASTM D6752 Mn/DOT modified (Corelok) | 2360.4E2a |
| Maximum Specific Gravity | " | AASHTO T209 MnDOT modified | 2360.4E3 |
| Air Voids (calculated) | " | AASHTO T312 | 2360.4E4 |
| Asphalt Content | " | Bit & Lab Manual | 2360.4E1 |
| VMA (Calculated) | " | AI MS 2 & SP 2 | 2360.4E5 |
| Gradation | 1 gradation per 1,800 metric tons (2,000 tons), or portion thereof (minimum of one per day) | AASHTO T11 & T27 | 2360.4E6 |
| Coarse Aggregate Angularity | 2 tests/day for a minimum of 2 days, then 1 per day if CAA is met. If CAA >8% of requirement, 1 sample/day but test 1/week. | ASTM D5821 | 2360.4E7 |
| Fine Aggregate Angularity (FAA)* | | | |
| TSR | 1 st sample at 5,000 tons or by second day of production, then sample at every 18,000 metric tons (20,000 tons) | ASTM D4867 MnDOT modified | 2360.4E9 |
| Aggregate Specific Gravity & Absorption | 1 per 9,000 metric tons (10,000 tons) | AASHTO T84 & T85, MnDOT modified | 2360.4E10 |
| Mixture Moisture Content | Daily unless exempted by Engineer | MnDOT 5-693.950 | 2360.4E11 |
| Asphalt Binder | Sample 1 st load (each grade) then 1 per 1,000,000 liter (250,000 gal)-sample size 1 qt. | MnDOT 5-693.920 | 2360.4E12 |
| Draindown | 1 test per day | AASHTO T305 | 2360.4E13 |
| Voids in Coarse Aggregate (VCA) Ratio | Divide the planned production by 1000. Round the number to the next higher whole number. | AASHTO PP41-02 | 2360.4E14 |

* No FAA requirement, however, fine aggregate shall be 100% crushed.

Replace 2360.4E2a with:

Gyratory Bulk Specific Gravity, G_{mb} (2 specimens).....ASTM D6752 Mn/DOT modified (Corelok).

Insert: 2360.4 E13 Draindown Test.....AASHTO T305

Draindown that exceeds 0.3% is unacceptable. The Contractor shall take appropriate action to bring draindown values into specification. This action may include checking to determine if the stabilizer is being added, if the rate of adding stabilizer is correct and

checking if the mixing temperature is excessive. The draindown test shall be performed at the production plant mixing temperature.

Insert:

2360.4 E14 Voids in Coarse Aggregate (VCA) Ratio Calculation...AASHTO PP41-02

A VCA ratio greater than 1.0% is unacceptable. If the VCA ratio is greater than 1.0% the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made.

Modify 2360.4F Documentation (Records) to include:

- 16. VCA ratio
- 17. Draindown value in %

Modify 2360.4 G to include:

- (6) VCA ratio
- (7) Draindown value in %

Replace Table 2360.4-H with:

**Table 2360.4-H
JMF Limits (N=4)**

| Item | JMF Limits |
|---|------------|
| VMA, % | - 0.3 |
| % G_{mm} @ N_{design} / Production Air Void | ± 1.0 |
| Asphalt Binder Content, Percent | ± 0.4 |
| Sieve - % Passing* | |
| 25, 19, 12.5, 9.5 mm (1", 3/4", 1/2", 3/8") | ± 4 |
| 4.75, 2.36 mm (No. 4, No. 8) | ± 3 |
| 0.075 mm (No. 200) | ± 2.0 |

* JMF target values are not allowed outside the broadband requirements in Table 2360.2-E.

2360.4E 10 Modify Title:

Aggregate Specific Gravity (Gsb) and Aggregate AbsorptionAASHTO T84 and T85 MnDOT modified

Modify 2360.5 B Restrictions as follows:

Placement of SMA mixtures will be allowed only when the ambient air temperatures are at least 10C (50F).

Replace 2360.6 Pavement Density, A General, with:

All pavements will be compacted in accordance with the Maximum Density Method unless otherwise specified in the contract special provisions or as noted in 2360.6C. Breakdown rolling shall start immediately after mixture placement. Steel-wheeled rollers in the vibratory mode and pneumatic-tired rollers will only be allowed when approved by the Engineer.

Replace 2360.6B1a Pavement Density Determination with:

The density of each lot shall be expressed as a percentage of the maximum specific gravity (% G_{mm}) obtained by dividing the average bulk specific gravity for the lot by the maximum specific gravity multiplied by 100, (maximum specific gravity basis is the average G_{mm} of QC tests done on the day that the individual lot was paved as described above). Determination of the bulk specific gravity of the cores shall be in accordance with ASTM D6752 Mn/DOT modified (Corelok).

Compaction operations shall be completed within 8 hours of mixture placement and before core samples are obtained for density determination. Only static steel rollers are permitted for any compactive effort performed between 6 and 8 hours after mixture placement.

Compacted mixtures represented by samples or tests having deficient densities shall not be re-rolled. The Contractor shall not operate below the specified minimum density on a continuing basis. A continual basis shall be defined as all lots in a day's production failing to meet minimum density or more than 50% of lots on multiple days which fail to meet minimum density requirements. Production shall be stopped until the source of the problem is determined and corrective action is taken to bring the work into compliance with specified minimum required density.

Replace Table 2360.6-B2 with:

**Table 2360.6-B2
Required Minimum Density for SMA**

| | |
|--------------|-------------|
| % Gmm | 93.0 |
|--------------|-------------|

Replace Table 2360.6-B5 with:

**Table 2360.6-B5
Payment Schedule for Maximum Density**

| Percent of Maximum Specific Gravity ⁽²⁾ | Percent Payment |
|--|-----------------|
| Above 97.0 | 98 |
| 93.0 – 97.0 | 100 |
| 91.0 – 92.9 | 98 |
| 89.0-90.9 | 95 |
| Less than 89.0 | (4) |

(4) See note (4) under 2360.6B5

Delete Table 2360.6-B5A