Transportation Technician
Qualification Program

ASPHALT I
Workbook

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Field Operating Procedures

PREFACE

This module is one of a set developed for the Western Alliance for Quality Transportation Construction (WAQTC). WAQTC is an alliance supported by the western state Transportation Departments, along with the Federal Highway Administration (FHWA) and the Western Federal Lands Highway Division (WFLHD) of FHWA. WAQTC's charter includes the following mission.

MISSION

Provide continuously improving quality in transportation construction.

Through our partnership, we will:

- Promote an atmosphere of trust, cooperation, and communication between government agencies and with the private sector.
- Assure personnel are qualified.
- Respond to the requirements of identified needs and new technologies that impact the products that we provide.

BACKGROUND

There are two significant driving forces behind the development of the WAQTC qualification program. One, there is a trend to the use of quality control/quality assurance (QC/QA) specifications. QC/QA specifications include qualification requirements for a contractor's QC personnel and will be requiring WAQTC qualified technicians. Two, Federal regulation on materials sampling and testing (23 CFR 637, *Quality Assurance Procedures for Construction*, published in June 1995) mandates that by June 29, 2000 all testing technicians whose results are used as part of the acceptance decision shall be qualified. In addition, the regulation allows the use of contractor test results to be used as part of the acceptance decision.

OBJECTIVES

WAQTC's objectives for its Transportation Technician Qualification Program include the following:

- To provide highly skilled, knowledgeable materials sampling and testing technicians.
- To promote uniformity and consistency in testing.
- To provide reciprocity for qualified testing technicians between states.
- To create a harmonious working atmosphere between public and private employees based upon trust, open communication, and equivalency of qualifications.

Training and qualification of transportation technicians is required for several reasons. It will increase the knowledge of laboratory, production, and field technicians – both industry and agency personnel – and increase the number of available, qualified testers. It will reduce problems associated with test result differences. Regional qualification eliminates the issue of reciprocity between states and allows qualified QC technicians to cross state lines without having the concern or need to be requalified by a different program.

The WAQTC Executive Board

FOREWORD

This module is one of seven developed to satisfy the training requirements prescribed by Western Alliance for Quality Transportation Construction (WAQTC) for technicians involved in transportation projects. The seven modules cover:

- Aggregate
- Concrete
- Asphalt I
- Asphalt II
- Embankment and Base
- In-place Density
- Embankment and Base/In-place Density
- Self-Consolidating Concrete

The modules are based upon AASHTO test methods along with procedures developed by WAQTC. They are narrative in style, illustrated, and include step-by-step instruction. There are review questions at the end of each test procedure, which are intended to reinforce the participants' understanding and help participants prepare for the final written and performance exams. Performance exam check lists are also included. The appendix includes WAQTC Field Operating Procedures (FOPs) in short form.

It is the technician's responsibility to stay current as changes are made to this living document.

The comments and suggestions of every participant are essential to the continued success and high standards of the Transportation Technician Qualification Program. Please take the time to fill out the Course Evaluation Form as the course progresses and hand it in on the last day of class. If you need additional room to fully convey your thoughts, please use the back of the form.

The WAQTC Executive Board

GUIDANCE FOR COURSE EVALUATION FORM

The Course Evaluation Form on the following page is very important to the continuing improvement and success of this course. The form is included in each Participant Workbook. During the course introduction, the Instructor will call the participants’ attention to the form, its content, and the importance of its thoughtful completion at the end of the course. Participants will be encouraged to keep notes, or write down comments as the class progresses, in order to provide the best possible evaluation. The Instructor will direct participants to write down comments at the end of each day and to make use of the back of the form if more room is needed for comments.

On the last day of the course, just before the written examination, the Instructor will again refer to the form and instruct participants that completion of the form after their last examination is a requirement before leaving. Should the course have more than one Instructor, participants should be directed to list them as A, B, etc., with the Instructor’s name beside the letter, and direct their answers in the Instructor Evaluation portion of the form accordingly.

WESTERN ALLIANCE FOR QUALITY TRANSPORTATION CONSTRUCTION COURSE EVALUATION FORM

The WAQTC Transportation Technician Qualification Program would appreciate your thoughtful completion of all items on this evaluation form. Your comments and constructive suggestions will be an asset in our continuing efforts to improve our course content and presentations.

Course Title: ____________________

Location: ____________________

Dates: ____________________

Your Name (Optional): ____________________

Employer: ____________________

Instructor(s) ____________________

COURSE CONTENT

Will the course help you perform your job better and with more understanding? Yes Maybe No

Explain: ____________________

____

Was there an adequate balance between theory, instruction, and hands-on application? Yes Maybe No

Explain: ____________________

____

Did the course prepare you to confidently complete both examinations? Yes Maybe No

Explain: ____________________

____

What was the most beneficial aspect of the course? ____________________

____

What was the least beneficial aspect of the course? ____________________

____

GENERAL COMMENTS

General comments on the course, content, materials, presentation method, facility, registration process, etc. Include suggestions for additional Tips!

INSTRUCTOR EVALUATION

Were the objectives of the course, and the instructional and exam approach, clearly explained? Yes Maybe No

Explain:

Was the information presented in a clear, understandable manner? Yes Maybe No

Explain:

Did the instructors demonstrate a good knowledge of the subject? Yes Maybe No

Explain:

Did the instructors create an atmosphere in which to ask questions and hold open discussion? Yes Maybe No

Explain:

COURSE OBJECTIVES AND SCHEDULE

Learning Objectives

Understanding:

- Quality Assurance (QA) concepts
- Measurements and calculations
- Highway materials terminology
- Safety issues
- Random sampling techniques
- Basics of asphalt
- Demonstrating proficiency in the following test procedures:

  FOP for AASHTO R 97
    Sampling Asphalt Mixtures

  FOP for AASHTO R 47
    Reducing Samples of Asphalt Mixtures to Testing Size

  FOP for AASHTO T 329
    Moisture Content of Asphalt Mixtures by Oven Method

  FOP for AASHTO T 308
    Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method

  FOP for AASHTO T 209
    Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures

  FOP for AASHTO T 166
    Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

  FOP for AASHTO R 66
    Sampling Asphalt Materials

  FOP for AASHTO T 30
    Mechanical Analysis of Extracted Aggregate

The overall goals of this asphalt course are to understand the basics of asphalt and to be competent with specific quality control test procedures identified for the Transportation Technician Qualification Program of the Western Alliance for Quality Transportation Construction (WAQTC). Additional studies beyond this course will be required for those desiring greater in-depth knowledge of the theory behind the test procedures included herein.

Course Outline and Suggested Schedule

Day One

Welcome
Introduction of Instructors
Introduction and Expectations of Participants

WAQTC Mission and TTQP Objectives
Instructional Objectives for the Course
Overview of the Course
Course Evaluation Form

Review of Quality Assurance Concepts

Background in Measurements and Calculations

Random Sampling

Basics of Asphalt

Sampling Asphalt Mixtures
FOP for AASHTO R 97

Reducing Samples of Asphalt Mixtures to Testing Size
FOP for AASHTO R 47

Moisture Content of Asphalt Mixtures by Oven Method
FOP for AASHTO T 329

Review with Questions and Answers Forum

Afternoon Laboratory Practice

Day Two

Questions from the Previous Day

Determining Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
FOP for AASHTO T 308

Sampling Asphalt Materials
FOP for AASHTO R 66

Mechanical Analysis of Extracted Aggregate
FOP for AASHTO T 30

Review with Questions and Answers Forum

Afternoon Laboratory Practice

Day Three

Questions from Previous Day

Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
FOP for AASHTO T 209

Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
FOP for AASHTO T 166

Review with Questions and Answers Forum

Afternoon Laboratory Practice

Day Four

Questions from Previous Day

Review with Questions and Answers Forum

Laboratory Practice

Day Five

Questions from the Previous Day

Review with Questions and Answers Forum

Laboratory Practice

Start Exams

Participants will break into groups so that written and performance exams may be given concurrently.

Day Five

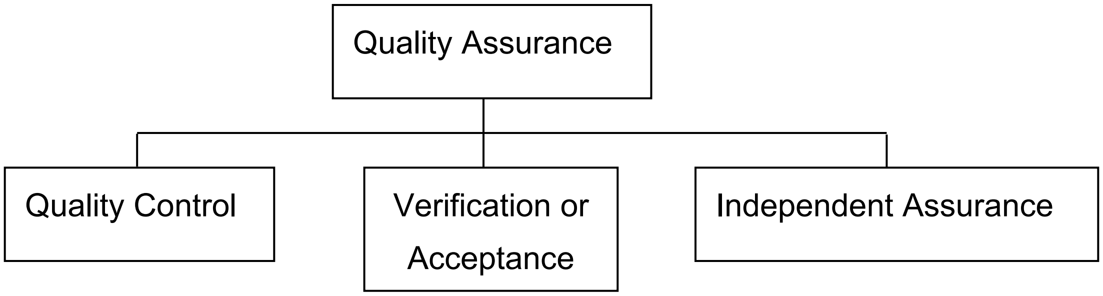
Exams

Evaluation

QUALITY ASSURANCE CONCEPTS 02

The Federal Highway Administration (FHWA) has established requirements that each State
Transportation Department must develop a Quality Assurance (QA) Program that is
approved by the FHWA for projects on the National Highway System (NHS). In addition to
complying with this requirement, implementing QA specifications in a construction program 03
includes the benefit of improvement of overall quality of highway and bridge construction.

A QA Program may include three separate and distinct parts as illustrated below. 04



Quality Assurance (QA) are those planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality.

Quality Control (QC) are those operational, process control techniques or activities that are 05
performed or conducted to fulfill contract requirements for material and equipment quality.
In some states, the constructor is responsible for providing QC sampling and testing, while in
other states the STD handles QC. Where the constructor is responsible for QC tests, the 06
results may be used for acceptance only if verified or accepted by additional tests performed
by an independent group.

Verification/Acceptance consists of the sampling and testing performed to validate QC sampling and testing and, thus, the quality of the product. Verification/Acceptance samples are obtained and tests are performed independently from those involved with QC. Samples taken for QC tests may not be used for Verification/Acceptance testing.

Independent Assurance (IA) are those activities that are an unbiased and independent 07
evaluation of all the sampling and testing procedures used in QC and
Verification/Acceptance. IA may use a combination of laboratory certification, technician
qualification or certification, proficiency samples, or split samples to assure that QC and
Verification/Acceptance activities are valid. Agencies may qualify or certify laboratories and
technicians, depending on the state in which the work is done.

BACKGROUND ON MEASUREMENTS AND CALCULATIONS

01

Introduction

This section provides a background in the mathematical rules and procedures used in making measurements and performing calculations. Topics include:

- Units: Metric vs. English
- Mass vs. Weight
- Balances and Scales
- Rounding
- Significant Figures
- Accuracy and Precision
- Tolerance

Also included is discussion of real-world applications in which the mathematical rules and procedures may not be followed.

02

Units: Metric vs. English

03 The bulk of this document uses dual units. Metric units are followed by Imperial, more commonly known as English, units in parentheses. For example: 25 mm (1 in.). Exams are presented in metric or English.

04 Depending on the situation, some conversions are exact, and some are approximate. One inch is exactly 25.4 mm. If a procedure calls for measuring to the closest 1/4 in., however, 5 mm is close enough. We do not have to say 6.35 mm. That is because 1/4 in. is half way between 1/8 in. and 3/8 in. – or half way between 3.2 and 9.5 mm. Additionally, the tape measure or rule used may have 5 mm marks, but may not have 1 mm marks and certainly will not be graduated in 6 mm increments.

In SI (Le Systeme International d'Unites), the basic unit of mass is the kilogram (kg) and the basic unit of force, which includes weight, is the Newton (N).

- Basic units in SI include:
- Length: meter, m
- Mass: kilogram, kg
- Time: second, s
-

SI units

Metric	English
25 mm	1 in.
1 kg	2.2 lb
1000 kg/m^3	62.4 lb/ft^3
25 MPa	3600 lb/in.^{2}

Some approximate conversions

Mass in this document is given in grams (g) or kg. See the section below on "Mass vs. Weight" for further discussion of this topic.

Mass vs. Weight

05 The terms mass, force, and weight are often confused. Mass, m, is a measure of an object's material makeup, and has no direction. Force, F, is a measure of a push or pull, and has the direction of the push or pull. Force is equal to mass times acceleration, a.

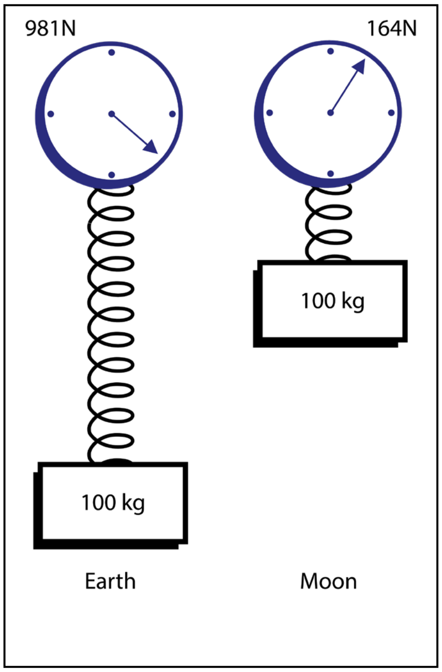
$$F = ma$$

06 Weight, W, is a special kind of force, caused by gravitational acceleration. It is the force required to suspend or lift a mass against gravity. Weight is equal to mass times the acceleration due to gravity, g, and is directed toward the center of the earth.

$$W = mg$$

In SI, the basic unit of mass is the kilogram (kg), the units of acceleration are meters per square second (m/s^2), and the unit of force is the Newton (N). Thus a person having a mass of 84 kg subject to the standard acceleration due to gravity, on earth, of 9.81 m/s^2 would have a weight of:

$$W = (84.0\ kg)(9.81\ m/s^2) = 824\ kg\text{-}m/s^2 = 824\ N$$



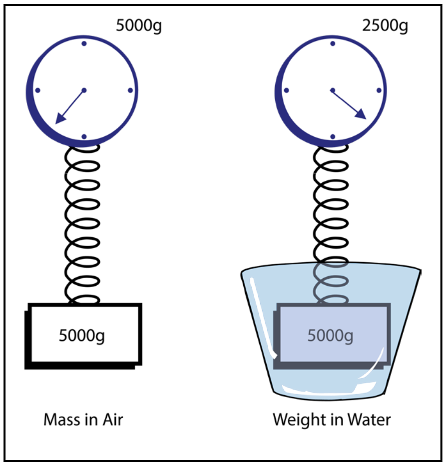
Comparison of mass and weight

In the English system, mass can be measured in pounds-mass (lb_m), while acceleration is in feet per square second (ft/s^2), and force is in pounds-force (lb_f). A person weighing 185 lb_f on a scale has a mass of 185 lb_m when subjected to the earth's standard gravitational pull. If this person were to go to the moon, where the acceleration due to gravity is about one-sixth of what it is on earth, the person's weight would be about 31 lb_f, while his or her mass would remain 185 lb_m. Mass does not depend on location, but weight does. 07

08

While the acceleration due to gravity does vary with position on the earth (latitude and elevation), the variation is not significant except for extremely precise work – the manufacture of electronic memory chips, for example.

As discussed above, there are two kinds of pounds,
lb$_m$ and lb$_f$. In laboratory measurements of mass,
the gram or kilogram is the unit of choice. But, is
09 this mass or force? Technically, it depends on the
instrument used, but practically speaking, mass is
the result of the measurement. When using a scale,
force is being measured – either electronically by
the stretching of strain gauges or mechanically by
the stretching of a spring or other device. When
using a balance, mass is being measured, because
the mass of the object is being compared to a
known mass built into the balance.



Submerged weight

In this document, mass, not weight, is used in test procedures except when determining "weight" in water. When an object is submerged in water (as is done in specific gravity tests), the term weight is used. Technically, what is being measured is the force the object exerts on the balance or scale while the object is submerged in water (or the submerged weight). This force is actually the weight of the object less the weight of the volume of water displaced. 10

11 In summary, whenever the common terms "weight" and "weighing" are used, the more appropriate terms "mass" and "determining mass" are usually implied, except in the case of weighing an object submerged in water. 12

Balances and Scales

Balances, technically used for mass determinations, and scales, used to weigh items, were discussed briefly above in the section on "Mass vs. Weight." In field operating procedures, we usually do not differentiate between the two types of instruments. When using either one for a material or object in air, we are determining <u>mass</u>. For those procedures in which the material or object is suspended in water, we are determining <u>weight</u> in water.

13 AASHTO recognizes two general categories of instruments. Standard analytical balances are used in laboratories. For most field operations, general purpose balances and scales are specified. Specifications for both categories are shown in Tables 1 and 2. 14

Table 1
Standard Analytical Balances

Class	Capacity	Readability and Sensitivity	Accuracy
A	200 g	0.0001 g	0.0002 g
B	200 g	0.001 g	0.002 g
C	1200 g	0.01 g	0.02 g

Table 2
General Purpose Balances and Scales

Class	Principal Sample Mass	Readability and Sensitivity	Accuracy
G2	2 kg or less	0.1 g	0.1 g or 0.1 percent
G5	2 kg to 5 kg	1 g	1 g or 0.1 percent
G20	5 kg to 20 kg	5 g	5 g or 0.1 percent
G100	Over 20 kg	20 g	20 g or 0.1 percent

Rounding

Numbers are commonly rounded up or down after measurement or calculation. For example, 53.67 would be rounded to 53.7 and 53.43 would be rounded to 53.4, if rounding were required. The first number was rounded up because 53.67 is closer to 53.7 than to 53.6. Likewise, the second number was rounded down because 53.43 is closer to 53.4 than to 53.5. The reasons for rounding are covered in the next section on “Significant Figures.”

If the number being rounded is followed by exactly 5, followed by only zeroes, two possibilities exist. In the more mathematically sound approach, numbers are rounded up or down depending on whether the number to the left of the 5 is odd or even. Thus, 102.25 would be rounded down to 102.2, while 102.35 would be rounded up to 102.4. This procedure avoids the bias that would exist if all numbers ending in 5 were rounded up or all numbers were rounded down. In some calculators, however, all rounding is up. This does result in some bias, or skewing of data, but the significance of the bias may or may not be significant to the calculations at hand.

When rounding numbers that are followed by exactly 5, follow agency guidelines. For the purpose of WAQTC training, if the number being rounded is followed by a 5, the number is increased by 1.

Significant Figures

- General

16 A general-purpose balance or scale, classified as G20 in AASHTO M 231, has a capacity of 20,000 g and an accuracy requirement of ±5 g. A mass of 18,285 g determined with such an instrument could actually range from 18,280 g to 18,290 g. Only <u>four</u> places in the measurement are significant. The fifth (last) place is <u>not</u> significant since it may change.

17 Mathematical rules exist for handling significant figures in different situations.

An example in Metric (**m**) or English(**ft**), when performing addition and subtraction, the number of significant figures in the sum or difference is determined by the least precise input. Consider the three situations shown below:

Situation 1	Situation 2	Situation 3
35.67	143.903	162
+ 423.938	- 23.6	+33.546
		- .022
= 459.61	= 120.3	= 196
not 459.608	not 120.303	not 195.524

Rules also exist for multiplication and division. These rules, and the rules for mixed operations involving addition, subtraction, multiplication, and/or division, are beyond the scope of these materials. AASHTO covers this topic to a certain extent in the section called "Precision" or "Precision and Bias" included in many test methods, and the reader is directed to those sections if more detail is desired.

