

**Standard Practice for
Volumetric Analysis of
Compacted Hot-Mix Asphalt (HMA)**

AASHTO Designation: PP19-93^{1,2} (Reapproved 1996)

1. Scope

1.1 This standard provides procedures to accomplish the volumetric analysis of compacted modified and unmodified HMA specimens.

1.2 This standard presents methods for determining (1) the volume percent of air voids (P_a , also termed the air voids content), (2) the volume percent of voids in the mineral aggregate (VMA), (3) the effective volume of asphalt binder (V_{fa} , also termed the voids filled with asphalt, Note 1), and (4) the effective asphalt content (P_{be}) of compacted HMA specimens. Values of these properties are calculated from the measured specific gravities of the asphalt binder, the coarse and fine aggregate, and the compacted HMA.

Note 1 -- This quantity is usually expressed as the percent voids filled with asphalt binder, P_{fa} ; this is the portion of the percent voids in the mineral aggregate that are filled with asphalt binder (Section 6.7).

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

2. Referenced Documents

2.1 AASHTO Standards:

- T84 Specific Gravity and Absorption of Fine Aggregate
- T85 Specific Gravity and Absorption of Coarse Aggregate
- T100 Specific Gravity of Soils

- T164 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
- T166 Bulk Specific Gravity of Compacted Bituminous Mixtures
- T168 Sampling Bituminous Paving Mixtures
- T170 Recovery of Asphalt from Solution by the Abson Method
- T209 Maximum Specific Gravity of Compacted Bituminous Mixtures
- T228 Specific Gravity of Semi-Solid Bituminous Materials

3. Terminology

3.1 Description of Terms Specific to this Standard

3.1.1 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 percent of the bulk volume of the compacted paving mixture. (Note 2)

Note 2 - Term defined in Asphalt Institute Manual MS-2.

3.1.2 Voids in the Mineral Aggregate, VMA - the volume of intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective asphalt content, expressed as a percent of the total volume of the specimen. (Note 2)

3.1.3 Effective Asphalt Content, P_{be} - the total asphalt content of a paving mixture less the portion of asphalt binder that is lost by absorption into the aggregate particles. (Note 2)

3.1.4 Voids Filled with Asphalt, V_{fa} - the portion of the voids in the mineral aggregate that contain asphalt binder. This represents the volume of the effective asphalt content. It is calculated by the equation:

¹ This standard is based on SHRP Product P004 and Asphalt Institute Manual MS-2, Mix Design Methods For Asphalt Concrete, 6th Edition, Chapter VI, Analysis of Compacted Paving Mixtures, The Asphalt Institute, Lexington, Kentucky, 1993 Printing.

² Approved in October 1993, this provisional standard was first published in March 1994. Reconfirmed in January 2001.

$$V_{fa} = VMA - V_a$$

3.1.5 Bulk Specific Gravity, G_{sb} - the ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass in air (of equal density) of an equal volume of gas-free distilled water at a stated temperature. (Note 2)

3.1.6 Effective Specific Gravity, G_{se} - the ratio of the mass in air of a unit volume of a permeable material (excluding voids permeable to asphalt) at a stated temperature to the mass in air (of equal density) of an equal volume of gas-free distilled water at a stated temperature. (Note 2)

3.1.7 Theoretical Maximum Specific Gravity, G_{mm} - the ratio of the mass of a given volume of voidless ($V_a = 0$) HMA at a stated temperature (usually 25°C) to a mass of an equal volume of gas-free distilled water at the same temperature.

3.1.8 Volume of Absorbed Asphalt, V_{ba} - the volume of asphalt binder in the HMA that has been absorbed into the pore structure of the aggregate. It may be calculated by the equation:

$$V_{ba} = V_a + V_b - VMA$$

where V_b is the volume of the total mass of asphalt binder in the HMA. V_{ba} is the volume of asphalt binder in the HMA that is not accounted for by the effective asphalt content.

4. Significance and Use

4.1 The proper design and field control of HMA volumetric parameters are critical to achieving satisfactory long-term pavement performance.

5. Procedure

5.1 Determine the percent of asphalt binder and aggregate by the total mass of the mixture using T164, and report the values determined as P_b and P_s , respectively. Recover the asphalt binder in the extract using T170.

5.2 Separate the aggregate into three fractions: the

coarse aggregate fraction (material retained on the 4.75-mm sieve), the fine aggregate fraction, and the mineral filler fraction (material passing the 0.075-mm sieve). Determine the percent of each fraction by the total mass of the aggregate and report as P_1 , P_2 and P_3 , respectively.

5.3 Measure the specific gravity of: the asphalt binder using T228, the coarse aggregate using T85, the fine aggregate using T84, and the mineral filler using T100. Report the specific gravity values determined as G_b , G_1 , G_2 and G_3 , respectively.

Note 3 - The accuracy of determinations of specific gravity for mix design is extremely important. When specific gravities are determined to less than three decimal places (four significant figures), an absolute error in the calculation of the air voids content of as much as 0.8 percent can occur (e.g. an actual value of 4.2 percent may be measured anywhere in the range of 3.4 to 5.0 percent). Therefore, balances of appropriate sensitivity to yield four significant figures should be used to measure the masses employed in the specific gravity determinations.

5.4 Measure the theoretical maximum specific gravity of the uncompacted HMA using T209 and report as G_{mm} . (Note 3)

Note 4 -- Caution should be used when measuring the theoretical maximum specific gravity of HMA containing highly absorptive aggregates. Work conducted in SHRP Contract A-003B demonstrated that absorption may continue over a period of hours, and the value of G_{mm} may change significantly until absorption is completed.

5.5 Measure the bulk specific gravity of the compacted HMA using T166 and report as G_{mb} . (Note 3)

6. Calculations

6.1 Calculate the bulk specific gravity, G_{sb} , of the combined aggregate recovered from the HMA by the following equation: