M 325

STANDARD SPECIFICATION FOR STONE MATRIX ASPHALT (SMA) FOP FOR AASHTO M 325

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Scope

This FOP covers the design of Stone Matrix Asphalt (SMA) using the Superpave Gyratory Compactor (SGC). The SMA design is based on volumetric properties of the SMA in terms of air voids (V_a), voids in mineral aggregate (VMA), and the presence of stone-on-stone contact.

This standard specifies minimum quality requirements governing binder, aggregate, mineral filler, stabilizing additives, and mixture specifications for SMA mix designs.

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Terminology

- **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.
- **SMA Mortar**
  A mixture of asphalt binder, filler (material passing the No. 200 sieve), and stabilizing additive.

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- **Stabilizing Additive**
  Either cellulose or mineral fiber.
- **Stone Matrix Asphalt (SMA)**
  A Hot-Mix Asphalt (HMA) mixture consisting of a coarse aggregate skeleton with stone-on-stone contact, and a rich asphalt binder mortar.

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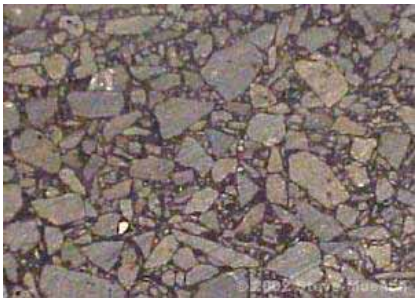
- **Stone-on-Stone Contact**
  The point where the VCA of the compacted mixture is less than the VCA of the dry-rodded coarse aggregate.



SMA
Stone-On-Stone Contact

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- **Voids in the Coarse Aggregate (VCA)**
  Volume of voids between coarse aggregate particles in the combined grading.
- **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.

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Significance and Use

- AASHTO M 325 may be used for designing and evaluating material and mixture properties for SMA.

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Binder Requirements

The binder shall meet the following:

- Performance-graded
- Meet requirements of AASHTO M 320
- Appropriate for climate and traffic loading
- Or as specified by the contract documents

Guidance for selection of the appropriate binder is provided in the FOP for AASHTO M 323.

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Aggregate Requirements

- Coarse Aggregate:
  Coarse aggregates shall be 100 percent crushed and conform to the quality requirements of Table 1.
- Fine Aggregate:
  Fine aggregates shall be 100 percent crushed and conform to the quality requirements of Table 2.

Table 1

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Coarse Aggregate Quality Requirements

Test	Method	Minimum	Maximum
Los Angeles (L.A.) Abrasion, percent loss	T 96	N/A	30 [a]
Flat and Elongated, percent [b] 3 to 1 ratio 5 to 1 ratio	D 4791	 N/A N/A	 20 5
Absorption, percent	T 85	N/A	2.0
Soundness (5 Cycles), percent [c] Sodium Sulfate, or Magnesium Sulfate	T 104	 N/A N/A	 15 20
Crushed Content, percent One Face Two Face	D 5821	 100 90	 N/A N/A

[a] Aggregates with higher L.A. Abrasion values have been used successfully to produce SMA mixes. However, when the abrasion exceeds 30, excessive breakdown may occur in the laboratory compaction process or during in-place compaction.

[b] Flat and Elongated criteria apply to the design aggregate blend.

[c] Sodium or magnesium sulfate may be used. It is not required to perform both methods.

Table 2

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Fine Aggregate Quality Requirements

Test	Method	Minimum	Maximum
Soundness (5 Cycles), percent [a] Sodium Sulfate, or Magnesium Sulfate	T 104	 N/A N/A	 15 20
Liquid Limit, percent	T 89	N/A	25
Plasticity Index, percent	T 90	Non-plastic	

[a] Sodium or magnesium sulfate may be used. It is not required to perform both methods.

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Note 1: It is recommended that mineral fillers with modified Rigden voids (IS 127) higher than 50 percent not be used in SMA. Experience has shown that such fillers excessively stiffen the SMA mortar.

Mineral Filler

- Consisting of finely divided mineral matter such as crusher fines and fly ash.
- Sufficiently dry to flow freely and essentially free of agglomerations.
- Free from organic impurities and having a plasticity index not greater than four.