18 - Real World Limitations

While the mathematical rules of significant digits have been established, they are not always followed. For example, AASHTO T 176, *Plastic Fines in Graded Aggregates and Soils by the Use of the Sand Equivalent Test*, prescribes a method for rounding and significant digits in conflict with the mathematical rules.

In this procedure, readings and calculated values are always rounded up. A clay reading of 7.94 would be rounded to 8.0 and a sand reading of 3.21 would be rounded to 3.3. The <u>rounded</u> numbers are then used to calculate the Sand Equivalent, which is the ratio of the two numbers multiplied by 100. In this case:

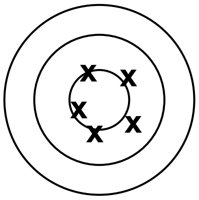
$$\frac{3.3}{8.0} \times 100 = 41.250 \ldots$$

rounded to 41.3 and reported as 42

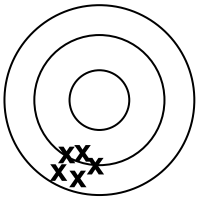
$$Not\text{:}\ \frac{3.21}{7.94} \times 100 = 40.428 \ldots$$

rounded to 40.0 and reported as 40

It is extremely important that engineers and technicians understand the rules of rounding and significant digits just as well as they know procedures called for in standard test methods.



ACCURATE BUT NOT PRECISE, SCATTERED



PRECISE BUT NOT ACCURATE, BIASED

Accuracy and Precision

19 Although often used interchangeably, the terms accuracy and precision do not mean the same thing. In an engineering sense, accuracy denotes nearness to the truth or some value accepted as the truth, while precision relates to the degree of refinement or repeatability of a measurement.

20 Two bulls-eye targets are shown to the left. The upper one indicates hits that are scattered and, yet, are very close to the center. The lower one has a tight pattern, but all the shots are biased from the center. The upper one is more accurate, while the lower one is more precise. A biased, but precise, instrument can often be adjusted physically or mathematically to provide reliable single measurements. A scattered, but accurate, instrument can be used if enough measurements are made to provide a valid average.

21 Consider the measurement of the temperature of boiling water at standard atmospheric pressure by two thermometers. Five readings were taken with each, and the values were averaged.

Thermometer No. 1		**Thermometer No. 2**	
101.2°	214.2°	100.6°	213.1°
101.1°	214.0°	99.2°	210.6°
101.2°	214.2°	98.9°	210.0°
101.1°	214.0°	101.0°	213.8°
101.2°	214.2°	100.3°	212.5°
AVG = 101.2°	214.2°	AVG = 100.0°	212.0°

22 No. 1 shows very little fluctuation, but is off the known boiling point (100°C or 212°F) by 1.2°C or 2.2°F. No. 2 has an average value equal to the known boiling point, but shows quite a bit of fluctuation. While it might be preferable to use neither thermometer, thermometer No. 1 could be employed if 1.2°C or 2.2°F were subtracted from each measurement. Thermometer No. 2 could be used if enough measurements were made to provide a valid average. 23

24 Engineering and scientific instruments should be
calibrated and compared against reference standards
periodically to assure that measurements are
accurate. If such checks are not performed, the
accuracy is uncertain, no matter what the precision.
Calibration of an instrument removes fixed error,
25 leaving only random error for concern.

Tolerance

Dimensions of constructed or manufactured objects,
including laboratory test equipment, cannot be
26 specified exactly. Some tolerance must be allowed.
Thus, procedures for including tolerance in
addition/subtraction and multiplication/division
operations must be understood.

- Addition and Subtraction

  When adding or subtracting two numbers that
  individually have a tolerance, the tolerance of
  27 the sum or difference is equal to the sum of the
  individual tolerances.

  An example in Metric (**m**) or English (**ft**), if the distance between two points is made up of two parts, one being 113.361 ±0.006 and the other being 87.242 ±0.005 then the tolerance of the sum (or the difference) is:

  $$(0.006) + (0.005) = 0.011$$

  and the sum would be 200.603 ±0.011.

- Multiplication and Division

  28 To demonstrate the determination of tolerance
  again in either Metric (**m**) or English (**ft**) for the
  product of two numbers, consider determining
  the area of a rectangle having sides of 76.254
  ±0.009 and 34.972 ±0.007. The percentage
  variations of the two dimensions are:

$$\frac{0.009}{76.254} \times 100 = 0.01\% \quad \frac{0.007}{34.972} \times 100 = 0.02\%$$

  The sum of the percentage variations is 0.03 percent – the variation that is employed in the area of the rectangle:

Area =

$$266.8\ (m^2 or\ ft^2) = \pm 0.03\%$$
$$= 2666.8 \pm 0.8\ (m^2 or\ ft^2)$$

- Real World Applications

29 Tolerances are used whenever a product is manufactured. For example, the mold used for determining soil density in AASHTO T 99 has a diameter of 101.60 ±0.41 mm(4.000 ±0.016 in) and a height of 116.43 ±0.13 mm(4.584 ±0.005 in).

Using the smaller of each dimension results in a volume of:

$$\left(\frac{\pi}{4}\right)(101.19\ mm)^2(116.30\ mm)$$
$$= 935{,}287\ mm^3 or\ 0.000935\ m^3$$

$$\left(\frac{\pi}{4}\right)(3.984\ in)^2(4.579\ in)$$
$$= 57.082\ in^3 or\ 0.0330\ ft^3$$

Using the larger of each dimension results in a volume of:

$$\left(\frac{\pi}{4}\right)(102.01\ mm)^2(116.56\ mm)$$
$$= 952.631\ mm^3 or\ 0.000953\ m^3$$

$$\left(\frac{\pi}{4}\right)(4.016\ in)^2(4.589\ in)$$
$$= 58.130\ in^3 or\ 0.0336\ ft^3$$

The average value is 0.000944 m^3 (0.0333), and AASHTO T 99 specifies a volume of:

0.000943 ±0.000008 m^3

or a range of

0.000935 to 0.000951 m^3

0.0333 ±0.0003 ft^3

or a range of

0.0330 to 0.0336 ft^3

Because of the variation that can occur, some agencies periodically standardize molds, and make adjustments to calculated density based on those calculations.

Summary

Mathematics has certain rules and procedures for making measurements and performing calculations that are well established. So are standardized test procedures. Sometimes these agree, but occasionally, they do not. Engineers and technicians must be familiar with both but must follow test procedures in order to obtain valid, comparable results.

TERMINOLOGY

Many of the terms listed below are defined differently by various agencies or organizations. The definitions of the American Association of State Highway and Transportation Officials (AASHTO) are the ones most commonly used in this document.

Absorbed water – Water drawn into a solid by absorption and having physical properties similar to ordinary water.

Absorption – The increase in the mass of aggregate due to water being absorbed into the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass.

Acceptance – See verification.

Acceptance program – All factors that comprise the State Transportation Department's (STD) determination of the quality of the product as specified in the contract requirements. These factors include verification sampling, testing, and inspection and may include results of quality control sampling and testing.

Admixture – Material other than water, cement, and aggregates in Portland cement concrete (PCC).

Adsorbed water – Water attached to the surface of a solid by electrochemical forces and having physical properties substantially different from ordinary water.

Aggregate – Hard granular material of mineral composition, including sand, gravel, slag, or crushed stone, used in roadway base and in Portland cement concrete (PCC) and asphalt mixtures.

- **Coarse aggregate** – Aggregate retained on or above the No. 4 (4.75 mm) sieve.
- **Coarse-graded aggregate** – Aggregate having a predominance of coarse sizes.
- **Dense-graded aggregate** – Aggregate having a particle size distribution such that voids occupy a relatively small percentage of the total volume.
- **Fine aggregate** – Aggregate passing the No. 4 (4.75 mm) sieve.
- **Fine-graded aggregate** – Aggregate having a predominance of fine sizes.
- **Mineral filler** – A fine mineral product at least 70 percent of which passes a No. 200 (75 µm) sieve.
- **Open-graded gap-graded aggregate** – Aggregate having a particle size distribution such that voids occupy a relatively large percentage of the total volume.
- **Well-Graded Aggregate** – Aggregate having an even distribution of particle sizes.

Aggregate storage bins – Bins that store aggregate for feeding material to the dryer in a hot mix asphalt (HMA) plant in substantially the same proportion as required in the finished mix.

Agitation – Provision of gentle motion in Portland cement concrete (PCC) sufficient to prevent segregation and loss of plasticity.

Air voids (V_a) – Total volume of the small air pockets between coated aggregate particles in asphalt mixtures; expressed as a percentage of the bulk volume of the compacted paving mixture.

Ambient temperature – Temperature of the surrounding air

Angular aggregate – Aggregate possessing well-defined edges at the intersection of roughly planar faces.

Apparent specific gravity (G_{sa}) – The ratio of the mass, in air, of a volume of the impermeable portion of aggregate to the mass of an equal volume of water at a stated temperature.

Asphalt – A dark brown to black cementitious material in which the predominate constituents are bitumens occurring in nature or obtained through petroleum processing. Asphalt is a constituent of most crude petroleums.

Asphalt emulsion – A mixture of asphalt binder and water.

Asphalt binder – An asphalt specially prepared in quality and consistency for use in the manufacture of asphalt mixtures.

Asphalt mixtures – High quality, thoroughly controlled mix of aggregate and asphalt binder.

- **Hot mix asphalt (HMA)** – Asphalt mixtures of well-graded aggregate and asphalt binder that are mixed and placed at high temperatures.
- **Stone matrix asphalt (SMA) –** A gap-graded hot asphalt mixture that is designed to maximize deformation (rutting) resistance and durability by using a structural basis of stone-on-stone contact.
- **Warm mix asphalt (WMA) –** Asphalt mixtures that, due to a variety of technologies, are mixed and placed at relatively lower temperatures than HMA.

Automatic cycling control – A control system in which the opening and closing of the weigh hopper discharge gate, the bituminous discharge valve, and the pugmill discharge gate are actuated by means of automatic mechanical or electronic devices without manual control. The system includes preset timing of dry and wet mixing cycles.

Automatic dryer control – A control system that automatically maintains the temperature of aggregates discharged from the dryer.

Automatic proportioning control – A control system in which proportions of the aggregate and asphalt binder fractions are controlled by means of gates or valves that are opened and closed by means of automatic mechanical or electronic devices without manual control.

Bag (of cement) – 94 lb of Portland cement (Approximately 1 ft^3 of bulk cement)

Base – A layer of selected material constructed on top of subgrade or subbase and below the paving on a roadway.

Bias – The offset or skewing of data or information away from its true or accurate position as the result of systematic error.

Binder – Asphalt binder or modified asphalt binder that binds the aggregate particles into a dense mass.

Boulders – Rock fragment, often rounded, with an average dimension larger than 300 mm (12 in.).

Bulk specific gravity– The ratio of the mass, in air, of a volume of aggregate (G_{sa}) or compacted HMA mix (G_{mb}) (including the permeable and impermeable voids in the particles, but not including the voids between particles) to the mass of an equal volume of water at a stated temperature.

Bulk specific gravity (SSD) – The ratio of the mass, in air, of a volume of aggregate (G_{sa} *SSD*) or compacted asphalt mixtures (G_{mb} *SSD*), including the mass of water within the voids (but not including the voids between particles), to the mass of an equal volume of water at a stated temperature. (See saturated surface dry.)

Cementitious Materials – cement and pozzolans used in concrete such as: Portland cement, fly ash, silica fume, and blast-furnace slag.

Clay – Fine-grained soil that exhibits plasticity over a range of water contents, and that exhibits considerable strength when dry, also, that portion of the soil finer than 2 µm.

Cobble – Rock fragment, often rounded, with an average dimension between 75 and 300 mm (3 and 12 in.).

Cohesionless soil – Soil with little or no strength when dry and unconfined or when submerged, such as sand

Cohesive soil – Soil with considerable strength when dry and that has significant cohesion when unconfined or submerged.

Compaction – Densification of a soil or asphalt mixtures by mechanical means.

Compaction curve (Proctor curve or moisture-density curve) – The curve showing the relationship between the dry unit weight or density and the water content of a soil for a given compactive effort.

Compaction test (moisture-density test) – Laboratory compaction procedure in which a soil of known water content is placed in a specified manner into a mold of given dimensions, subjected to a compactive effort of controlled magnitude, and the resulting density determined.

Compressibility – Property of a soil or rock relating to susceptibility to decrease in volume when subject to load.

Constant mass – The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Constructor – The builder of a project. The individual or entity responsible for performing and completing the construction of a project required by the contract documents. Often called a contractor, since this individual or entity contracts with the owner.

Cutback asphalt – Asphalt binder that has been modified by blending with a chemical solvent.

Crusher-run – The total unscreened product of a stone crusher.

Delivery tolerances – Permissible variations from the desired proportions of aggregate and asphalt binder delivered to the pugmill.

Density – The ratio of mass to volume of a substance. Usually expressed in lb/ft^3 (kg/m^3).

Design professional – The designer of a project. This individual or entity may provide services relating to the planning, design, and construction of a project, possibly including materials testing and construction inspection. Sometimes called a “contractor,” since this individual or entity contracts with the owner.

Dryer – An apparatus that dries aggregate and heats it to specified temperatures.

Dry mix time – The time interval between introduction of aggregate into the pugmill and the addition of asphalt binder.

Durability – The property of concrete that describes its ability to resist disintegration by weathering and traffic. Included under weathering are changes in the pavement and aggregate due to the action of water, including freezing and thawing.

Dust Proportion – DP (Dust to Effective (asphalt) Binder Ratio) – The percent passing the No. 200 sieve divided by the percent of effective asphalt binder.

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 binder) 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.

Effective diameter (effective size) – D_{10}, particle diameter corresponding to 10 percent finer or passing.

Embankment – Controlled, compacted material between the subgrade and subbase or base in a roadway.

End-result specifications – Specifications that require the Constructor to take the entire responsibility for supplying a product or an item of construction. The Owner's (the highway agency's) responsibility is to either accept or reject the final product or to apply a price adjustment that is commensurate with the degree of compliance with the specifications. Sometimes called performance specifications, although considered differently in highway work. (See performance specifications.)

Family of curves – a group of soil moisture-density relationships (curves) determined using AASHTO T 99 or T 180, which reveal certain similarities and trends characteristic of the soil type and source.

Field operating procedure (FOP) – Procedure used in field testing on a construction site or in a field laboratory. (Based on AASHTO or NAQTC test methods.)

Fineness modulus – A factor equal to the sum of the cumulative percentages of aggregate retained on certain sieves divided by 100; the sieves are 150, 75, 37.5, 19.0, 9.5, 4.75, 2.36, 1.18, 0.60, 0.30, and 0.15 mm. Used in the design of concrete mixes. The lower the fineness modulus, the more water/cement paste that is needed to coat the aggregate.

Fines – Portion of a soil or aggregate finer than a 75 µm (No. 200) sieve. Also silts and clays.

Fractured criteria – The specified requirement for fractured particles determined by each agency.

Fractured face – An angular, rough, or broken surface of an aggregate particle created by crushing or by other means. A face is considered a "fractured face" whenever one-half or more of the projected area, when viewed normal to that face, is fractured with sharp and well-defined edges. This excludes small nicks.

Fractured particle – A particle of aggregate having at least the minimum number of fractured faces specified.

Free water – Water on aggregate available for reaction with hydraulic cement. Mathematically, the difference between total moisture content and absorbed moisture content.

Glacial till – Material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water.

Gradation (grain-size distribution) – The proportions by mass of a soil or fragmented rock distributed by particle size.

Gradation analysis (grain size analysis or sieve analysis) – The process of determining grain-size distribution by separation of sieves with different size openings.

Hot aggregate storage bins – Bins that store heated and separated aggregate before final proportioning into the mixer.

Hot Mix Asphalt (HMA) batch plant – A manufacturing facility for producing hot mix asphalt (HMA) that proportions aggregate by weight and asphalt by weight or volume.

HMA continuous mix plant – A manufacturing facility for producing HMA that proportions aggregate and asphalt binder by a continuous volumetric proportioning system without specific batch intervals.

Hydraulic cement – Cement that sets and hardens by chemical reaction with water.

Independent assurance – Unbiased and independent evaluation of all the sampling and testing procedures, equipment, and technicians involved with Quality Control (QC) and Verification/Acceptance.

In situ – Rock or soil in its natural formation or deposit.

J-Ring – a rigid ring made of steel connecting 100 mm (4 in.) vertical smooth bars used in testing the passing ability of SCC.

Liquid limit – Moisture content corresponding to the boundary between the liquid and plastic states.

Loam – A mixture of sand, silt or clay, or a combination thereof, with organic matter.

Lot – A quantity of material to be controlled. It may represent a specified mass, a specified number of truckloads, or a specified time period during production.

Manual proportioning control – A control system in which proportions of the aggregate and asphalt binder fractions are controlled by means of gates or valves that are opened and closed by manual means. The system may or may not include power assisted devices in the actuation of gate and valve opening and closing.

Materials and methods specifications – Also called prescriptive specifications. Specifications that direct the Constructor to use specified materials in definite proportions and specific types of equipment and methods to place the material.

Maximum size – One sieve larger than nominal maximum size.

Mesh – The square opening of a sieve.

Moisture content – The ratio, expressed as a percentage, of the mass of water in a material to the dry mass of the material.

Nominal maximum size – One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.
Note: The first sieve to normally retain more than 10 percent of the material usually is the second sieve in the stack but may be the third sieve.

Nuclear gauge – Instruments used to measure in-place density, moisture content, or asphalt binder content through the measurement of nuclear emissions.

Optimum moisture content (optimum water content) – The water content at which a soil can be compacted to a maximum dry density by a given compactive effort.

Organic soil – Soil with a high organic content.

Owner – The organization that conceives of and eventually operates and maintains a project. A State Transportation Departments (STD) is an Owner.

Passing ability – An indication of the ability of the SCC to flow around and between reinforcement without blocking.

Paste – Mix of water and hydraulic cement that binds aggregate in Portland cement concrete (PCC).

Penetration – The consistency of a bituminous material, expressed as the distance in tenths of a millimeter (0.1 mm) that a standard needle vertically penetrates a sample of the material under specified conditions of loading, time, and temperature.

Percent of Absorbed (asphalt) Binder (P_{ba}) – The total percent of the asphalt binder that is absorbed into the aggregate, expressed as a percentage of the mass of aggregate rather than as a percentage of the total mass of the mixture. This portion of the asphalt binder content does not contribute to the performance of the mix.

Percent aggregate (stone) (P_s) – The percent aggregate (stone) content, expressed as a percentage of the total mass of the sample.

Percent of Effective (asphalt) Binder (P_{be}) – The total asphalt binder content of a paving mixture minus the portion of asphalt binder that is lost by absorption into the aggregate particles, expressed as a percentage of the mass of aggregate. It is the portion of the asphalt binder content that remains as a coating on the outside of the aggregate particles.

Percent compaction – The ratio of density of a soil, aggregate, or asphalt mixtures in the field to a maximum density determined by a standard compaction test, expressed as a percentage.

Performance specifications – Specifications that describe how the finished product should perform. For highways, performance is typically described in terms of changes over time in physical condition of the surface and its response to load, or in terms of the cumulative traffic required to bring the pavement to a condition defined as “failure.” Specifications containing warranty/guarantee clauses are a form of performance specifications.

Plant screens – Screens located between the dryer and hot aggregate storage bins that separate the heated aggregates by size.

Plastic limit – Moisture content corresponding to the boundary between the plastic and the semisolid states.

Plasticity – Property of a material to continue to deform indefinitely while sustaining a constant stress.

