
Standard Specification for Superpave Volumetric Mix Design

AASHTO Designation: M 323-22¹

Technically Revised: 2022

**Technical Subcommittee: 2d, Proportioning
of Asphalt–Aggregate Mixtures**



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1. SCOPE

- 1.1. This specification for Superpave volumetric mix design uses aggregate and mixture properties to produce job-mix formulas for asphalt mixtures. It includes the original Superpave design method based on four percent air voids and the Superpave5 design method based on five percent air voids.
- 1.2. This standard specifies minimum quality requirements for binder, aggregate, and asphalt mixtures 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.*
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2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- < M 320, Performance-Graded Asphalt Binder
 - < M 332, Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test
 - < R 28, Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
 - < R 35, Superpave Volumetric Design for Asphalt Mixtures
 - < R 59, Recovery of Asphalt Binder from Solution by Abson Method
 - < T 11, Materials Finer Than 75- μ m (No. 200) Sieve in Mineral Aggregates by Washing
 - < T 27, Sieve Analysis of Fine and Coarse Aggregates
 - < T 164, Quantitative Extraction of Asphalt Binder from Asphalt Mixtures
 - < T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
 - < T 240, Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
 - < T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
 - < T 304, Uncompacted Void Content of Fine Aggregate
 - < T 308, Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
 - < T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
 - < T 313, Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)

- T 315, Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
- T 319, Quantitative Extraction and Recovery of Asphalt Binder from Asphalt Mixtures
- T 335, Determining the Percentage of Fracture in Coarse Aggregate

2.2. *ASTM Standard:*

- D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

2.3. *National Asphalt Pavement Association Publication:*

- IS 128, HMA Pavement Mix Type Selection Guide
<https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/asphalt/HMA.pdf>

2.4. *Other References:*

- *LTPP Seasonal Asphalt Concrete Pavement Temperature Models*. LTPPBind, <https://infopave.fhwa.dot.gov/Tools/LTPPBindOnline>

Note 1—The different generations of the LTPPBind program use different algorithms and weather databases for determining the PG high temperature for a location. The choice of which LTPPBind version to use is up to the specifier.

- *NCHRP Report 452: Recommended Use of Reclaimed Asphalt Pavement in the Superpave Mix Design Method: Technician's Manual*. National Cooperative Highway Research Program Project D9-12, TRB, National Research Council, Washington, DC, 2001.

3. TERMINOLOGY

- 3.1. *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.
- 3.2. *binder content* (P_b)—the percent by mass of binder in the total mixture, including binder and aggregate.
- 3.3. *binder content RAP* (P_{bRAP})—the percent by mass of binder in the RAP based on total RAP, including binder and aggregate.
- 3.4. *asphalt mixtures*—includes hot mix and warm mix asphalt.
- 3.5. *design ESALs*—design equivalent (80-kN) single-axle loads.
- 3.5.1. *discussion*—design ESALs are the anticipated project traffic level expected on the design lane over a 20-yr period. For pavements designed for more or less than 20 yr, determine the design ESALs for 20 yr when using this standard.
- 3.6. *dust-to-binder ratio* ($P_{0.075}/P_{be}$)—by mass, the ratio between the percent of aggregate passing the 75- μm (No. 200) sieve ($P_{0.075}$) and the effective binder content (P_{be}).
- 3.7. *maximum aggregate size*—one size larger than the nominal maximum aggregate size (Note 2).

Note 2—The definitions given in Sections 3.7 and 3.8 apply to Superpave mixtures only and differ from the definitions published in other AASHTO standards.

- 3.8. *nominal maximum aggregate size*—one size larger than the first sieve that retains more than 10 percent aggregate (Note 2).
- 3.9. *primary control sieve (PCS)*—the sieve defining the break point between fine- and coarse-graded mixtures for each nominal maximum aggregate size.
- 3.10. *reagent-grade solvent*—a solvent meeting the level of chemical purity as to conform to the specifications for “reagent grade” as established by the *Committee on Analytical Reagents of the American Chemical Society* and used to extract the asphalt binder from the mixture. When asphalt binder is intended to be extracted and then tested for additional properties, a reagent-grade solvent must be used. Non-reagent-grade solvents may contain epoxy resins that may affect the properties of the recovered binder. In particular, certain acid-modified binders may be affected by non-reagent grade solvents.
- 3.11. *reclaimed asphalt pavement (RAP)*—removed and/or processed pavement materials containing asphalt binder and aggregate.
- 3.12. *reclaimed asphalt pavement binder ratio (RAPBR)*—the ratio of the RAP binder in the mixture divided by the mixture’s total binder content.
- 3.13. *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 percentage of the total volume of the specimen.
- 3.14. *voids filled with asphalt (VFA)*—the percentage of the VMA filled with binder (the effective binder volume divided by the VMA).

4. SIGNIFICANCE AND USE

- 4.1. This standard may be used to select and evaluate materials for Superpave volumetric mix designs. At an agency’s discretion, this standard may be used to select and evaluate materials for Superpave5 volumetric mix designs. Unless noted, all sections apply to Superpave and Superpave5. Requirements specific to Superpave5 are contained in Annex A.