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Stabilizing Additive

- A stabilizer such as cellulose or mineral fiber will be added to the mixture to prevent excessive draindown. To maximize durability (through binder volume), fibers may be added regardless of draindown.
- Maximum draindown performed according to the FOP for AASHTO T 305 shall not exceed 0.3 percent by weight of the mix when held at the plant temperature for one hour.
- Cellulose dosage rate: Approximately 0.3 percent or more by total mixture mass and sufficient to prevent draindown.
- Mineral fiber dosage rate: Approximately 0.4 percent by total mixture mass and sufficient to prevent draindown.

Note 2: If the draindown from plant-produced samples exceeds that of laboratory-prepared samples the quantity of the stabilizer should be increased.

SMA Design Requirements

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Combined Aggregate Requirements

- The combined aggregates shall conform to the requirements of Table 3.
- When the oven-dry bulk specific gravities, G_{sb}(OD), of the different materials to be used in the mixture vary by more than 0.2, the trial blend gradation shall be based on volumetric percentage.

Table 3

SMA Specification Gradation Bands

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Sieve Size, in. (mm)	Nominal Maximum Aggregate Size					
	3/4" (19 mm)		1/2" (12.5 mm)		3/8" (9.5 mm)	
	Lower	Upper	Lower	Upper	Lower	Upper
1 (25)	100	---	---	---	---	---
3/4 (19)	90	100	100	---	---	---
1/2 (12.5)	50	88	90	100	100	---
3/8 (9.5)	25	60	50	80	70	95
No. 4 (4.75)	20	28	20	35	30	50
No. 8 (2.36)	16	24	16	24	20	30
No. 16 (1.18)	---	---	---	---	---	21
No. 30 (0.60)	---	---	---	---	---	18
No. 50 (0.30)	---	---	---	---	---	15
No. 200 (0.075)	8.0	11.0	8.0	11.0	8.0	12.0

17 **SMA Mixture Design Requirements**.

- The designed SMA mixture shall meet the requirements of Table 4.
- Determine Tensile Strength Ratio (TSR) of the SMA mixture according to the FOP for T 283 at 6.0 ± 1.0 percent air voids. Compact specimens according to the FOP for T 312.
- Draindown sensitivity shall be determined on the SMA mixture according to the FOP for T 305.

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Table 4

SMA Mixture Specifications for Superpave Gyratory Compactor [a]

Property	Requirement
Air Voids, percent	4.0 (Note 3)
VMA, percent	17.0 minimum
VCA_{MIX}	Less than VCA_{DRC} (Note 4)
TSR	0.80 minimum
Draindown at Production Temperature, percent	0.3 maximum
Asphalt Binder Content, percent	6.0 minimum (Note 5)

[a] SMA Mixture Specification refers to specimens compacted in accordance with T 312 at 100 gyrations. When aggregates have an abrasion loss greater than 30 percent, the desirable number of SGC design gyrations is 75.

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Note 3: For low-traffic volume roadways or colder climates, target air void contents less than 4.0 percent can be used, but should not be less than 3.0 percent.

Note 4: See R 46 for instructions on calculating VCA_{MIX} and VCA_{DRC}.

Note 5: Binder contents should be from 6.0 to 7.0 percent. Lowering the binder content below 6.0 percent may be detrimental to the SMA durability. Refer to guidance given on this issue in the FOP for R 46 when an SMA mixture cannot be designed within the minimum binder limits of Table 4.

REVIEW QUESTIONS

1. With what specification must the binder comply?

2. What are the binder requirements for use in SMA mix design?

3. What tests are performed for evaluation of compliance with coarse and fine aggregate requirements? How does this differ from those for standard Superpave mixes as described in M 323?

4. Describe requirements for mineral filler.

5. Why are stabilizing additives used? What approximate dosage rates are specified for the types noted in the FOP?

6. What is the maximum draindown permitted according to the FOP? What AASHTO test method is used for determining draindown characteristics?

7. When is it required to calculate combined aggregate grading based on volume rather than mass?

8. How do TSR requirements differ from those specified for standard Superpave mixes?

9. Describe requirements for target air void content. How does this differ from that specified for standard Superpave mixes?

10. How many gyrations of the SGC are required for an SMA design? How does this differ from that specified for standard Superpave mixes?