Plasticity index – Numerical difference between the liquid limit and the plastic limit and, thus, the range of water content over which the soil is plastic.

Portland cement – Hydraulic cement produced by pulverizing Portland cement clinker.

Portland cement concrete (PCC) – A controlled mix of aggregate, Portland cement, and water, and possibly other admixtures.

PCC batch plant – A manufacturing facility for producing Portland cement concrete.

Prescriptive specifications – See Materials and Methods specification.

Proficiency samples – Homogeneous samples that are distributed and tested by two or more laboratories. The test results are compared to assure that the laboratories are obtaining the same results.

Pugmill – A shaft mixer designed to mix aggregate and cement.

Quality assurance – Planned and systematic actions necessary to provide confidence that a product or service will satisfy given requirements for quality. The overall system for providing quality in a constructed project, including Quality Control (QC), Verification/Acceptance, and Independent Assurance (IA).

Quality assurance specifications – Also called QC/QA specifications. A combination of end-result (performance) specifications and materials and methods (prescriptive) specifications. The Constructor is responsible for quality control, and the Owner (highway agency) is responsible for acceptance of the product.

Quality control (QC) – Operational, process control techniques or activities that are performed or conducted to fulfill contract requirements for material or equipment quality.

Random sampling – Procedure for obtaining non-biased, representative samples.

Recycled (reclaimed) asphalt materials – Recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS) used as a component in asphalt mixtures.

Sand – Particles of rock passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (75 µm) sieve.

Saturated surface dry (SSD) – Condition of an aggregate particle, asphalt mixtures or Portland cement concrete (PCC) core, or other porous solid when the permeable voids are filled with water, but no water is present on exposed surfaces. (See bulk specific gravity.)

Self-Consolidating Concrete (SCC) – A highly flowable non-segregating concrete mix that spreads into place and is able to flow and fill all corners of the formwork, even in the presence of congested reinforcement by means of its own mass with no mechanical vibration.

Segregation – The separation of aggregate by size resulting in a non-uniform material.

Sieve – Laboratory apparatus consisting of wire mesh with square openings, usually in circular or rectangular frames.

Silt – Material passing the (75 µm) sieve that is non-plastic or very slightly plastic, and that exhibits little or no strength when dry and unconfined. Also, that portion of the soil finer than 75 µm and coarser than 2 µm.

Slump – Measurement related to the workability of concrete.

Slump flow – Assesses the horizontal free flow, filling ability of self-compacting concrete in the absence of obstructions and may give some indication of resistance to segregation. It does not indicate the ability of the SCC to pass between reinforcement without blocking.

Soil – Sediments or unconsolidated accumulations of solid particles produced by the physical and chemical disintegration or rocks, and which may or may not contain organic matter.

Specific gravity – The ratio of the mass of a volume of a material to the mass of an equal volume of water at a stated temperature.

- **G_{mm}** – theoretical maximum specific gravity (Gravity $_{\text{mix max}}$)
  The ratio of the mass of a given volume of asphalt mixtures with no air voids to the mass of an equal volume of water, both at a stated temperature.

- **G_{mb}** – measured bulk specific gravity (Gravity $_{\text{mix bulk}}$)
  The ratio of the mass, in air, of a volume of compacted HMA mix (including the permeable and impermeable voids in the particles, but not including the voids between particles) to the mass of an equal volume of water at a stated temperature.

- **G_{sb}** – oven-dry bulk specific gravity of aggregate (Gravity $_{\text{stone bulk}}$)
  The ratio of the mass, in air, of a volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) to the mass of an equal volume of water at a stated temperature.

- **G_{sa}** – apparent specific gravity of aggregate (Gravity $_{\text{stone apparent}}$)
  The ratio of the mass, in air, of a volume of the impermeable portion of aggregate to the mass of an equal volume of water at a stated temperature.

- **G_{se}** – effective specific gravity of aggregate (Gravity $_{\text{stone effective}}$)
  The ratio of the mass in air of a unit volume of a permeable material (excluding voids permeable to asphalt binder) 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.

- **G_b** – specific gravity of the binder (Gravity $_{\text{binder}}$)
  The ratio of the mass of a volume of asphalt binder to the mass of an equal volume of water at a stated temperature.

Spine – smooth line extending through the point of maximum density and optimum moisture content of a family of moisture-density curves.

Stability – The ability of an asphalt mixture to resist deformation from imposed loads. Stability is dependent upon internal friction, cohesion, temperature, and rate of loading.

Static segregation - The tendency for coarse aggregate to separate from the sand-cement mortar in SCC.

Stratified random sampling – Procedure for obtaining non-biased, representative samples in which the established lot size is divided into equally-sized sublots.

Subbase – A layer of selected material constructed between the subgrade and the base coarse in a flexible HMA roadway, or between the subgrade and Portland cement concrete (PCC) pavement in a rigid PCC roadway.

Subgrade – Natural soil prepared and compacted to support a structure or roadway pavement.

Sublot – A segment of a lot chosen to represent the total lot.

Superpave™ – Superpave™ (Superior Performing Asphalt Pavement) is a trademark of the Strategic Highway Research Program (SHRP). Superpave™ is a product of the SHRP asphalt research. The Superpave™ system incorporates performance-based asphalt materials characterization with design environmental conditions to improve performance by controlling rutting, low temperature cracking and fatigue cracking. The three major components of Superpave™ are the asphalt binder specification, the mix design and analysis system, and a computer software system.

Theoretical maximum specific gravity (G_{mm}) – The ratio of the mass of a given volume of asphalt mixtures with no air voids to the mass of an equal volume of water, both at a stated temperature.

Topsoil – Surface soil, usually containing organic matter.

Uniformity coefficient – C_u, a value employed to quantify how uniform or well-graded an aggregate is: $C_u = D_{60}/D_{10}$. 60 percent of the aggregate, by mass, has a diameter smaller than D_{60} and 10 percent of the aggregate, by mass, has a diameter smaller than D_{10}.

Unit weight – The ratio of weight to volume of a substance. The term “density” is more commonly used.

µm – Micro millimeter (micron) Used as measurement for sieve size.

Vendor – Supplier of project-produced material that is other than the constructor.

Verification – Process of sampling and testing performed to validate Quality Control (QC) sampling and testing and, thus, the quality of the product. Sometimes called Acceptance.

Visual stability index (VSI) – The Visual Stability Index (VSI) is used to assess the stability of SCC. The stability (or segregation resistance) of an SCC mixture is the ability of the mixture to remain homogeneous during transport, during placement, and after placement. The VSI determination is useful for quality control and consistency testing.

Void in the mineral aggregate (VMA) – The volume of inter-granular void space between aggregate particles of compacted asphalt mixtures that includes air and asphalt binder; expressed as a percentage of the bulk volume of the compacted paving mixture.

Voids filled with asphalt (VFA) – The portion of the void in the mineral aggregate (VMA) that contains asphalt binder; expressed as a percentage of the bulk volume of mix or the VMA.

Wet mixing period – The time interval between the beginning of application of asphalt binder and the opening of the mixer gate.

Zero air voids curve (saturation curve) – Curve showing the zero air voids density as a function of water content.

SAFETY

The procedures included in this manual may involve hazardous materials, operations, and equipment. The procedures do not address all of the safety issues associated with their use. It is the responsibility of the employer to assess workplace hazards and to determine whether personal protective equipment (PPE) must be used. PPE must meet applicable American National Standards Institute (ANSI) standards and be properly used and maintained. The employer must establish appropriate safety and health practices, in compliance with applicable state and federal laws, for these procedures and associated job site hazards. Hazardous materials must be addressed in a Hazard Communication program, and Material Safety Data Sheets (MSDS) must be obtained and available to workers. Supervisors and employees should be aware of job site hazards and comply with their employer's safety and health program. The following table identifies some areas that may affect individuals performing the procedures in this manual.

Body Part Affected	Potential Hazards	PPE/Procedures That May Be Appropriate
Head	Falling or fixed overhead objects; electrical shock	Hard hat or other protective helmet
Eyes and Face	Flying objects, radiation, molten metal, chemicals	Safety glasses, goggles, face shields; prescription or filter lenses
Ears	Noise	Ear plugs, earmuffs
Respiratory System	Inhalation of dusts, chemicals; O_2 deficiency	Properly fit and used respiratory protection consistent with the hazard
Skin	Chemicals including cement; heat	Appropriate chemical or heat resistant gloves, long-sleeve shirts, coveralls
Mouth, digestive system	Ingestion of toxic materials	Disposable or washable gloves, coveralls; personal hygiene
Hands	Physical injury (pinch, cut, puncture), chemicals	Appropriate gloves for physical hazards and compatible with chemicals present
Feet	Falling, sharp objects; slippery surfaces, chemicals	Safety shoes or boots (steel toed, steel shank); traction soles; rubber boots – chemicals, wet conditions
Joints, muscles, tendons	Lifting, bending, twisting, repetitive motions	Proper training and procedures; procedure modifications
Body/Torso	Falls; Burial	Fall protection; trench sloping or shoring
Miscellaneous	Traffic	Visibility, awareness, communication; driver training, safety awareness
Whole body	Radiation	Radiation safety training

RANDOM SAMPLING OF CONSTRUCTION MATERIALS

01

Significance

Sampling and testing are two of the most important functions in quality control (QC). Data from the tests are the tools with which the quality of product is controlled. For this reason, great care must be used in following standardized sampling and testing procedures.

02

In controlling operations, it is necessary to obtain numerous samples at various points along the production line. Unless precautions are taken, sampling can occur in patterns that can create a bias to the data gathered. Sampling at the same time, say noon, each day may jeopardize the effectiveness of any quality program. This might occur, for example, because a material producer does certain operations, such as cleaning screens at an aggregate plant, late in the morning each day. To obtain a representative sample, a reliable system of random sampling must be employed.

Scope

The procedure presented here eliminates bias in sampling materials. Randomly selecting a set of numbers from a table or calculator will eliminate the possibility for bias. Random numbers are used to identify sampling times, locations, or points within a lot or sublot. This method does not cover how to sample, but rather how to determine sampling times, locations, or points.

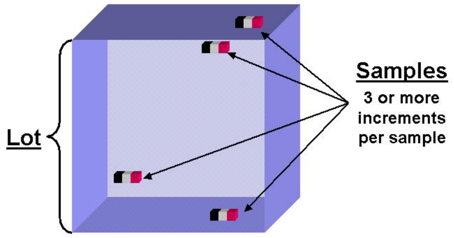
Sampling Concepts

03
04

A lot is the quantity of material evaluated by QC procedures. A lot is a preselected quantity that may represent hours of production, a quantity or number of loads of material, or an interval of time. A lot may be comprised of several portions that are called sublots or units. The number of sublots comprising a lot will be determined by the agency’s specifications.

Straight Random Sampling

One or more sample locations may be selected, using the entire lot as a single unit

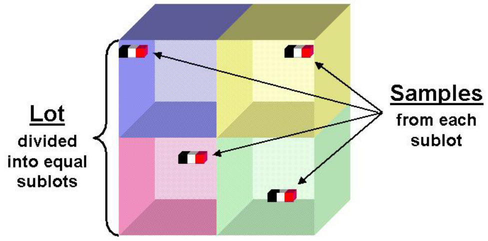


05 **Straight Random Sampling vs. Stratified Random Sampling:** Straight random sampling considers an entire lot as a single unit and determines each sample location based on the entire lot size. Stratified random sampling divides the lot into a specified number of sublots or units and then determines each sample location within a distinct sublot. Both methods result in random distribution of samples to be tested for compliance with the agency's specification.

06 Agencies stipulate when to use straight random sampling or stratified random sampling. AASHTO R 90, Sampling Aggregate Products, for example, specifies a straight random sampling procedure.

Stratified Random Sampling

The lot is divided into two or more equal sublots. Samples are taken from each sublot



Picking Random Numbers from a Table

07 Table 1 contains pairs of numbers. The first number is the "pick" number and the second is the Random Number, "RN". The table was generated with a spreadsheet and the cells (boxes at the intersection of rows and columns) containing the RNs actually contain the "random number function." Every time the spreadsheet is opened or changed, all the RNs change.

1. Select a Pick number in a random method. The first two or last two digits in the next automobile license plate you see would be one way to select. Another would be to start a digital stop watch and stop it several seconds later, using the decimal part of the seconds as your Pick number.
2. Find the RN matching the Pick number.

Picking Random Numbers with a Calculator

08 09 Many calculators have a built-in random number function. To obtain a random number, key in the code or push the button(s) the calculator's instructions call for. The display will show a number between 0.000 and 1.000 and this will be your random number.

TABLE 1
Random Numbers

Pick	RN	Pick	RN	Pick	RN	Pick	RN	Pick	RN
01	0.998	21	0.758	41	0.398	61	0.895	81	0.222
02	0.656	22	0.552	42	0.603	62	0.442	82	0.390
03	0.539	23	0.702	43	0.150	63	0.821	83	0.468
04	0.458	24	0.217	44	0.001	64	0.187	84	0.335
05	0.407	25	0.000	45	0.521	65	0.260	85	0.727
06	0.062	26	0.781	46	0.462	66	0.815	86	0.708
07	0.370	27	0.317	47	0.553	67	0.154	87	0.161
08	0.410	28	0.896	48	0.591	68	0.007	88	0.893
09	0.923	29	0.848	49	0.797	69	0.759	89	0.255
10	0.499	30	0.045	50	0.638	70	0.925	90	0.604
11	0.392	31	0.692	51	0.006	71	0.131	91	0.880
12	0.271	32	0.530	52	0.526	72	0.702	92	0.656
13	0.816	33	0.796	53	0.147	73	0.146	93	0.711
14	0.969	34	0.100	54	0.042	74	0.355	94	0.377
15	0.188	35	0.902	55	0.609	75	0.292	95	0.287
16	0.185	36	0.674	56	0.579	76	0.854	96	0.461
17	0.809	37	0.509	57	0.887	77	0.240	97	0.703
18	0.105	38	0.013	58	0.495	78	0.851	98	0.866
19	0.715	39	0.497	59	0.039	79	0.678	99	0.616
20	0.380	40	0.587	60	0.812	80	0.122	00	0.759

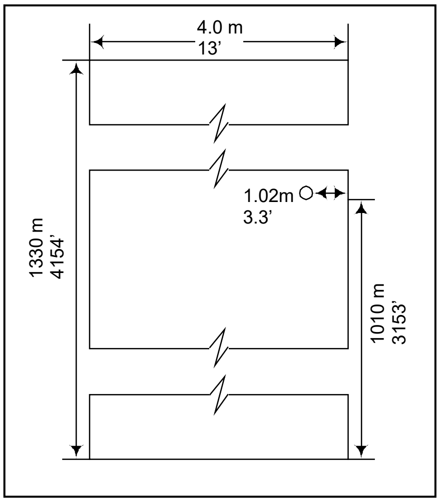
Examples of Straight Random Sampling Procedures Using Random Numbers

10 **Sampling from a Belt or Flowing Stream:** Agencies specify the frequency of sampling in terms of time, volumes, or masses. The specification might call for one sample from every 1,000,000 kg(1000 t) or 1100 Tons(T) of aggregate. If the random number was 0.317, the sample would be taken at (0.317)(1,000,000 kg) = 317,000 kg (317 t). Or (.317) (1100 T) = 349 T.

11 One sample per day might also be specified. If the day were 9 hours long and the random number 0.199, the sample would be taken at (0.199) (9 hrs) = 1.79 hr = 1 hr, 48 minutes into the day.

12 **Sampling from Haul Units:** Based on the agency's specifications – in terms of time, volume, or mass – determine the number of haul units that comprise a lot. Multiply the selected random number(s) by the number of units to determine which unit(s) will be sampled.

For example, if 20 haul units comprise a lot and one sample is needed, pick one RN. If the RN were 0.773, then the sample would be taken from the (0.773) (20) = 15.46, or 16th haul unit.



Sampling from a roadway

Sampling from a Roadway with Previously Placed Material: The agency's specified frequency of sampling – in time, volume, or mass – can be translated into a location on a job. For example, if a sample is to be taken every 800 m^3 (1000yd^3) and material is being placed 0.15 m
13 (0.50 ft) thick and 4.0 m (13 ft) wide, then the lot is 1330 m (4154 ft) long. You would select two RNs in this case. To convert yd^3 to ft^3 multiply by
14 27.

The first RN would be multiplied by the length to determine where the sample would be taken along
15 the project. The second would be multiplied by the width to determine where, widthwise, the sample would be taken. For example, a first RN of 0.759
16 would specify that the sample would be taken at (0.759)(1330 m) or (4154 ft) = 1010 m or 3153 ft from the beginning. A second RN of 0.255 would specify that the sample would be taken at (0.255)(4.0 m) or (13 ft) = 1.02 m or 3.3 ft from the right edge of the material. To avoid problems associated with taking samples too close to the edge, no sample is taken closer than 0.3 m (1 ft) to the edge. If the RN specifies a location closer than 0.3 m (1 ft), then 0.3 m (1 ft) is added to or subtracted from the distance calculated.

17 **Sampling from a Stockpile:** AASHTO R 90 recommends against sampling from stockpiles. However, some agencies use random procedures in determining sampling locations from a stockpile. Bear in mind that stockpiles are prone to segregation and that a sample obtained from a stockpile may not be representative. Refer to AASHTO R 90 for guidance on how to sample from a stockpile.

In-Place Density Testing: Agency specifications will indicate the frequency of tests. For example, one test per 500 m^3 (650 yd^3) might be required. If

the material is being placed 0.15 m (0.50 ft) thick
18 and 10.0 m (33 ft) wide, then the lot is 333 m
(1090 ft) long. You would select two RNs in this
case.

The first RN would be multiplied by the length to
determine where the sample would be taken along
the project. The second would be multiplied by the
width to determine where, widthwise, the sample
19 would be taken. For example, a first RN of 0.387
would specify that the sample would be taken at
(0.387)(333 m) or (1090 ft) = 129 m or (422 ft)
from the beginning. A second RN of 0.558 would
specify that the sample would be taken at
(0.588)(10.0 m) or (33 ft) = 5.88 m or (19 ft) from
the right edge of the material. To avoid problems
associated with taking samples too close to the
edge, no sample is taken closer than 0.3 m (1 ft) to
the edge. If the RN specifies a location closer than
0.3 m (1 ft), then 0.3 m (1 ft) is added to or
subtracted from the distance calculated.

BASICS OF ASPHALT MIXTURES

Slice through asphalt core

01 Introduction

02 Asphalt mixtures are comprised of two primary ingredients: aggregate and asphalt binder. The asphalt binder coats and holds the aggregate together in a moderately flexible rock-like mass. Hot mix asphalts (HMA) are mixes that are produced at high temperature. Warm mix asphalts 03 (WMA) are mixtures that, due to a variety of technologies, are mixed and placed at relatively lower temperatures.

Asphalt mixtures are generally divided into three types based on the gradation of the aggregate: dense-graded, open-graded, and gap-graded.

04 Dense-graded asphalt mixtures consist of asphalt binder and well-graded aggregate, which is aggregate having an even distribution of particle sizes.

Open-graded asphalt mixtures consist primarily of coarse aggregate, minimal fine aggregate, and asphalt binder. These mixtures have an open surface texture that allows water to drain into the mix. The large aggregate and stone-to-stone contact carries the load of vehicles traveling over the surface.

Gap-graded asphalt mixtures are similar to open-graded mixes except that mid-size aggregate, between the 4.75 mm (No. 4) and 425 µm (No. 40) sieves, is missing or present only in small amounts.