5. BINDER REQUIREMENTS

- 5.1. The binder shall be a performance-graded (PG) binder, meeting the requirements of M 320 or M 332, 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 can 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 are not available, and representative data from the nearest appropriate weather stations 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 the requirements of M 320 apply and the 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. If the requirements of M 332 apply, follow those requirements for the appropriate binder selection.

Table 1—Binder Selection on the Basis of Traffic Speed and Traffic Level for Binder Meeting M 320

Design ESALs ^b (Million)	Adjustment to the High-Temperature Grade of the Binder ^a		
	Traffic Load Rate		
	Standard ^c	Slow ^d	Standing ^e
<0.3	—	—	— ^f
0.3 to <3	—	1	2
3 to <10	—	1	2
10 to <30	— ^f	1	2
≥30	1	1	2

^a 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.

^b The anticipated project traffic level expected on the design lane over a 20-yr period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 yr.

^c *Standard traffic*—where the average traffic speed is greater than 70 km/h.

^d *Slow traffic*—where the average traffic speed ranges from 20 to 70 km/h.

^e *Standing traffic*—where the average traffic speed is less than 20 km/h.

^f Consideration should be given to increasing the high-temperature grade by one grade equivalent.

Note 4—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).

- 5.3. If RAP is to be used in the mixture, it may be specified according to percent dry weight (mass) of the mixture or by reclaimed asphalt pavement binder ratio.
- 5.3.1. *Percent dry weight (mass) of mixture*—If the agency elects to use RAP adjustments by percent dry weight (mass) of the mixture, the binder grade selected in Sections 5.1.3 and 5.2 needs to be adjusted according to Table 2 to account for the amount and stiffness of the RAP binder. Procedures for developing a blending chart are included in Appendix X1.

Table 2—Binder Selection Guidelines for Reclaimed Asphalt Pavement (RAP) Mixtures

Recommended Virgin Asphalt Binder Grade	RAP Percentage
No change in binder selection	<15
Select virgin binder one grade softer than normal (e.g., select a PG 58-28 if a PG 64-22 would normally be used)	15 to 25
Follow recommendations from Appendix X1	>25

Note 5—An Agency may alter the virgin binder selection criteria from Table 2 based on the research procedures provided in Appendix X2 and field experiences.

- 5.3.2. *Reclaimed asphalt pavement binder ratio*—If the agency elects to use the RAPBR method, the binder grade selected in Sections 5.1.3 and 5.2 must be adjusted according to Table 3 to account for the amount of stiffness of the RAP binder. Procedures for developing a blending chart are included in Appendix X2.

Table 3—Binder Selection Guidelines for Reclaimed Asphalt Pavement (RAP) Mixtures

Recommended Virgin Asphalt Binder Grade	RAPBR
No change in binder selection	<0.25
Follow recommendations from Appendix X2	>0.25

$$RAPBR = \frac{(P_{bRAP} \times P_{RAP})}{100 \times P_{bTotal}} \quad (1)$$

where:

$RAPBR$ = Reclaimed asphalt pavement binder ratio to nearest 0.01;

P_{bRAP} = Binder content of the RAP to nearest 0.1%;

P_{RAP} = RAP percentage by weight of mixture to nearest 0.1%; and

P_{bTotal} = Total binder content in the mixture to nearest 0.1%.

Note 6—A mixture performance test for cracking implemented by an agency is acceptable in lieu of the RAPBR binder selection criteria in Section 5.3.2.

6. COMBINED AGGREGATE REQUIREMENTS

6.1. Size Requirements:

6.1.1. *Nominal Maximum Aggregate Size*—The combined aggregate shall have a nominal maximum aggregate size of 4.75 to 19.0 mm for asphalt pavement surface courses and no larger than 37.5 mm for asphalt pavement subsurface courses.

Note 7—Additional guidance on selection of the appropriate nominal maximum aggregate size mixture can be found in the National Asphalt Pavement Association's IS 128.

6.1.2. *Gradation Control Points*—The combined aggregate shall conform to the gradation requirements specified in Table 4 when tested according to T 11 and T 27.

Table 4—Aggregate Gradation Control Points

Sieve Size, mm	Nominal Maximum Aggregate Size—Control Points (% Passing)											
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm		4.75 mm	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
50.0	100	—	—	—	—	—	—	—	—	—	—	—
37.5	90	100	100	—	—	—	—	—	—	—	—	—
25.0	—	90	90	100	100	—	—	—	—	—	—	—
19.0	—	—	—	90	90	100	100	—	—	—	—	—
12.5	—	—	—	—	—	90	90	100	100	—	100	—
9.5	—	—	—	—	—	—	—	90	90	100	95	100
4.75	—	—	—	—	—	—	—	—	90	90	90	100
2.36	15	41	19	45	23	49	28	58	32	67	—	—
1.18	—	—	—	—	—	—	—	—	—	—	30	55
0.075	0	6	1	7	2	8	2	10	2	10	6	13

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 5 (also see Figure 1). All other gradations shall be classified as fine-graded.