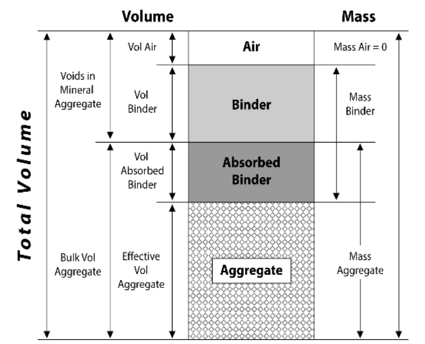
The asphalt binder is divided into two categories: asphalt binder that is absorbed into the aggregate 05 (P_{ba}) and effective asphalt binder (P_{be}), asphalt binder that coats the surfaces and binds aggregate particles together. Asphalt mixtures also have air voids as well as aggregate and asphalt binder.

06 Five factors affect pavement performance:

- structural design of pavement layers
- mix design properties

- workmanship used to produce, place, and compact the mix
- loading factors
- environmental conditions

The best specifications, if not followed, will not ensure a high quality, long-lasting pavement. The best mix design, if not duplicated at the plant, will not guarantee the life of the pavement. The most sophisticated equipment, if not operated properly, will not produce a roadway that withstands the effects of traffic and the environment. Poor workmanship can negate all those items and cause premature failure of pavement materials or pavement structure, or both. Accurate materials testing, and construction inspection are critical to a successful project.



Asphalt mixture phase diagram

07

Design Parameters

08 The total volume of the mix includes entrapped air voids, moisture, effective and absorbed asphalt binder, and mineral aggregate.

09 10 Whether a mix design is developed through a Marshall, Hveem, or Superpave mix design process there are common volumetric requirements. Volumetric properties (measurements by volume) include bulk specific gravity (G_{mb}), theoretical maximum specific gravity (G_{mm}), air voids (V_a), voids in mineral aggregate (VMA), and voids filled with asphalt (VFA).

The total mass of a specimen divided by the corresponding total volume (bulk) of a specimen is known as bulk density. Bulk density is calculated by determining the bulk specific gravity, G_{mb}, of the sample and multiplying by the density of water.

11 There are two procedures for calculating G_{mb} in the FOP for AASHTO T 166 – suspension and volumeter. In the suspension procedure, G_{mb} is calculated as follows.

$$G_{mb} = \frac{A}{B - C}$$

where:

G_{mb} = Bulk specific gravity

A = Mass of dry, compacted specimen in air

B = Mass of saturated surface dry (SSD) compacted specimen in air

C = Weight of compacted specimen in water at 25°C (77°F)

12 The combined masses of asphalt binder and aggregate divided by the volume of these components is the maximum density. Maximum density contains no air voids. The maximum density provides a reference to determine the amount of air in the compacted mix, among other things. Maximum density is determined on uncompacted asphalt mixtures by determining the theoretical maximum specific gravity, G_{mm}, according to the FOP for AASHTO T 209 and multiplying by the density of water.

13 There are two procedures for calculating G_{mm} – bowl and flask. In the flask procedure, G_{mm} is calculated as follows.

$$G_{mm} = \frac{A}{A + D - E}$$

where:

G_{mm} = Theoretical maximum specific gravity

A = Mass of dry specimen in air

D = Mass of flask filled with water at 25°C (77°F)

E = Mass of flask filled with water and specimen at 25°C (77°F)

14 Air voids are expressed as a percentage of total sample volume. Percent air voids, V_a, is calculated as follows:

$$V_a = \left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right) \times 100$$

where:

V_a = Percent air voids of total mix mass

G_{mb} = Bulk specific gravity of compacted mix

G_{mm} = Theoretical maximum specific gravity

15 Voids between aggregate particles may contain air or asphalt binder. Voids in the mineral aggregate, VMA, are those spaces in laboratory compacted specimens that include air and effective, but not absorbed, asphalt binder.

16

$$VMA = 100 - \left(\frac{G_{mb} \times P_s}{G_{sb}}\right)$$

where:

VMA = Voids in the mineral aggregate

G_{mb} = Bulk specific gravity of compacted mix

G_{sb} = Bulk specific gravity of aggregate

P_s = Percent aggregate content in mix by mass of total mix

17 Finally, the voids filled with asphalt (VFA) is expressed as the percentage of the VMA that contains asphalt.

$$VFA = \left(\frac{VMA - V_a}{VMA}\right) \times 100$$

where:

VFA = Voids filled with asphalt

VMA = Voids in the mineral aggregate

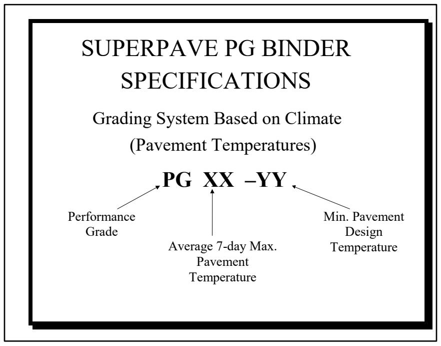
V_a = Percent air voids by total mass of mix

These properties are used to design asphalt mixtures and need to be verified during construction to ensure a quality pavement.

18

Asphalt Binder

Performance Graded (PG) asphalt binders were introduced in 1994 and are now the industry standard. The PG system of specifying asphalt binder is based on a complex series of performance-based tests. The specification system includes modified and unmodified asphalt binders.



SUPERPAVE PG BINDER SPECIFICATIONS

Grading System Based on Climate (Pavement Temperatures)

PG XX –YY

Performance Grade

Average 7-day Max. Pavement Temperature

Min. Pavement Design Temperature

19

Superpave PG Asphalt Binder specification

The Superpave PG asphalt binder specification, as outlined in *AASHTO M 320, Performance Graded Asphalt Binder*, measures the physical properties of asphalt binders that are related to field performance.

The Superpave asphalt binder grading system indicates the range of in-service temperatures of the asphalt binder capable of resisting rutting, fatigue and thermal cracking. The first number is the “high temperature grade,” and means the asphalt binder possesses adequate physical properties up to this pavement temperature. The second number is the “low temperature grade,” and means the asphalt binder possesses adequate physical properties down to this pavement temperature. A PG 64-34 performs up to 64°C (147° F) maximum pavement temperature and down to -34°C (-29°F)

Asphalt Binder selection

The selection of the asphalt binder depends on the climate of the project site:

- Low temperature

  Lowest pavement temperature (not air temperature)

- High temperature

  Average 7-day maximum pavement temperature (not air temperature)

The asphalt binder selection also adjusts for the anticipated traffic load known as the ‘equivalent single axle load (ESAL).’

Types of Manufacturing Plants

Drum plants and batch plants are two common
20 types of plants. Both are capable of producing
asphalt mixtures. They are similar in that both have
cold feed systems for aggregate. Aggregate
material of different sizes is dropped from bins onto
belts, transported to a mixer, blended, and then
dropped onto another belt for transport to the dryer.
The plants are different in the means of production
21 following heating in the dryer.

Aggregate feed bins

Drum Plants – In drum plants, scales under the
22 belts from each bin control the mass flow rate of
each aggregate size. The percent of asphalt binder
is based on dry mass, so the mass of aggregate is
mathematically corrected for moisture. The
introduction of asphalt binder is controlled by a
metered delivery pump. Aggregate and asphalt
binder are mixed in the far end (near the exit) of the
drum and then stored temporarily in a silo.

When the drum plant is supplying to a single project, the amount of aggregate and asphalt binder, as measured by the scales and meter, can be compared with the amount of material delivered to the project.

Drum plants

23 Drum plants are typically used for large jobs and are more portable. Drum plants continuously feed aggregate and asphalt binder into the drum and produce large quantities of asphalt mixtures during the course of a run. Drum plants, however, cannot switch mix designs with ease and require close control of material being fed to the dryer. Drum plants are better suited to produce the same mix over an extended period, not several different mixes in a day as with batch plants.

Batch Plant

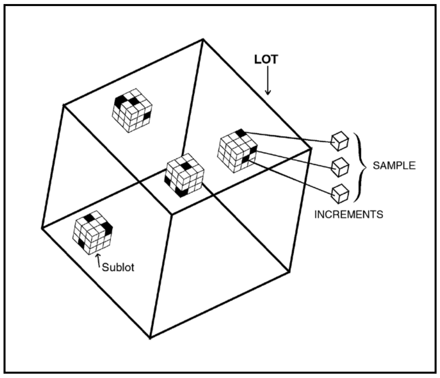
Batch Plants – In batch plants, aggregate is
24 rescreened and stored in separate bins after drying.
25 Aggregate is taken from each bin, based on the mix
design, and the mass is determined in the aggregate
hopper. A separate hopper is used for determining
the mass of the asphalt binder. Aggregate and
asphalt binder are mixed in a chamber, or pugmill,
and then dropped into a truck or stored temporarily
in a silo.

Batch plants are less efficient than drum plants because they only mix a certain amount of asphalt mixture at a time. They are more flexible, however, because several different mixtures can be made in a day. In fact, a batch plant can switch from one mix to another fairly quickly, as long as both mixes use aggregates from the same source.

Summary

26 High quality asphalt mixtures require a proper combination of materials and workmanship. The testing technician plays a critical role by testing materials according to proper procedures to determine if the materials meet the project specification. No amount of proper workmanship can compensate for poor material quality.

SAMPLING ASPHALT MIXTURES
FOP FOR AASHTO R 97



Sampling from a lot

Significance

01 Testing asphalt mixtures in the field begins with obtaining and preparing the sample to be tested. Standardized procedures for obtaining a representative sample have been established. Producing strong, durable, reliable pavement in roadways requires careful sampling and accurate testing.

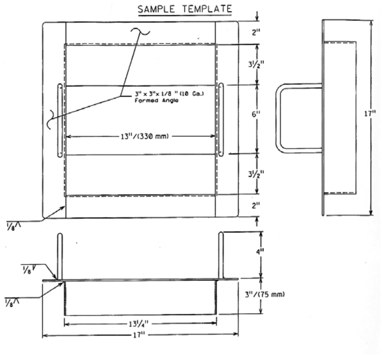
02 Technicians must be patient and follow these procedures. If one considers that the specifications require tests to be performed on only a small portion of the total material placed, the need for a truly representative sample is apparent.

Asphalt mixture sample

Scope

03 This procedure covers sampling of asphalt mixtures from plants, haul units, and roadways, in 04 accordance with AASHTO R 97-19. Sampling is as important as testing. Use care to obtain a 05 representative sample. Avoid segregation and contamination of the material during sampling.

This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.



Cookie Cutter Sampling Device

Apparatus

- 06 Shovel or Metal Scoops, or Other Equipment: square-head metal shovels at least 125 mm (5.5 in.) wide.
- Sample containers: cardboard boxes, metal cans, stainless steel bowls, or other agency-approved containers
- Sampling plate: thick metal plate, minimum 8 gauge, sized to accommodate sample requirements, with a wire attached to one corner long enough to reach from the center of

the paver to the outside of the farthest auger extension. A minimum of one hole 6 mm (0.25 in.) in diameter must be provided in a corner of the plate.

- Cookie cutter sampling device: formed steel angle with two 100 by 150 mm by 9 mm (4 in. by 6 in. by 3/8 in.) handles, sized to accommodate sample requirements. Minimum 50 mm (2 in.) smaller than the sampling plate when used together.

  Example: Sampling plate 380 mm (15 in.) square and a cookie cutter sampling device 330 mm (13 in.) square.

- Mechanical sampling device: a permanently attached device that allows a sample receptacle to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation.
- Agency approved release agent: a non-stick product that prevents the asphalt mixture from sticking to the apparatus and does not contain solvents or petroleum-based products that could affect asphalt binder properties.

Sample Size

07 Sample size depends on the test methods specified by the agency for acceptance. Check agency requirement for the size required.

Procedure

08

General

- Select sample locations using a random or stratified random sampling procedure, as specified by the agency. The material shall be tested to determine variations. The supplier/contractor shall provide equipment for 09 safe and appropriate sampling including sampling devices on plants, when required.
- Ensure the container(s) and sampling equipment are clean and dry before sampling.

- For dense graded mixture samples use cardboard boxes, stainless steel bowls or other agency approved containers.
- For hot open graded mixture samples use stainless steel bowls. Cardboard boxes can used if the sample has cooled to the point that asphalt binder will not migrate from the aggregate.

Attached Sampling Devices

Attached sampling device

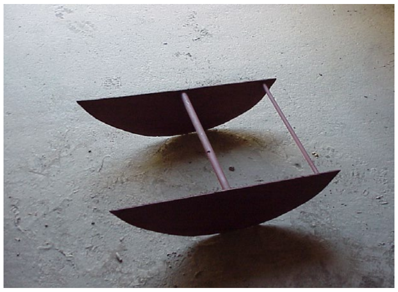
12 These are normally permanently attached devices that allow a sample container to pass perpendicularly through the entire stream of material Operation may be manual, pneumatic, or hydraulic and allow the sample container to pass through the stream twice without overfilling. A sampling device may divert the entire stream of material into the container.

10

1. Lightly coat the container attached to the sampling device with an agency-approved release agent or preheat it, or both to approximately the same discharge temperature of the mix.
2. Pass the container twice, once in each direction, through the material perpendicularly without overfilling the container.
3. Transfer the asphalt mixture to an agency-approved container without loss of material. 11
4. Repeat until proper sample size has been obtained.
5. Combine the increments to form a single sample.

13
14

Conveyor Belts

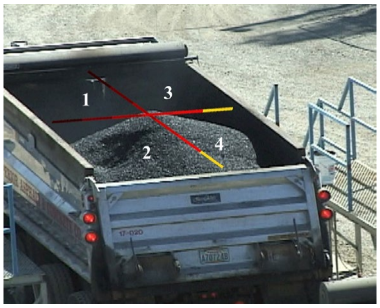


Belt template

1. Avoid sampling at the beginning or end of an asphalt mixture production run due to the potential for segregation.
2. Stop the belt containing asphalt mixture.
3. Set the sampling template into the asphalt mixture on the belt, avoiding intrusion by adjacent material.

4. Remove the asphalt mixture from inside the template, including all fines, and place in a sample container.
5. Repeat, obtaining equal size increments, until proper sample size has been obtained.
6. Combine the sample increments to form a single sample.

15
Haul Units

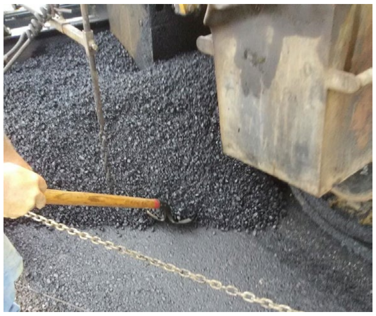


Ouadrants in a load

1. Visually divide the haul unit into approximately four equal quadrants.
2. 16 Identify one sampling location in each quadrant.
3. Dig down and remove approximately 0.3 m (1 ft.) of material to avoid surface segregation. Obtain each increment from below this level.
4. 17 Combine the increments to form a sample of the required size.

Asphalt mixture in a haul unit

18
Paver Auger



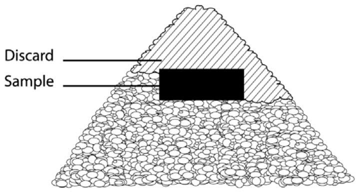
Sampling from paver auger

1. Obtain samples from the end of the auger using a square head shovel.
2. Place the shovel in front of the auger extension, with the shovel blade flat upon the surface to be paved over.
3. Allow the front face of the auger stream to cover the shovel with asphalt mixture, remove the shovel before the auger reaches it by lifting as vertically as possible.
4. 19 Place asphalt mixture in a sample container.
5. Repeat until proper sample size has been obtained.
6. Combine the sample increments to form a sample of the required size.

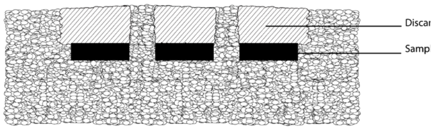
Note 1: First full shovel of material may be discarded to preheat and 'butter' the shovel.

20
21
Windrow

1. Obtain samples from the windrow of a transport unit. Avoid the beginning or the end of the windrow section.



Windrow cross section



Windrow side view

2. Visually divide the windrow from the haul unit into approximately three equal sections.
3. Remove approximately 0.3 m (1 ft) from the top.

22
23

4. Fully insert the shovel into the flat surface as vertically as possible, exclude the underlying material, roll back the shovel and lift the material slowly out of the windrow to avoid material rolling off the shovel.
5. Place in a sample container.
6. Repeat, obtaining equal size increments, in each of the remaining thirds.
7. Combine the increments to form a sample of the required size.

Roadway before Compaction

24

There are two conditions that will be encountered when sampling asphalt mixtures from the roadway before compaction. The two conditions are:

- Laying asphalt mixture on grade or untreated base material requiring Method 1.
- Laying asphalt mixture on existing asphalt or laying a second lift of asphalt mixture allowing Method 2.

Cookie cutter and plate

SAFETY:

25 Sampling is performed behind the paving machine in front of the breakdown roller. For safety, the breakdown roller must remain at least 3 m (10 ft.) behind the sampling operation until the sample has been obtained and the hole filled with loose asphalt mixture.

Method 1 requires a plate to be placed in the roadway in front of the paving operation. There is always concern when working in the path of moving equipment. It is safest to stop the paving train while a plate is installed in front of the paver. When this is not possible the following safety rules must be followed.

1. The plate placing operation must be at least 3 m (10 ft.) in front of the paver or pickup device. The technician placing the plate must have eye contact and communication with the

paving machine operator. If eye contact cannot be maintained at all times, a third person must be present to provide communication between the operator and the technician.

2. No technician is to be between the asphalt supply trucks and the paving machine. The exception to this rule is if the supply truck is moving forward creating a windrow, in which case the technician must be at least 3 m (10 ft.) behind the truck.

If at any time the Engineer feels that the sampling technique is creating an unsafe condition, the operation is to be halted until it is made safe, or the paving operation will be stopped while the plate is being placed.

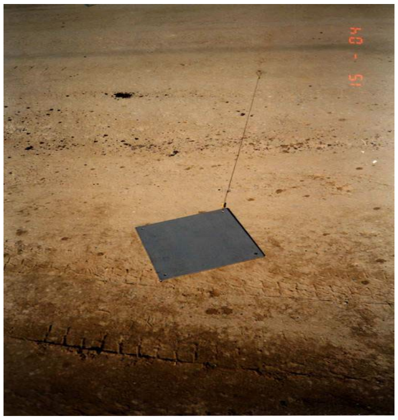


Plate on untreated base

26 Method 1 - Obtaining a Sample on Grade or Untreated Base (Plate Method)

28

1. Following the safety rules detailed above, the technician is to:
    a. Smooth out a location in front of the paver at least 0.5 m (2 ft.) inside the edge of the mat.
    b. Lay the plate down diagonally with the direction of travel, keeping it flat and tight to the base with the lead corner facing the paving machine.

Note 2: The plate may be secured by driving a nail through the hole in the lead corner of the plate.

2. Pull the wire, attached to the outside corner of the plate, taut past the edge of the asphalt mixture mat and secure it. Let the paving operation pass over the plate and wire.

29

3. Using the exposed end of the wire, pull the wire up through the fresh asphalt mixture to locate the corner of the plate.
    a. Plate only:
        i. Using a small square head shovel, scoop, or both, remove the full depth of the asphalt mixture from the plate.

Take care to prevent sloughing of adjacent material.

   ii. Place asphalt mixture, including any material adhering to the plate and scoop or shovel in a sample container.
   iii. Remove the plate from the roadway. The hole made from the sampling must be filled by the contractor with loose asphalt mixture.

b. “Cookie Cutter”:

   i. Place the “cookie cutter” sampling device, just inside the end of the wire; align the cutter over the plate. Press “cookie cutter” device down through the asphalt mixture to the plate.
   ii. Using a small square tipped shovel, scoop, or both, carefully remove all the asphalt mixture from inside of the cutter and place in a sample container.
   iii. Remove the sample cutter and the plate from the roadway. The hole made from the sampling must be filled by the contractor with loose asphalt mixture.

Using the cookie cutter

Method 2 – Obtaining a Sample on Asphalt Surface (Non-plate Method)

1. After the paving machine has passed the sampling point, immediately place the “cookie cutter” sampling device on the location to be sampled.
2. Push the cutter down through the asphalt mixture until it is flat against the underlying asphalt mat.
3. Using a small square-tipped shovel or scoop, or both, carefully remove all the asphalt mixture from inside of the cutter and place in a sample container.

4. Remove the cutter from the roadway. The hole made from the sampling must be filled by the contractor with loose asphalt mixture.

Stockpiles

31 Remove at least 0.1 m (4 in.) from the surface before sampling; mixtures in a stockpile may develop an oxidized crust.

Method 1 – Loader

32
1. Direct the loader operator to enter the stockpile with the bucket at least 0.3 m (1 ft) above ground level without contaminating the stockpile.
2. Obtain a full loader bucket of the asphalt mixture; tilt the bucket back and up.
3. Form a small sampling pile at the base of the stockpile by gently rolling the asphalt mixture out of the bucket with the bucket just high enough to permit free flow of the mixture. Repeat as necessary.
4. Create a flat surface by having the loader "back-drag" the small pile.

33
5. Obtain approximately equal increments from at least three randomly selected locations on the flat surface at least 0.3 m (1 ft) from the edge.
6. Fully insert the shovel, exclude the underlying material, roll back the shovel and lift the asphalt mixture slowly out of the pile to avoid mixture rolling off the shovel.
7. Combine the sample increments to form a sample.

Method 2 – Stockpile Face

34
1. Create horizontal surfaces with vertical faces in the top, middle, and bottom third of the stockpile with a shovel or a loader if one is available.
2. Shove a flat board against the vertical face behind the sampling location to prevent sloughing of asphalt mixture. Discard the

sloughed mixture to create the horizontal surface.

35 3. Obtain the sample from the horizontal surface as close as possible to the intersection of the horizontal and vertical faces.

36 4. Obtain at least one sample increment of equal size from each of the top, middle, and bottom thirds of the pile.

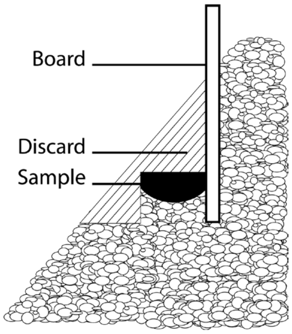
5. Combine the increments to form a single sample.

37 Identification and Shipping

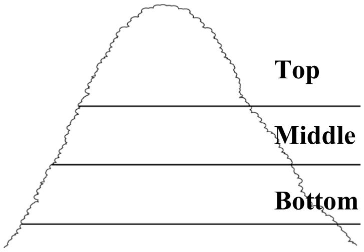
1. Identify sample containers as required by the agency.
2. Ship samples in containers that will prevent loss, contamination, or damage.

38 Report

- On forms approved by the agency
- Sample ID
- Date
- Time
- Location
- Quantity represented



Sampling from a stockpile face



39 Tips!

Check agency requirements for:

- Sample size needed
- Sampling device requirements
- Allowable sampling techniques

REVIEW QUESTIONS

1. Asphalt mixture sample sizes are based on what?

2. What types of containers are used for asphalt mixture samples?

3. Describe how samples are obtained from:

    - Attached sampling devices
    - Conveyor belt
    - Haul units
    - Auger
    - Windrow
    - Roadway
    - Stockpile

PERFORMANCE EXAM CHECKLIST

SAMPLING ASPHALT MIXTURES
FOP FOR AASHTO R 97

Participant Name ______________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
Attached Sampling Device		
1. Container coated or preheated or both?	_____	_____
2. Sampling device passed through stream twice perpendicular to material?	_____	_____
3. Sampling device not over filled?	_____	_____
Conveyor Belt		
4. Belt stopped?	_____	_____
5. Sampling template set on belt, avoiding intrusion of adjacent material?	_____	_____
6. Sample, including all fines, scooped off?	_____	_____
Haul Units		
7. Unit divided into four quadrants?	_____	_____
8. Increment obtained from each quadrant, 0.3 m (1ft.) below surface?	_____	_____
9. Increments combined to make up the sample?	_____	_____
Paver Auger		
10. Shovel blade flat on the surface to be paved?	_____	_____
11. Shovel lifted vertically after it is filled?	_____	_____
Windrow		
12. Beginning and end avoided?	_____	_____
13. Equal increments obtained from three sections?		
14. Approximately 0.3 m (1 ft) removed from top of each section?	_____	_____
15. Underlying material excluded?	_____	_____
Roadway Before Compaction (Method 1)		
16. Plate placed well in front of paver?	_____	_____
17. Wire pulled to locate plate corner?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
18. Cookie cutter (if used) placed on asphalt and pushed through to plate?	_____	_____
19. All material removed from inside the cutter?	_____	_____
Roadway Before Compaction (Method 2)		
20. Cookie cutter placed on asphalt and pushed through to underlying material?	_____	_____
21. All material removed from inside the cutter?	_____	_____
Stockpile Method 1– (Loader sampling)		
22. Loader operator directed to enter the stockpile with the bucket at least 0.3 m (1 ft) above ground level without contaminating the stockpile?	_____	_____
23. The loader obtained a full loader bucket of the material with the bucket tilted back and up?	_____	_____
24. A small sampling pile formed at the base of the stockpile by gently rolling the material out of the bucket with the bucket just high enough to permit free-flow of the material?	_____	_____
25. A flat surface created by the loader back dragging the small pile?	_____	_____
26. Increment sampled from three locations at least 0.3 m (1 ft) from the edge by fully inserting the shovel into the flat pile as vertically as possible, care taken to exclude the underlying material?	_____	_____
Stockpile Method 2 (Stockpile Face)		
27. Created horizontal surfaces with vertical faces?	_____	_____
28. Sample obtained from the horizontal face as close as possible to the vertical face?	_____	_____
29. At least one increment taken from each of the top, middle, and bottom thirds of the stockpile?	_____	_____
General		
30. Sample placed in appropriate container?	_____	_____
31. Sample size meets agency requirements?	_____	_____
32. Sample identified as required?	_____	_____

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass______Fail_____

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Examiner Signature ______________________________ WAQTC #:_______________

PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING ASPHALT MIXTURES
FOP FOR AASHTO R 97

Participant Name ______________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. At the hot plant, how must a sample be obtained using an attached sampling device?		
a. Coat or preheat sample container.	____	_____
b. Sampling device passed through stream twice, once in each direction, perpendicular to material.	____	_____
c. The sampling device cannot be overfilled.	____	_____
2. How is a sample obtained from a conveyor belt?		
a. Stop the belt.	_____	_____
b. Set the sampling template on belt, avoiding intrusion of adjacent material.	_____	_____
c. All the material is removed from belt including all fines.	_____	_____
3. What must be done to sample from transport units?		
a. Divide the unit into four quadrants.	_____	_____
b. Obtain increments from each quadrant, 0.3 m (1 ft) below surface.	_____	_____
4. How is a sample obtained from the paver auger?		
a. Shovel blade is placed flat on the surface to be paved in front of the auger extension.	_____	_____
b. Shovel is filled and removed by lifting as vertically as possible.	_____	_____
5. Describe the procedure for sampling from a windrow.		
a. Do not sample from the beginning or end of the windrow.	_____	_____
b. Approximately 0.3 m (1 ft) removed from the top.	_____	_____
c. Underlying material is excluded	_____	_____
d. Equal increments obtained from 3 locations along the windrow.	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
6. Describe how to take samples from the roadway using Method 1 (plate).		
a. Place the plate well in front of the paver.	_____	_____
b. Pull the wire to locate the corner of the plate.	_____	_____
c. Place the cutter (if used) on the asphalt material above the plate and push it down to the plate.	_____	_____
d. Collect all the material inside the cutter.	_____	_____
7. Describe how to take samples from the roadway using Method 2.		
a. Place the cutter on the asphalt material and push it down to the underlying material.	_____	_____
b. Collect all the material inside the cutter.	_____	_____
8. Describe the procedure for sampling a stockpile Method 1 (Loader Sampling).		
a. Loader removes surface and creates sampling pile.	_____	_____
b. Loader back drags pile to create a flat surface.	_____	_____
c. Take three approximately equal increments from at least 0.3 m (1 ft) from the edge, excluding the underlying material.	_____	_____
9. Describe the procedure for sampling a stockpile Method 2 (Stockpile Face Sampling).		
a. Create horizontal surfaces with vertical faces with a shovel.	_____	_____
b. At least one increment taken from each of the top, middle, and bottom thirds of the stockpile.	_____	_____
10. Increments combined to form a sample of required size?	_____	_____
11. What types of containers can be used?		
a. Cardboard boxes, stainless steel bowls, or other agency approved containers.	_____	_____
12. What dictates size of sample?		
a. Agency requirements.	_____	_____
b. Specified by test method.	_____	_____

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass_____Fail_____

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Examiner Signature ______________________________ **WAQTC #:**________________

REDUCING SAMPLES OF ASPHALT MIXTURES TO TESTING SIZE
FOP FOR AASHTO R 47

Mix sample

Significance

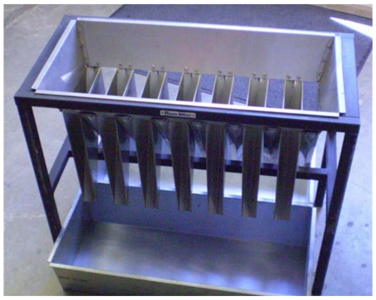
Samples of asphalt mixtures taken in accordance
01 with the FOP for AASHTO R 97 are composites
and typically large in size. Materials sampled in
the field need to be reduced to appropriate sizes
02 for testing. It is extremely important that the
procedure used to reduce the field sample not
03 modify the material properties.

04 Scope

This procedure covers sample reduction of asphalt mixtures to testing size in accordance with AASHTO R 47-23. The reduced portion is to be representative of the original sample.

05 Apparatus

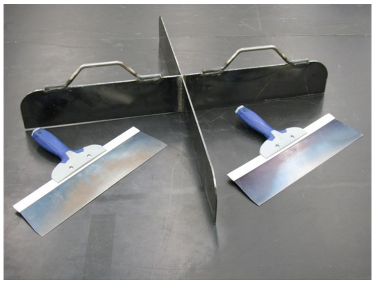
- Thermostatically controlled oven capable of maintaining a temperature of at least 110°C (230°F) or high enough to heat the material to a pliable condition for splitting.
- Non-contact temperature measuring device.
- Metal spatulas, trowels, metal straightedges, drywall taping knives, or a combination thereof; for removing asphalt mixture samples from the quartering device, cleaning surfaces used for splitting, etc.
- Square-tipped flat-bottom scoop, shovel, or trowel for mixing asphalt mixture before quartering.
- Miscellaneous equipment: hot plate, non-asbestos heat-resistant gloves or mittens,
06 pans, buckets, and cans.
- Sheeting: Non-stick heavy paper or other material as approved by the agency.
- Agency-approved release agent, free of solvent or petroleum-based material that could affect asphalt binder.



Mechanical Splitter Type B (Riffle)

07

- Mechanical Splitter Type B (Riffle): having a minimum of eight equal-width chutes discharging alternately to each side with a minimum chute width of at least 50 percent larger than the largest particle size. A hopper or straight-edged pan with a width equal to or slightly smaller than the assembly of chutes in the riffle splitter to permit uniform discharge of the asphalt mixture through the chutes without segregation or loss of material. Sample receptacles of sufficient width and capacity to receive the reduced portions of asphalt mixture from the splitter without loss of material.



Quartering template and straight edges

08

- Quartering Template: formed in the shape of a 90- degree cross with equal sides that exceed the diameter of the flattened cone of material sufficient to allow complete separation of the quartered sample. The height of the sides must be sufficient to extend above the thickness of the flattened cone of the sample to be quartered. Manufactured of metal that will withstand heat and use without deforming. Non-stick mixing surface that is hard, heat-resistant, clean, level, and large enough to permit asphalt mixture samples to be mixed without contamination or loss of material.

Sampling

Obtain samples according to the FOP for AASHTO R 97.

Sample Preparation

09 The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily. Do not exceed either the temperature or time limits specified in the test method(s) to be performed.

Selection of Procedure (Method)

Refer to agency requirements when determining
the appropriate method(s) of sample reduction.
10 In general, the selection of a particular method to
reduce a sample depends on the initial size of the
sample vs. the size of the sample needed for the
specific test to be performed. It is recommended
that, for large amounts of material, the initial
11 reduction be performed using a mechanical
splitter. This decreases the time needed for
reduction and minimizes temperature loss.
Further reduction of the remaining asphalt
mixture may be performed by a combination of
the following methods, as approved by the
agency.

The methods for reduction are:

- Mechanical Splitter Type B (Riffle) Method
- 12 Quartering and Sectoring Methods
  - Quartering
  - Sectoring
- Incremental Method

13 Procedure

When heating of the equipment is desired, it shall be heated to a temperature not to exceed the maximum mixing temperature of the job mix formula (JMF).

Mechanical Splitter Type B (Riffle) Method

14
1. Clean the splitter and apply a light coating of agency-approved release agent to the surfaces that will come in contact with the asphalt mixture (hopper or straight-edged pan, chutes, receptacles).
2. Place two empty receptacles under the splitter.
3. Carefully empty the asphalt mixture from the agency-approved container(s) into the hopper or straight-edged pan without loss of material. Uniformly distribute from side to side of the hopper or pan.

4. Discharge the asphalt mixture at a uniform rate, allowing it to flow freely through the chutes.
5. Any asphalt mixture that is retained on the surface of the splitter shall be removed and placed into the appropriate receptacle.

15

6. Reduce the remaining asphalt mixture as needed by this method or a combination of the following methods as approved by the agency.
7. Using one of the two receptacles containing asphalt mixture, repeat the reduction process until the asphalt mixture contained in one of the two receptacles is the appropriate size for the required test.
8. After each split, remember to clean the splitter hopper and chute surfaces if needed.
10. Retain and properly identify the remaining unused asphalt mixture sample for further testing if required by the agency.

16

Quartering and Sectoring Methods

Quartering Template (In Place)

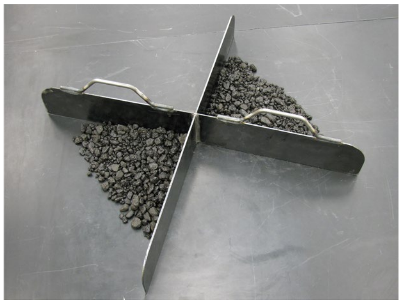
1. If needed, apply a light coating of agency-approved release agent to quartering template.

18

2. Place the sample from the agency approved container(s) into a conical pile on a hard, "non-stick," clean, level surface where there will be neither a loss of material nor the accidental addition of foreign material. The surface can be made non-stick by the application of an agency-approved release agent or sheeting.
3. Mix the material thoroughly by turning the entire sample over a minimum of four times with a flat-bottom scoop; or by alternately lifting each corner of the sheeting and pulling it over the sample diagonally toward the opposite corner, causing the material to be rolled. Create a conical pile by either depositing each scoop or shovelful of the last turning on top of the preceding one or lifting both opposite corners.

4. Flatten the conical pile to a uniform diameter and thickness where the diameter is four to eight times the thickness. Make a visual observation to ensure that the material is homogeneous.
5. Divide the flattened cone into four equal quarters using the quartering template or straightedges assuring complete separation.
6. Reduce to appropriate sample mass by quartering or sectoring.

Quartered sample



Diagonally opposite quarters removed

Quartering

a. Remove diagonally opposite quarters, including all the fine material, and place in a container to be retained.

b. Remove the quartering template, if used

c. Combine the remaining quarters.

d. If further reduction is necessary, repeat Quartering Method Step 4 through 6.

e. Repeat steps until appropriate sample mass is obtained. The final sample must consist of the two remaining diagonally opposite quarters.

f. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Sectoring

Asphalt mixture from the apex of the quarter to the outer edge.

23 a. Using a straightedge, obtain a sector by slicing through a quarter of the asphalt mixture from the center point to the outer edge of the quarter.

24 b. Pull or drag the sector from the quarter with two straight edges or hold one edge of the straightedge in contact with quartering device.

25 c. Remove an approximately equal sector from the diagonally opposite quarter.

26 d. If necessary, repeat until the appropriate sample mass has been obtained.

Equal portion from the diagonally opposite quarter

27 e. Continue using sectoring with the unused portion of the asphalt mixture until samples have been obtained for all required tests.

f. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

28

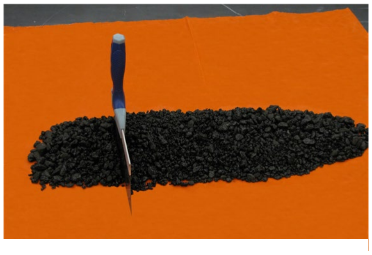
Incremental Method

Mixing the sample

1. Cover a hard, clean, level surface with sheeting. This surface shall be large enough that there will be neither a loss of material nor the accidental addition of foreign material.
2. Place the sample from the agency approved container(s) into a conical pile on that surface.
3. 29 Mix the material thoroughly by turning the entire sample over a minimum of four times.
   a. Use a flat-bottom scoop; or
   b. Alternately lift each corner of the sheeting and pull it over the sample diagonally toward the opposite corner, causing the material to be rolled.
4. Create a conical pile by either depositing each scoop or shovelful of the last turning on

top of the preceding one or lifting both opposite corners.

5. Grasp the sheeting and roll the conical pile into a cylinder (loaf), then flatten the top. Make a visual observation to determine that the material is homogenous.



Slicing off one quarter

30 6. Remove one quarter of the length of the loaf and place in a container to be saved by either:
    a. Pull sheeting over the edge of the counter and drop into a container.
    31 b. Use a straightedge at least as wide as the full loaf to slice off material and place into a container.

32 7. Obtain an appropriate sample mass for the test to be performed, by either:
    a. Pull sheeting over edge of counter and drop cross sections of the material into container until proper sample mass has been obtained.
    33 b. Use a straightedge at least as wide as the full loaf to slice off cross sections of the material until proper sample mass has been obtained and place into container.

Appropriate sample mass dropped into container

Note 1: When reducing the sample to test size it is advisable to take several small increments, determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size, use the sample as reduced for the test.

8. Repeat step 7 until all the samples for testing have been obtained or until the final quarter of the original loaf is reached.

9. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Tips! 34

- Remember, the reduced sample must be representative of the whole.
- Proceed quickly so that splitting is done when the material is hot.
- Check agency requirements about what splitting device(s) or method(s) may be used.
- Inspect mechanical splitter surfaces for build-up of asphalt mixture, ensuring they are cleaned such that the material falls into the appropriate receptacles.
- With full quartering, remember that the final sample consists of the two remaining diagonally opposite quarters.

REVIEW QUESTIONS

1. Describe how the material is mixed before quartering.

2. Describe how the equipment is heated?

3. What is the difference between quartering and sectoring?

4. Are any of the reduction methods preferred? When and why?

5. Can multiple splitting methods be used in reducing a sample?

PERFORMANCE EXAM CHECKLIST

REDUCING SAMPLES OF ASPHALT MIXTURES TO TESTING SIZE FOP FOR AASHTO R 47

Participant Name ______________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample made soft enough to separate easily without exceeding temperature limits?	_____	_____
2. Splitting apparatus and tools, if preheated, not exceeding maximum mixing temperature from the JMF?	_____	_____
Mechanical Splitter Type B (Riffle) Method		
1. Splitter cleaned, and surfaces coated with release agent?	_____	_____
2. Two empty receptacles placed under splitter?	_____	_____
3. Sample placed in hopper or straight edged pan without loss of material and uniformly distributed from side to side?	_____	_____
4. Material discharged across chute assembly at controlled rate allowing free flow of asphalt mixture through chutes?	_____	_____
5. Splitter surfaces cleaned of all retained asphalt mixture allowing it to fall into appropriate receptacles?	_____	_____
6. Further reduction with the riffle splitter:		
a. Material from one receptacle discharged across chute assembly at controlled rate, allowing free flow of asphalt mixture through chutes?	_____	_____
b. Splitting process continued until appropriate sample mass obtained, with splitter surfaces cleaned of all retained asphalt mixture after every split?	_____	_____
7. Remaining unused asphalt mixture stored in suitable container, properly labeled?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
Quartering Method		
1. Sample placed in a conical pile on a hard, non-stick, heat-resistant splitting surface such as metal or sheeting?	_____	_____
2. Sample mixed by turning the entire sample over a minimum of 4 times?	_____	_____
3. Conical pile formed and then flattened uniformly to diameter equal to about 4 to 8 times thickness?	_____	_____
4. Sample divided into 4 equal quarters either with a metal quartering template or straightedges such as drywall taping knives?	_____	_____
5. Quartering:		
a. Two diagonally opposite quarters removed and placed in a container to be retained?	_____	_____
b. Two other diagonally opposite quarters combined?	_____	_____
c. Process continued, if necessary, until appropriate sample mass has been achieved?	_____	_____
6. Sectoring:		
a. Using two straightedges or a quartering device and one straightedge, sector obtained from one of the quarters from the center point to the outer edge of the quarter?	_____	_____
b. Equal sector obtained taken from the diagonally opposite quarter?	_____	_____
7. Increments combined to produce appropriate sample mass?	_____	_____
8. Remaining unused asphalt mixture stored in suitable container, properly labeled?	_____	_____

OVER

Procedure Element	Trial 1	Trial 2
Incremental Method		
1. Sample placed on hard, non-stick, heat-resistant splitting surface covered with sheeting?	_______	_______
2. Sample mixed by turning the entire sample over a minimum of 4 times?	_______	_______
3. Conical pile formed?	_______	_______
4. Asphalt mixture rolled into loaf and then flattened?	_______	_______
5. The first quarter of the loaf removed by slicing off or dropping off edge of counter and set aside?	_______	_______
6. Proper sample mass sliced off or dropped off edge of counter into sample container?	_______	_______
7. Process continued until all samples are obtained or final quarter is remaining?	_______	_______
8. All remaining unused asphalt mixture stored in suitable container, properly labeled?	_______	_______

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass_____Fail_____

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Examiner Signature _________________________ WAQTC #:_______________

MOISTURE CONTENT OF ASPHALT MIXTURES BY OVEN METHOD
FOP FOR AASHTO T 329

Significance

Even though aggregate used in asphalt mixtures is
01 heated and dried at high temperatures, some types
of aggregate retain moisture. The moisture content
of the asphalt mixture must be known to correctly
02 determine the asphalt binder content of the mix.
Moisture (water) in the mix will yield erroneously
high asphalt binder content values when asphalt
binder content is determined by the ignition furnace
method.

03 Scope

This procedure covers the determination of moisture content of asphalt mixtures in accordance with AASHTO T 329-22.

Overview

04 Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

Constant mass – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Oven

Quartering

Apparatus

- Balance or scale: 2 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- 05 Forced draft, ventilated, or convection oven: Capable of maintaining the temperature surrounding the sample at 163 ±14°C (325 ±25°F). 06
- Container: Clean, dry, not affected by heat and of sufficient size to contain a test sample without danger of spilling.
- Thermometer or other suitable device with a temperature range of 50 to 200°C (122 to 392°F) and readable to the nearest 2°C (4°F).

07 Sample

The test sample shall be obtained in accordance with the FOP for AASHTO R 97 and reduced in accordance with the FOP for AASHTO R 47. The size of the test sample shall be a minimum of 1000 g.

Procedure

08

1. Preheat the oven to the Job Mix Formula (JMF) mixing temperature range. If the mixing temperature is not supplied, a temperature of 163 ±14ºC (325 ±25ºF) is to be used.

Mass of sample container

2. Determine and record the mass of the container including release media to the nearest 0.1 g.

Note 1: When using paper or other absorptive material to line the container ensure it is dry before determining initial mass of container.

3. Place the wet sample in the container.
4. 09 Determine and record the temperature of the
   10 sample to the nearest 2°C (4°F).
5. Determine and record the mass of the sample and container to the nearest 0.1 g.
6. Determine and record the wet mass (M_i) of the sample by subtracting the container mass determined in Step 2 from the mass of the sample and container determined in Step 5.

Mass determination

7. 11 Place the sample and container in the oven and
   12 dry for 90 ±5 min.
8. Determine the mass of sample and container.
9. Determine and record the mass of the sample by subtracting the container mass determined in Step 2 from the mass of the sample and container determined in Step 8.
10. Return sample and container to the oven for and
    13 dry 30 ±5 min.
11. Determine the mass of sample and container.
12. Determine and record the mass of the sample by subtracting the container mass determined in Step 2 from the mass of the sample and container determined in Step 11.

13. Determine percent change by subtracting the 14 new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.
14. 15 Continue drying, performing Steps 10 through 13, until there is less than 0.05 percent change after additional drying time.
15. Cool the sample and container to ±9°C (±15°F) of the temperature determined in Step 4.
16. Determine and record the dry mass of the sample and container to the nearest 0.1 g.
17. Determine and record mass of the dry sample (M_f) by subtracting the mass of the container determined in Step 2 from the dry mass of the sample and container determined in Step 16.

Note 2: Moisture content and the number of samples in the oven will affect the rate of drying at any given time. Placing wet samples in the oven with nearly dry samples could affect the drying process.

Calculations

Constant Mass:

Calculate constant mass using the following formula:

$$\%\,Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement

M_n = new mass measurement

Example: 16

Mass of container and release media:		232.6 g
Initial mass of sample and container:		1367.5 g
Initial mass of sample (M_i):	1367.5 g – 232.6 g =	1134.9 g
Mass of sample and container after first drying cycle:		1361.8 g
Mass, M_p, of sample:	1361.8 g – 232.6 g =	1129.2 g
Mass of sample and container after second drying cycle:		1360.4 g
Mass, M_n, of sample:	1360.4 g – 232.6 g =	1127.8 g

$$\% \, Change = \frac{1129.2\,g - 1127.8\,g}{1129.2\,g} \times 100 = 0.12\%$$ 17

0.12 percent is not less than 0.05 percent, so continue drying the sample.

Mass of sample and container after third drying cycle: 1359.9 g

Mass, M_n, of sample: 1359.9 g – 232.6 g = 1127.3 g

$$\% \, Change = \frac{1127.8\,g - 1127.3\,g}{1127.8\,g} \times 100 = 0.04\%$$ 18

0.04 percent is less than 0.05 percent, so constant mass has been reached.

Moisture Content:

Calculate the moisture content, as a percent, using the following formula. 19

$$Moisture\ Content = \frac{M_i - M_f}{M_f} \times 100$$

Where:

M_i = initial, wet mass

M_f = final, dry mass

Example: 20

M_i = 1134.9 g

M_f = 1127.3 g

$$Moisture\ Content = \frac{1134.9\,g - 1127.3\,g}{1127.3\,g} \times 100 = 0.674, \text{report } 0.67\%$$

Report

21

- On forms approved by the agency
- Sample ID
- Moisture content to the nearest 0.01 percent

22

Tips!

- Ensure release media is included in the mass of the container.
- Moisture is a percent of final dry mass.

REVIEW QUESTIONS

1. What is the minimum sample size needed?

2. The sample shall be initially dried for _________ minutes.

3. Further drying shall be in _______ minute intervals.

4. How is constant mass defined for this procedure?

PERFORMANCE EXAM CHECKLIST

MOISTURE CONTENT OF ASPHALT MIXTURES BY OVEN METHOD FOP FOR AASHTO T 329

Participant Name ____________________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Mass of clean dry container including release media determined to 0.1 g?	_____	_____
2. Representative sample obtained; 1000 g minimum?	_____	_____
3. Initial temperature taken and recorded?	_____	_____
4. Mass of sample determined to the nearest 0.1 g?	_____	_____
5. Sample placed in drying oven for 90 ±5 minutes?	_____	_____
6. Sample dried at a temperature not to exceed the JMF (if known) mixing temp or 163 ±14ºC (325 ±25ºF)?	_____	_____
7. Constant mass checked at 30 ±5 minute intervals and reached?	_____	_____
8. Sample and container cooled to ±9°C (15°F) of the initial temperature before final dry mass determined to 0.1 g?	_____	_____
9. Calculation of moisture content performed correctly to 0.01 percent?	_____	_____

$$Moisture\ Content = \frac{M_i - M_f}{M_f} \times 100$$

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass_____Fail_____

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Examiner Signature ___________________________WAQTC #:_______________

DETERMINING THE ASPHALT BINDER CONTENT OF ASPHALT MIXTURES BY THE IGNITION METHOD
FOP FOR AASHTO T 308

01 Significance

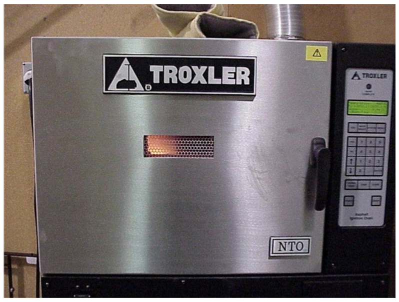
The quality of asphalt mixtures is greatly dependent
on having the correct content of asphalt binder.
02 Asphalt mixtures placed on the job must be tested to
03 ensure that the binder content is within the specified
range.

04 Scope

This procedure covers the determination of asphalt binder content of asphalt mixtures by ignition of the binder in accordance with AASHTO T 308-22.

05 Overview

The sample is heated in a furnace at 538°C
06 (1000°F) or less; samples may be heated by
convection or direct infrared irradiation (IR). The
aggregate remaining after burning can be used for
sieve analysis using the FOP for AASHTO T 30.



Ignition furnace

Some agencies allow the use of recycled asphalt mixtures. When using recycled asphalt mixtures, check with the agency for specific correction procedures.

Asphalt binder in the asphalt mixture is ignited in a furnace. Asphalt binder content is calculated as the percentage difference between the initial mass of the asphalt mixture and the mass of the residual aggregate, with asphalt binder correction factor, and moisture content subtracted. The asphalt binder content is expressed as a percent of moisture-free mix mass.

Ignition furnace

Two methods, A and B, are presented

Apparatus

Note 1: The apparatus must be calibrated for the specific mix
07 design. See "Correction Factors" at the end of this FOP.

08 The apparatus for Methods A and B is the same
except that the furnace for Method A requires an
09 internal balance.

Ignition Furnace

- Ignition Furnace – A forced air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining the temperature between at least 530 and 545°C (986 and 1013°F) and have a temperature control accurate within ±5°C (±9°F).

  For Method A, the furnace will be equipped with an internal scale thermally isolated from the furnace chamber and accurate to 0.1 g. The scale shall be capable of determining the mass of a 3500 g sample in addition to the sample baskets. A data collection system will be included so that mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate change in mass of the sample and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes. Perform lift test according to manufacturer’s instructions weekly during use, if applicable. The furnace shall be designed to permit the operator to change the ending mass loss percentage from both 0.01 percent to 0.02 percent.

  For both Method A and Method B, the furnace chamber dimensions shall be adequate to accommodate a 3500 g sample. The furnace door shall be equipped so that it cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided and the furnace shall be vented so that no emissions escape into the laboratory. The furnace shall have a fan to pull air through the furnace to expedite the test and to eliminate the escape of smoke into the laboratory.

- Sample Basket Assembly: Consisting of sample basket(s), catch pan, and basket guards. Sample basket(s) will be of appropriate size allowing samples to be thinly spread and allowing air to flow through and around the sample particles. Sets of two or more baskets shall be nested. A catch pan: of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught. Basket guards will completely enclose the basket and be made of screen mesh, perforated stainless steel plate, or other suitable material.
- Thermometer, or other temperature measuring device, with a temperature range of 10 -260°C (50 - 500°F).
- Oven capable of maintaining 110 ±5°C (230 ±9°F).
- Balance or scale: Capacity sufficient for the sample mass and conforming to the requirements of M 231, Class G2.
- **Safety equipment**: Safety glasses or face shield, high temperature gloves, long sleeved jacket, a heat resistant surface capable of withstanding 650°C (1202°F), a protective cage capable of surrounding the sample baskets during the cooling period, and a particle mask for use during removal of the sample from the basket assembly.
- Miscellaneous equipment: A container larger than the sample basket(s) for transferring sample after ignition, large flat pan, spatulas, bowls, and wire brushes.

Sampling

11

1. Obtain samples of asphalt mixture in accordance with the FOP for AASHTO R 97.
2. If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan in an oven at 110 ±5°C (230 ±9°F) until workable.
3. Reduce asphalt mixture samples in accordance with the FOP for AASHTO R 47.

12 4. Test sample size shall conform to the mass requirement shown in Table 1.

Note 2: When the mass of the test specimen exceeds the capacity of the equipment used, the test specimen may be divided into suitable increments, tested, and the results appropriately combined through a weighted average for calculation of the asphalt binder content.

Table 1

Nominal Maximum Size* mm (in.)	**Minimum Mass Specimen g**	**Maximum Mass Specimen g**
37.5 (1 ½)	4000	4500
25.0 (1)	3000	3500
19.0 (3/4)	2000	2500
12.5 (1/2)	1500	2000
9.5 (3/8)	1200	1700
4.75 (No. 4)	1200	1700

13

17

Sample

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

General

14 1. For the convection-type furnace, preheat the ignition furnace to 538 ± 5°C (1000 ± 9°F) or to the temperature determined in the Correction Factors Annex of this method. Manually record the furnace temperature (set point) before the initiation of the test if the furnace does not record automatically. For the direct IR irradiation-type furnace, use the same burn profile as used during the correction factor determination.

Two nested baskets and catch pan

Procedure – Method A (Internal Balance)

1. Dry the sample to constant mass according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.

15 2. Determine and record the mass of the sample basket assembly to the nearest 0.1 g.

16 3. Evenly distribute the sample in the sample basket assembly, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.

4. Determine and record the total mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g.

5. Calculate the initial mass of the sample by subtracting the mass of the sample basket from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. . Designate this mass as (M_i).

18 6. Record the asphalt binder correction factor or input into the furnace controller for the specific asphalt mixtures.

Placing sample in furnace

7. Input the initial mass (M_i) of the sample into the ignition furnace controller. Verify that the correct mass has been entered. 19

8. Verify the furnace scale is reading zero, if not, reset to zero.

CAUTION: Operator should wear safety equipment – high temperature gloves, face shield, fire-retardant shop coat – when opening the door to load or unload the sample.

9. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Close the chamber door and verify that the sample mass displayed on the furnace scale equals the total mass of the sample and sample basket assembly recorded in Step 5 within ±5 g.

Note 3: Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall.

Note 4: Furnace temperature will drop below the set point when the door is opened but will recover when the door is closed, and ignition begins. Sample ignition typically increases the temperature well above the set point – relative to sample size and asphalt binder content.

10. Initiate the test by pressing the start button. This will lock the sample chamber and start the combustion blower. 20

Safety note: Do not attempt to open the furnace door until the asphalt binder has been completely burned off.

11. Allow the test to continue until the stable light and audible stable indicator indicate that the change in mass does not exceed 0.01 percent for three consecutive minutes. Press the stop button. This will unlock the sample chamber and cause the printer to print out the test results.

Note 5: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

12. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 minutes). 21

13. Determine and record the mass of the sample and sample basket assembly after ignition to the nearest 0.1 g.

Sample basket(s) and protective cage

14. Calculate the mass of the sample by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as M_f.

22

15. Use the asphalt binder content percentage from the printed ticket. Subtract the moisture content, and the correction factor if not input into the furnace controller, from the printed ticket asphalt binder content and report the difference as the corrected asphalt binder content.

    Asphalt binder content percentage can also be calculated using the formula from step 16 of Method B.

Calculation

23

Corrected asphalt binder content:

$$P_b = BC - MC - C_f{}^*$$

*If correction factor is not entered into the furnace controller

where:

P_b = Corrected asphalt binder content as a percent by mass of the asphalt mixture

BC = Asphalt binder content shown on printed ticket

MC = Moisture content of the companion asphalt mixture sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried before initiating the procedure, MC=0).

C_f= Asphalt binder correction factor as a percent by mass of the asphalt mixture sample

Procedure – Method B (External Balance)

1. Dry the sample to constant mass according to the FOP for AASHTO T 329 or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329. 24
2. Determine and record the mass to the nearest 0.1 g of the sample basket assembly.
3. Place the sample basket(s) in the catch pan. Evenly distribute the sample in the sample basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample. 25
4. Determine and record the mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g.
5. Calculate the initial mass of the sample by subtracting the mass of the sample basket from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as (M_i).
6. Record the asphalt binder correction factor for the specific asphalt mixture. 26
7. Open the chamber door and gently set the sample basket assembly in the furnace.

Carefully position the sample basket assembly so it is not in contact with the furnace wall. Burn the asphalt mixture sample in the furnace for 45 minutes or the length of time determined in the “Correction Factors" section.

27 8. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample and allow it to cool to room temperature (approximately 30 min).

28 9. Determine and record the mass of the sample and basket assembly to the nearest 0.1 g.

10. Calculate the sample mass by subtracting the mass of the sample basket assembly and record to the nearest 0.1 g.

11. Place the sample basket assembly back into the furnace.

12. Burn the sample for at least 15 minutes after the furnace reaches the set temperature.

13. Open the chamber door, remove the sample
29 basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 min.).

14. Determine and record mass of the sample and sample basket assembly to the nearest 0.1 g.

15. Calculate the mass of the sample by subtracting the mass of the sample basket assembly and record to the nearest 0.1 g.

30 16. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.

17. If the percent change exceeds 0.01 percent of the previous sample mass, repeat Steps 11 through 16 until the percent change does not exceed 0.01 percent.

Note 6: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

31

18. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
19. Calculate the final sample mass by subtracting the mass of the sample basket assembly and record to the nearest 0.1 g. Designate this mass as M_f.
20. Calculate the asphalt binder content of the sample.

Calculations

Constant Mass 32

Calculate %change:

$$\% \, Change = \frac{M_p - M_n}{M_p} \times 100$$

where:

M_p = sample mass after ignition

M_n = sample mass after 15 min. additional ignition

Example

Initial mass of sample and basket = 5292.7 g

Mass of basket assembly = 2931.5 g 33

M_i = 2361.2 g

Sample mass and basket after first ignition = 5154.4 g

Sample mass after first ignition = 2222.9 g

Sample mass and basket after additional 15 min ignition = 5154.2 g

Sample mass after additional 15 min ignition = 2222.7 g

Constant mass

$$\%change = \frac{2222.9\ g - 2222.7\ g}{2222.9\ g} \times 100 = 0.009\%$$

%change is not greater than 0.01 percent, so $\mathbf{M_f}$ = 2222.7 g

Percent asphalt binder (P_b)

34

Calculate the asphalt binder content of the sample as follows:

$$P_b = \frac{M_i - M_f}{M_i} \times 100 - MC - C_f$$

where:

P_b = the corrected asphalt binder content as a percent by mass of the asphalt mixture sample

M_f = the final sample mass after ignition, g

M_i = the initial mass of the asphalt mixture sample before ignition, g

MC= moisture content of the companion asphalt mixture sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried before initiating the procedure, MC = 0).

C_f = correction factor as a percent by mass of the asphalt mixture sample

Example

35

Correction factor = 0.42%

Moisture content = 0.04%

Initial mass of sample and basket = 5292.7 g

Mass of basket assembly = 2931.5 g

M_i = 2361.2 g

M_f = 2222.7 g

$$P_b = \frac{2361.2\ g - 2222.7\ g}{2361.2\ g} \times 100 - 0.04\% - 0.42\% = 5.41\%$$

P_b= 5.41%

Gradation

Emptying sample baskets

36

1. Empty contents of the basket(s) into a container, being careful to capture all material. Use a small wire brush to ensure all residual fines are removed from the baskets.

37

Note 7: Particle masks are a recommended safety precaution.

2. Perform the gradation analysis in accordance with the FOP for AASHTO T 30.

Report

38

- On forms approved by the agency
- Sample ID
- Method of test (A or B)
- Corrected asphalt binder content, P_b, to the nearest 0.01 percent or per agency standard
- Correction factor, C_f, to the nearest 0.01 percent
- Temperature compensation factor (Method A only)
- Total percent loss
- Sample mass
- Moisture content to the nearest 0.01 percent
- Test temperature

Attach the original printed ticket with all intermediate values (continuous tape) to the report for furnaces with internal balances.

Tips!

39

- Check specific agency requirements.
- Make sure apparatus is calibrated to specific mix design.
- Do not open door until asphalt binder has burned off.

40

ANNEX – CORRECTION FACTORS ASPHALT BINDER AND AGGREGATE

(Mandatory Information)

Asphalt binder content results may be affected by the type of aggregate in the mixture and by the ignition furnace. Asphalt binder and aggregate correction factors must, therefore, be established by testing a set of correction specimens for each Job Mix Formula (JMF) mix design. Each ignition furnace will have its own unique correction factor determined in the location where testing will be performed.

41 This procedure must be performed before any acceptance testing is completed, and repeated each time there is a change in the mix ingredients or design.

Any changes greater than 5 percent in stockpiled aggregate proportions should require a new correction factor.

All correction samples will be prepared by a central / regional laboratory unless otherwise directed.

42 **Asphalt binder correction factor**: A correction factor must be established by testing a set of correction specimens for each Job Mix Formula (JMF). Certain aggregate types may result in unusually high correction factors (> 1.00 percent). Such mixes should be corrected and tested at a lower temperature as described below.

Aggregate correction factor: Due to potential aggregate breakdown during the ignition process, a
43 correction factor will need to be determined for the
following conditions:

a) Aggregates that have a proven history of excessive breakdown.

b) Aggregate from an unknown source.

This correction factor will be used to adjust the acceptance gradation test results obtained according to the FOP for AASHTO T 30.

Procedure

44 1. Obtain samples of aggregate in accordance with the FOP for AASHTO R 90.

2. Obtain samples of asphalt binder in accordance with the FOP for AASHTO R 66.

Note 8: Include other additives that may be required by the JMF.

45 3. Prepare an initial, or "butter," mix at the design asphalt binder content. Mix and discard the butter mix before mixing any of the correction specimens to ensure accurate asphalt content.

4. Prepare two correction specimens at the JMF
   design asphalt binder content. Aggregate used
   for correction specimens shall be sampled from
   material designated for use on the project. An
   agency approved method will be used to
   46 combine aggregate. An additional "blank"
   specimen shall be batched and tested for
   aggregate gradation in accordance with the FOP
   for AASHTO T 30. The gradation from the
   "blank" shall fall within the agency specified
   mix design tolerances.

47 5. Place the freshly mixed specimens directly into the sample basket assembly. If mixed specimens are allowed to cool before placement in the sample basket assembly, the specimens must be dried to constant mass according to the FOP for AASHTO T 329. Do not preheat the sample basket assembly.

6. Test the specimens in accordance with Method
   48 A or Method B of the procedure.

7. Once both correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed ignition furnace tickets, if available.

8. Calculate the difference between asphalt binder
   49 contents of the two specimens:

   a. If the difference between the asphalt binder contents of the two specimens does not exceed 0.15 percent, use these two results to determine the correction factor.

   b. If the difference between the asphalt binder contents of the two specimens exceeds 0.15 percent, repeat with two more specimens and, from the four results, discard the high and low results. Determine the correction factor from the two remaining results.

50 9. Calculate the difference between the actual and measured asphalt binder contents to 0.01 percent. The asphalt binder correction factor, C_f, is the average of the differences expressed as a percent by mass of asphalt mixture.

51 10. If the asphalt binder correction factor exceeds 1.00 percent, the test temperature must be lowered to 482 ± 5°C (900 ± 9°F) and new samples must be burned. If the correction factor is the same or higher at the lower temperature, it is permissible to use the higher temperature. The temperature for determining the asphalt binder content of asphalt mixture samples by this procedure shall be the same temperature determined for the correction samples.

52 11. For the direct IR irradiation-type burn furnaces, the **default** burn profile should be used for most materials. The operator may select burn-profile Option 1 or Option 2 to optimize the burn cycle. The burn profile for testing asphalt mixture samples shall be the same burn profile selected for correction samples.

   Option 1 is designed for aggregate that requires a large asphalt binder correction factor (greater than 1.00 percent) – typically very soft aggregate (such as dolomite).

   Option 2 is designed for samples that may not burn completely using the **default** burn profile.

53 12. Perform a gradation analysis on the residual aggregate in accordance with the FOP for AASHTO T 30, if required. The results will be utilized in developing an "Aggregate Correction Factor" and should be calculated and reported to 0.1 percent.

54 13. Subtract the percent passing for each sieve, for each sample, from the percent passing each

sieve of the “Blank” specimen gradation results in Step 4.

55 14. Determine the average difference of the two values. If the difference for any single sieve exceeds the allowable difference of that sieve as listed in Table 2, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by the FOP for AASHTO T 30. If the 75 µm (No. 200) is the only sieve outside the limits in Table 2, apply the aggregate correction factor to only the 75 µm (No. 200) sieve.

Table 2 56
Permitted Sieving Difference

Sieve	**Allowable Difference**
Sizes larger than or equal to 2.36 mm (No.8)	± 5.0%
Sizes larger than to 75 µm (No.200) and smaller than 2.36 mm (No.8)	± 3.0%
Sizes 75 µm (No.200) and smaller	± 0.5%

Examples: 57

Sieve Size mm (in.)	Correction Factor Blank Sample, % Passing	Correction Factor Sample #1, % Passing	Correction Factor Sample #2, % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
19.0(3/4)	100	100	100	0/0	0.0	
12.5(1/2)	86.3	87.4	86.4	-1.1/-0.1	-0.6	
9.5(3/8)	77.4	76.5	78.8	+0.9/-1.4	-0.3	
4.75(No. 4)	51.5	53.6	55.9	-2.1/-4.4	-3.3	
2.36(No. 8)	34.7	36.1	37.2	-1.4/-2.5	-2.0	
01.18(No. 16)	23.3	25.0	23.9	-1.7/-0.6	-1.2	
0.600 (No. 30)	16.4	19.2	18.1	-2.8/-1.7	-2.3	
0.300 (No. 50)	12.0	11.1	12.7	+0.9/-0.7	+0.1	
0.150 (No. 100)	8.1	9.9	6.3	-1.8/+1.8	0.0	
75 µm (No. 200)	5.5	5.9	6.2	-0.4/-0.7	-0.6	**- 0.6**

In this example all gradation test results performed on the residual aggregate (FOP for AASHTO T 30) would have an aggregate correction factor applied to the percent passing the 75 µm (No. 200) sieve. The correction factor must be applied because the average difference on the 75 µm (No. 200) sieve is outside the tolerance from Table 2.

In the following example, aggregate correction factors would be applied to each sieve because the average difference on the 4.75mm (No. 4) is outside the tolerance from Table 2. 58

Sieve Size mm (in.)	Correction Factor Blank Sample, % Passing	Correction Factor Sample #1, % Passing	Correction Factor Sample #2, % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
19.0 (3/4)	100	100	100	0/0	0.0	0.0
12.5 (1/2)	86.3	87.4	86.4	-1.1/-0.1	-0.6	-0.6
9.5 (3/8)	77.4	76.5	78.8	+0.9/-1.4	-0.3	-0.3
4.75 (No. 4)	51.5	55.6	57.9	-4.1/-6.4	-5.3	**-5.3**
2.36 (No. 8)	34.7	36.1	37.2	-1.4/-2.5	-2.0	-2.0
01.18 (No. 16)	23.3	25.0	23.9	-1.7/-0.6	-1.2	-1.2
0.600 (No. 30)	16.4	19.2	18.1	-2.8/-1.7	-2.3	-2.3
0.300 (No. 50)	12.0	11.1	12.7	+0.9/-0.7	+0.1	+0.1
0.150 (No. 100)	8.1	9.9	6.3	-1.8/+1.8	0.0	0.0
75 µm (No. 200)	5.5	5.9	6.2	-0.4/-0.7	-0.6	-0.6

REVIEW QUESTIONS

1. Summarize the sampling procedures used for the various materials tested.

2. Upon what is the size of the test sample based?

3. Describe when and how the two Correction Factors are used.

4. Describe the difference in the apparatus for the two methods – A and B.

5. Describe one of the two methods – A or B.

6. What is done with the material removed from the ignition furnace?

PERFORMANCE EXAM CHECKLIST

DETERMINING THE ASPHALT BINDER CONTENT OF ASPHALT MIXTURES BY THE IGNITION METHOD
FOP FOR AASHTO T 308

Participant Name ______________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Oven at correct temperature 538 ± 5°C (1000 ± 9°F) or correction factor temperature?	_____	_____
Or: for IR ovens, correct burn profile applied?	_____	_____
2. Sample reduced to correct size?	_____	_____
3. Asphalt mixture sample or companion moisture sample taken and dried per FOP for AASHTO T 329?	_____	_____
4. Mass of sample basket assembly recorded to 0.1 g?	_____	_____
5. With pan below basket assembly, sample evenly distributed in basket assembly keeping material away from the edges?	_____	_____
6. Mass of sample basket and sample recorded to 0.1 g?	_____	_____
7. Sample mass conforms to the required mass?	_____	_____
8. Method A		
a. Initial mass entered into furnace controller?	_____	_____
b. Internal scale reading zero?	_____	_____
c. Sample correctly placed into furnace?	_____	_____
d. Test continued until stable indicator signals?	_____	_____
e. Uncorrected asphalt binder content obtained on printed ticket?	_____	_____
f. Sample cooled to room temperature?	_____	_____
g. Sample mass determined to nearest 0.1 g.?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
9. Method B		
a. Sample correctly placed into furnace?	_____	_____
b. Sample burned for 45 min or time determined by correction process?	_____	_____
c. Sample cooled to room temperature?	_____	_____
d. Sample burned to constant mass?	_____	_____
e. Sample cooled to room temperature?		
f. Sample mass determined to nearest 0.1 g?	_____	_____
g. Uncorrected asphalt binder content calculated correctly and recorded?	_____	_____
10. Asphalt binder content corrected for Correction Factor if needed?	_____	_____
11. Asphalt binder content corrected for moisture per the FOP for AASHTO T 329 if needed?	_____	_____
12. Corrected asphalt binder content recorded?	_____	_____
13. Contents of the basket(s) carefully emptied into a pan?	_____	_____

Comments: First attempt: Pass_____Fail______ Second attempt: Pass_____Fail_____

____

____

____

Examiner Signature _________________________WAQTC #:______________

THEORETICAL MAXIMUM SPECIFIC GRAVITY (G_{mm}) AND DENSITY OF ASPHALT MIXTURES
FOP FOR AASHTO T 209

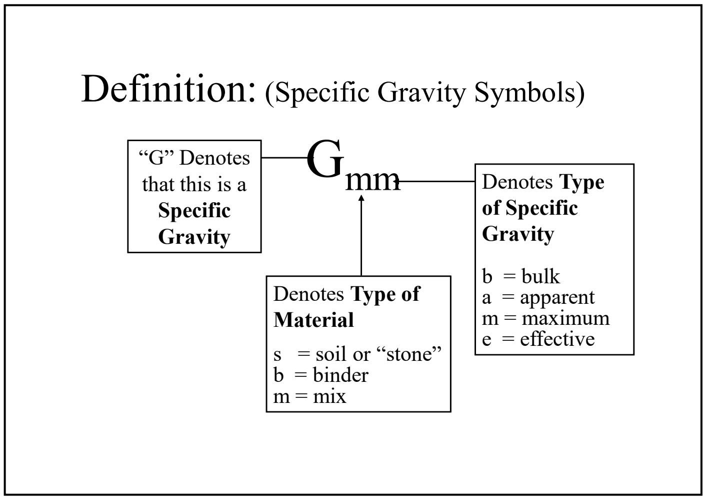
Significance

Maximum specific gravity (G_{mm}) is the ratio of the
01 mass of a given volume of cooled asphalt mixture at
25°C (77°F) to the mass of an equal volume of water
at the same temperature. The procedure is often
called the Rice test after its developer, James Rice.
G_{mm} is used in conjunction with bulk specific gravity
to determine in-place density and percent air voids or
02 both in compacted asphalt mixture. Percentage of air
voids, V_a, is significant because durability
characteristics of asphalt mixture are influenced by
the number of voids in the compacted material.

Scope

This procedure covers the determination of the
03 maximum specific gravity (G_{mm}) of uncompacted
asphalt mixture in accordance with AASHTO T 209-
23. Two methods using different containers – bowl
and pycnometer / volumetric flask – are covered.

Specimens prepared in the laboratory shall be cured according to the agency standard.



Definition: (Specific Gravity Symbols)

G_{mm}

"G" Denotes that this is a **Specific Gravity**

Denotes **Type of Material**

s = soil or "stone"
b = binder
m = mix

Denotes **Type of Specific Gravity**

b = bulk
a = apparent
m = maximum
e = effective

04

05
Apparatus

- Balance or scale: 10,000 g capacity, readable to 0.1 g, meeting AASHTO M 231, Class G2
- Container: A glass, metal, or plastic bowl, pycnometer, or volumetric flask between 2000 and 10,000 mL as required by the minimum sample size requirements in Table 1 and capable of withstanding a full vacuum applied

Metal container/ Volumetric Flask

- Pycnometer / volumetric flask cover: A glass plate or a metal or plastic cover with a vented opening 06
- 07 Vacuum lid: A transparent lid with a suitable vacuum connection. The vacuum opening to be covered with a fine wire mesh.
- Vacuum pump or water aspirator: Capable of evacuating air from the container to a residual pressure of 3.4 kPa (25 mm Hg)

Vacuum pump

- Vacuum measurement device: Residual pressure manometer or vacuum gauge capable of measuring residual pressure down to 3.4 kPa (25 mm Hg) or less and readable to at least 0.2 kPa (2 mm Hg)
- Suspension apparatus: Suitable apparatus and holder to permit determining the mass of the sample while suspended below the balance. The wire suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length for Bowl Method.
- Water bath: A constant-temperature water bath (optional for Pycnometer or Volumetric Flask Method)
- Thermometers: Thermometric devices accurate to 0.25°C (0.5°F)
- Bleeder valve to adjust vacuum
- Automatic vacuum control unit (optional)
- Timer
- Towel

08 Standardization

Use a container that has been standardized according to the Annex. The container shall be standardized periodically in conformance with procedures established by the agency.

09 Test Sample Preparation

1. Obtain samples in accordance with the FOP for AASHTO R 97 and reduce according to AASHTO R 47.
2. Test sample size shall conform to the requirements of Table 1. Samples larger than the capacity of the container may be tested in two or more increments. Results will be combined by calculating the weighted average ($G_{mm\ (avg)}$.). If the increments have a specific gravity difference greater than 0.013, the test must be re-run.
3. Plant-produced samples may be short-term conditioned according to AASHTO R 30 as specified by the agency.

Note 1: Short-term conditioning at the specified temperature is especially important when absorptive aggregates are used. This short-term conditioning will ensure the computation of realistic values for the amount of asphalt absorbed by the aggregate and void properties of the mix. Plant-produced asphalt mixtures should be evaluated to make sure short-term conditioning has taken place during production and delivery.

10

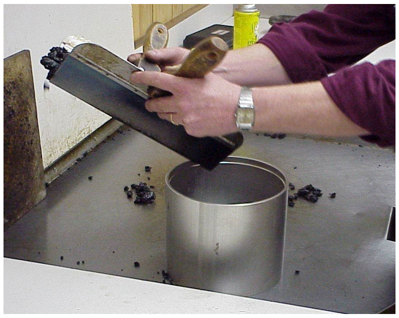
Table 1
Test Sample Size for G_{mm}

Nominal Maximum Aggregate Size* mm (in.)	Minimum Mass g
37.5 or greater (1 ½)	4000
19 to 25 (3/4 to 1)	2500
12.5 or smaller (1/2)	1500

12

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained.

Separating particles



Placing sample in the flask

Determining mass

Manually agitating container

Mechanically agitating container

Procedure – General

11 Two procedures – bowl and pycnometer / volumetric flask – are covered. The first 11 steps are the same for both.

1. Separate the particles of the sample, taking care 14 not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 6.3 mm (1/4 in.). If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven only until it is pliable enough for separation.
2. Cool the sample to room temperature.
3. 13 Determine and record the mass of the dry container to the nearest 0.1 g.
4. Place the sample in the container.
5. Determine and record the mass of the container and sample to the nearest 0.1 g.
6. 15 Determine and record the mass of the sample by subtracting the mass determined in Step 3 from the mass determined in Step 5. Designate this mass as “A.”
7. 16 Add sufficient water at approximately 25°C (77°F) to cover the sample by about 25 mm (1 in).

Note 1: The release of entrapped air may be facilitated by the addition of a wetting agent. Check with the agency to see if this is permitted and, if it is, for a recommended agent.

8. Place the lid on the container and attach the vacuum line. To ensure a proper seal between the container and the lid, wet the O-ring or use a petroleum gel.
9. 17 Remove entrapped air by subjecting the sample 18 to a partial vacuum of 4.0 ±0.6 kPa (30 ±5 mm Hg) residual pressure for 15 ±1 minutes.
10. Agitate the container and sample, either continuously by mechanical device or manually by vigorous shaking, at 2-minute intervals. This agitation facilitates the removal of air.

Manometer

19 11. Release the vacuum. Increase the pressure to atmospheric pressure in 10 to 15 seconds if the vacuum release is not automated. Turn off the vacuum pump and remove the lid. When performing the pycnometer / volumetric flask method, complete steps 12B through 16B within 10 ±1 minute.

Procedure – Bowl

20 12A. Fill the water bath to overflow level with water at 25 ±1°C (77 ±2°F) and allow the water to stabilize.

13A. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.

14A Suspend and immerse the bowl and sample in water at 25 ±1°C (77 ±2°F) for 10 ±1 minute.

21 15A. Determine and record the submerged weight of the bowl and sample to the nearest 0.1 g. Designate as "C." 23

Determining temperature

Procedure – Pycnometer or Volumetric Flask

22 12B. Immediately fill the pycnometer / volumetric flask with water.

13B. Stabilize the temperature of the pycnometer / volumetric flask and sample so that final temperature is within 25 ±1°C (77 ±2°F).

24 14B. Finish filling the pycnometer / volumetric flask with water that is 25 ±1°C (77 ±2°F), place the metal or plastic cover or a glass plate on the pycnometer / volumetric flask and eliminate all air. 25

Eliminating air

Note 2: When using a metal pycnometer and cover, place the cover on the pycnometer and push down slowly, forcing excess water out of the hole in the center of the cover. Use care when filling the pycnometer to avoid reintroducing air into the water. 26

Determining mass

15B. Towel dry the outside of the pycnometer / volumetric flask and cover.

16B. Determine and record the mass of the pycnometer / volumetric flask, cover, de-

27 aired water, and sample to the nearest 0.1 g within 10 ±1 minute of completion of Step 11. Designate this mass as “E.”

Procedure – Mixtures Containing Uncoated Porous Aggregate

28 If the pores of the aggregates are not thoroughly sealed by an asphalt binder film, they may become saturated with water during the vacuuming procedure, resulting in an error in G_{mm} and theoretical maximum density.

To determine if this has occurred, complete the general procedure and then:

1. Carefully drain water from sample through a towel held over the top of the container to prevent loss of material.
2. Spread sample in a flat shallow pan and place before an electric fan to remove surface moisture.

29

3. Determine the mass of the sample when the surface moisture appears to be gone.
4. Continue drying and determine the mass of the sample at 15-minute intervals until less than a 0.5 g loss is found between determinations.
5. Record the mass as the saturated surface dry mass to the nearest 0.1 g. Designate this mass as “A_{SSD}.”
6. Calculate, as indicated below, G_{mm} using “A” and “A_{SSD},” and compare the two values.

Calculation

Calculate the G_{mm} to three decimal places as follows.

Bowl Procedure 30

$$G_{mm} = \frac{A}{A + B - C} \qquad or \qquad G_{mm} = \frac{A}{A_{SSD} + B - C}$$

(for mixes containing uncoated aggregate materials)

Where:

A = mass of dry sample in air, g

A_{SSD} = mass of saturated surface dry sample in air, g

B = standardized submerged weight of the bowl, g (see Annex)

C = submerged weight of sample and bowl in water, g

Example 31

$$G_{mm} = \frac{1432.7\ g}{1432.7\ g + 286.3\ g - 1134.9\ g} = 2.453 \qquad or$$

$$G_{mm} = \frac{1432.7\ g}{1434.2\ g + 286.3\ g - 1134.9\ g} = 2.447$$

Given:

A = 1432.7 g

A_{SSD} = 1434.2 g

B = 286.3 g

C = 1134.9 g

Pycnometer / Volumetric Flask Procedure 32

$$G_{mm} = \frac{A}{A + D - E} \qquad or \qquad G_{mm} = \frac{A}{A_{SSD} + D - E}$$

(for mixtures containing uncoated materials)

Where:

A = mass of dry sample in air, g

A_{SSD} = mass of saturated surface dry sample in air, g

D = standardized mass of pycnometer / volumetric flask filled with water at 25°C (77°F), g, (See Annex)

E = mass of pycnometer / volumetric flask filled with water and test sample at test temperature, g

Example (two increments of a large sample): 33

$$G_{mm_1} = \frac{2200.3\ g}{2200.3\ g + 7502.5\ g - 8812.0\ g} = 2.470$$

$$G_{mm_2} = \frac{1960.2\ g}{1960.2\ g + 7525.5\ g - 8690.8\ g} = 2.466$$

Given:

Increment 1	Increment 2
A_1 = 2200.3 g	A_2 = 1960.2 g
D_1 = 7502.5 g	D_2 = 7525.5 g
E_1 = 8812.0 g	E_2 = 8690.8 g

Variation = 2.470 - 2.466 = 0.004, which is < 0.013

Allowable variation is: 0.013. The values may be used.

Weighted average

34

For large samples tested a portion at a time, calculate the $G_{mm\,(avg)}$ by multiplying the dry mass of each increment by its G_{mm}, add the results together (Σ) and divide by the sum (Σ) of the dry masses.

$$G_{mm(avg)} = \frac{\sum\left(A_x \times G_{mm_x}\right)}{\sum A_x}$$

or

$$G_{mm(avg)} = \frac{\left(A_1 \times G_{mm_1}\right) + \left(A_2 \times G_{mm_2}\right)}{A_1 + A_2}\ etc.$$

Where:

A_x = mass of dry sample increment in air, g

G_{mmx} = theoretical maximum specific gravity of the increment

Example:

35

$$G_{mm(avg)} = \frac{(2200.3\ g \times 2.470) + (1960.2\ g \times 2.466)}{2200.3\ g + 1960.2\ g} = \frac{10{,}268.6}{4160.5\ g} = 2.468$$

Theoretical Maximum Density

36

To calculate the theoretical maximum density at 25°C (77°F) use one of the following formulas. The density of water at 25°C (77°F) is 997.1 kg/ m^3 in Metric units or 62.245 lb/ft^3 in English units.

Theoretical maximum density kg/m^3 = G_{mm} × 997.1 kg/ m^3

2.468 × 997.1 kg/ m^3 = 2461 kg/ m^3

Or:

Theoretical maximum density lb/ft^3 = G_{mm} × 62.245 lb/ft^3

2.468 × 62.245 lb/ft^3 = 153.6 lb/ft^3

37

Report

- On forms approved by the agency
- Sample ID
- G_{mm} to the nearest 0.001
- Theoretical maximum density to the nearest 1 kg/m^3 (0.1 lb/ft^3)

38

Tips!

- Use a standardized container.
- Check for absorption in uncoated aggregate.

A1

ANNEX – STANDARDIZATION OF BOWL AND PYCNOMETER OR VOLUMETRIC FLASK

(Mandatory Information)

A2

Bowl – Standardization

1. Fill the water bath to overflow level with 25 ±1°C (77 ±2°F) water and allow the water to stabilize.
2. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
3. Suspend and completely immerse the bowl for 10 ±1 minute.
4. Determine and record the submerged weight of the bowl to the nearest 0.1 g.

A3

5. Refill the water bath to overflow level.
6. Perform Steps 2 through 5 two more times for a total of three determinations.
7. If the range of the three determinations is less than or equal to 0.3 g., average the determinations. Designate as “B.”
8. If the range of the three determinations is greater than 0.3 g., take corrective action and perform the standardization procedure again.

A4

Bowl – Check

1. Fill the water bath to overflow level 25 ±1°C (77 ±2°F) water and allow the water to stabilize.
2. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
3. Suspend and completely immerse the bowl for 10 ±1 minute.
4. Determine and record the submerged weight of the bowl to the nearest 0.1 g.

A5

5. If this determination is within 0.3 g of the standardized value, use the standardized value for "B."

6. If it is not within 0.3 g, take corrective action and perform the standardization procedure again. A6

7. For labs that check the bowl standardization frequently (such as daily), calculate the moving average and range of the last three mass determinations. Designate the average of the last three masses as "B."

8. If the moving range exceeds 0.3 g at any time, take corrective action and perform the standardization procedure again.

Determining temperature

Pycnometer or Volumetric Flask – Standardization

1. A7 Fill the pycnometer / volumetric flask with water at approximately 25°C (77°F).

2. A8 Place the metal or plastic cover, or a glass plate on the pycnometer / volumetric flask and A9 eliminate all air. (See Note 2.)

3. Stabilize the pycnometer / volumetric flask at 25 ± 1ºC (77 ± 2ºF) for 10 ± 1 min.

Remove all the air

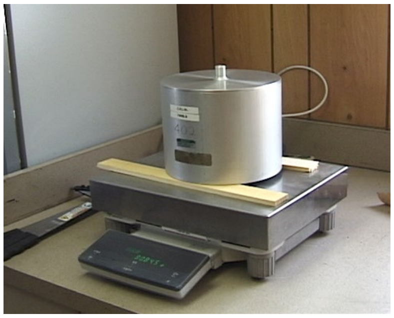
4. A10 Towel dry the outside of the pycnometer / volumetric flask and cover to the nearest 0.1 g.

5. A11 Determine and record the mass of the pycnometer / volumetric flask, water, and cover or plate.

6. Perform Steps 2 through 5 two more times for a total of three determinations.

7. A12 If the range of the three determinations is less than or equal to 0.3 g, average the three determinations. Designate as "D."

8. If the range of the determinations is greater than 0.3 g, take corrective action and perform the "Pycnometer or Volumetric Flask – Standardization" again.



Determining mass

A13

Pycnometer or Volumetric Flask – Check

1. Fill the pycnometer / volumetric flask with water at approximately 25°C (77°F).
2. Place the metal or plastic cover or a glass plate on the pycnometer / volumetric flask and eliminate all air. (See Note 2.)
3. Stabilize the pycnometer / volumetric flask at 25 ± 1ºC (77 ± 2ºF) for 10 ± 1 min.
4. Towel dry the outside of the pycnometer / volumetric flask and cover.

A14

5. Determine and record the mass of the pycnometer / volumetric flask, water, and cover or plate.
6. If this determination is within 0.3 g of the standardized value, use the standardized value for "D."
7. If it is not within 0.3 g, perform the standardization procedure again.

REVIEW QUESTIONS

1. A mix with the nominal maximum aggregate size of 25 mm (1 in.) should use what size sample?

2. Describe the standardization procedure for:

   Bowl

   Pycnometer / Volumetric Flask

3. At what temperature should the sample be for testing?

4. Removing entrapped air from the container and sample by a partial vacuum is done for how long?

5. How and why is the container and sample agitated?

PERFORMANCE EXAM CHECKLIST

THEORETICAL MAXIMUM SPECIFIC GRAVITY (G_{mm}) AND DENSITY OF ASPHALT MIXTURES
FOP FOR AASHTO T 209

Participant Name ________________________________ Exam Date _______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample reduced to correct size?	______	______
2. Particles carefully separated insuring that aggregate is not fractured?	______	______
3. After separation, fine aggregate particles not larger than 6.3 mm (1/4 in.)?	______	______
4. Sample at room temperature?	______	______
5. Standardized container (bowl or pycnometer / volumetric flask)?	______	______
6. Mass of container determined to 0.1 g?	______	______
7. Mass of sample and container determined to 0.1 g?	______	______
8. Mass of sample calculated and conforms to required size?	______	______
9. Water at approximately 25°C (77°F) added to cover sample?	______	______
10. O-ring wet or petroleum gel used?	______	______
11. Entrapped air removed using partial vacuum of 4.0 ±0.6 kPa (30 ±5 mm Hg) residual pressure for 15 ±1 min?	______	______
12. Container and sample agitated continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes?	______	______
13. Vacuum released to atmospheric pressure in 10 to 15 seconds if not auto controlled?	_____	_____
14. Vacuum pump turned off?	_____	_____
15. Bowl determination:		
a. Water bath filled to the overflow level?	______	______
b. Balance tared?	______	______
c. Bowl and sample suspended in water at 25 ±1°C (77 ±2°F) for 10 ±1 minute?	______	______
d. Suspension apparatus submerged?	______	______
e. Submerged weight of bowl and sample determined to 0.1 g?	______	______

OVER

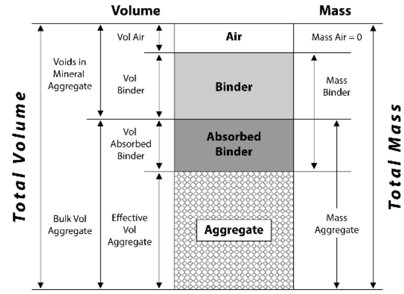
Procedure Element	**Trial 1**	**Trial 2**
16. Pycnometer / Volumetric Flask determination:		
a. Pycnometer / volumetric flask filled with water without reintroducing air into the sample?	_____	_____
b. Contents stabilized at 25 ±1°C (77 ±2°F)	_____	_____
c. Pycnometer / volumetric flask completely filled with water that is 25 ±1°C (77 ±2°F)?	_____	_____
d. Mass of filled pycnometer / volumetric flask and cover determined to 0.1 g, 10 ±1 min. after removal of entrapped air completed?	_____	_____
17. G_{mm} calculated correctly and reported to 0.001?	_____	_____
18. Density calculated correctly and reported to 1 kg/m^3 (0.1 lb/ft^3)?	_____	_____

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass_____Fail_____

Examiner Signature _______________________________WAQTC #:_______________

BULK SPECIFIC GRAVITY (G_{mb}) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS
FOP FOR AASHTO T 166

Asphalt mixture core



Asphalt mixture phase diagram

01 Significance

Compacted asphalt mixtures include voids that may contain gas, such as air, or liquid, such as water. The voids may be permeable; that is, they
02 connect to the surface and can fill with water. They may also be impermeable and, thus, filled only with air.

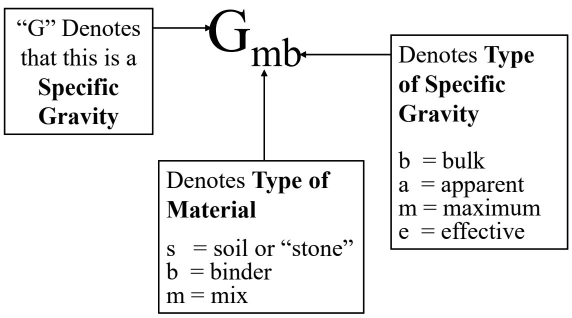
Because voids exist and contain air or water, the overall, or bulk, density of the compacted mix is less than the density of a theoretical mix of aggregate and binder having no voids. Thus, bulk density and associated bulk specific gravity are indications of void and air content – both of which impact various properties of bituminous roadways.

Bulk specific gravity is the ratio of the mass of a given volume of dry, compacted mix at 25°C (77°F) in air to the mass of an equal volume of water at the same temperature. The weight of the sample in water is subtracted from the mass of a
04 saturated surface-dry (SSD) sample in air in order to determine the mass of the water displaced by the specimen. The measurement of void volume, which includes permeable internal and surface pores occupied by water, is useful for mix quality control because it takes into consideration the volume of voids permeable to water within the specimen.

Scope

This procedure covers the determination of bulk
03 specific gravity (G_{mb}) of compacted asphalt
05 mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-22. This FOP is for use on specimens not having open or interconnecting voids or not absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids and/or absorbing more than 2.00 percent water by volume AASHTO T 275 or AASHTO T 331 should be performed.

Definition: (Specific Gravity Symbols) 06



G_{mb}

"G" Denotes that this is a **Specific Gravity**

Denotes **Type of Material**

s = soil or "stone"
b = binder
m = mix

Denotes **Type of Specific Gravity**

b = bulk
a = apparent
m = maximum
e = effective

Overview

- Method A: Suspension
- Method B: Volumeter
- 07 Method C: Rapid test for A or B

Test Specimens

08 Test specimens may be either laboratory-molded or sampled from asphalt mixture pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one- and one-half times the maximum size of the aggregate.

Terminology

09 *Constant Mass:* The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus – Method A (Suspension)

Suspension apparatus

- Balance or scale: 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.
- 10 Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- 11 Water bath: For immersing the specimen in water while suspended under the balance or scale and equipped with an overflow outlet for maintaining a constant water level
- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of 52 ± 3°C (126 ± 5°F) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 15 to 45°C (59 to 113°F), graduated in 0.1°C (0.2°F) subdivisions.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

12 Procedure – Method A (Suspension)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
    a. 13 Oven method
        i. Initially dry overnight at 52 ±3°C (125 ±5°F).
        ii. Determine and record the mass of the specimen. Designate this mass as M_p.
        iii. Return the specimen to the oven for at least 2 hours.

iv. Determine and record the mass of the specimen. Designate this mass as M_n.

v. Determine percent change by subtracting the new mass determination, M_n, from the previous mass determination, M_p, dividing by the previous mass determination, M_p, and multiplying by 100.

vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).

vii. Constant mass has been achieved; sample is defined as dry.

Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C. 14

b. Vacuum dry method according to the FOP for AASHTO R 79.

15 2. Cool the specimen in air to 25 ±5°C (77 ±9°F), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.

3. Fill the water bath to overflow level with water at 25 ±1°C (77 ±2°F) and allow the water to stabilize.

4. Zero or tare the balance with the suspension apparatus attached, ensuring that the suspension apparatus is completely submerged and not touching the sides or the bottom of the water bath.

Submerged specimen

16 5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for 4 ±1 min.

6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as C. 17

7. Remove the sample from the water and quickly surface dry with a damp cloth towel within 5 sec.

8. Zero or tare the balance.

9. Immediately determine and record the mass of the saturated surface-dry (SSD) specimen to nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen. Do not exceed 15 sec. performing Steps 7 through 9.

Calculations – Method A (Suspension)

Constant Mass: 18

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

19

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B - C}$$

$$Percent\ Water\ Absorbed\ (by\ volume) = \frac{B - A}{B - C} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water at 25 ±1°C (77 ±2°F), g

Example:

20

$$G_{mb} = \frac{4833.6\ g}{4842.4\ g - 2881.3\ g} = 2.465$$

$$\%\ Water\ Absorbed\ (by\ volume) = \frac{4842.4\ g - 4833.6\ g}{4842.4\ g - 2881.3\ g} \times 100 = 0.45\%$$

Given:

A = 4833.6 g

B = 4842.4 g

C = 2881.3 g

Apparatus – Method B (Volumeter)

- 21 Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: For immersing the specimen in water, capable of maintaining a uniform temperature at 25 ± 1°C (77 ± 2°F).
- Thermometer: Range of 15 to 45°C (59 to 113°F) and graduated in 0.1°C (0.2°F) subdivisions.
- 22 Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of 52 ± 3°C (126 ± 5°F). for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

23 Procedure – Method B (Volumeter)

Method B is not acceptable for use with specimens that have more than 6 percent air voids.

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

24

1. Dry the specimen to constant mass, if required.
   a. Oven method
      i. Initially dry overnight at 52 ±3°C (125 ±5°F).
      ii. Determine and record the mass of the specimen. Designate this mass as M_p.
      iii. Return the specimen to the oven for at least 2 hours.
      iv. Determine and record the mass of the specimen. Designate this mass as M_n.
      v. Determine percent change by subtracting the new mass determination, M_n, from the previous mass determination, M_p, dividing by the previous mass determination, M_p, and multiplying by 100.
      vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
      vii. Constant mass has been achieved; sample is defined as dry.

Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

25

   b. Vacuum dry according to the FOP for AASHTO R 79.

Surface drying

26

2. Cool the specimen in air to 25 ±5°C (77 ±9°F), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Immerse the specimen in the temperature-controlled water bath at 25 ±1°C (77 ±2°F) for at least 10 minutes.

27

4. At the end of the ten-minute period, fill the volumeter with distilled water at 25 ±1°C (77

±2°F), making sure some water escapes through the capillary bore of the tapered lid.

Determining mass of SSD specimen

5. 28 Wipe the volumeter dry and determine the mass of the volumeter and water to the nearest 0.1 g. Designate this mass as D.
6. 29 Remove the specimen from the water bath and quickly surface dry with a damp towel within 5 sec.
7. 30 Immediately determine and record the mass of 31 the SSD specimen to the nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.
8. Place the specimen in the volumeter and let stand 60 sec.
9. 32 Bring the temperature of the water to 25 ±1°C (77 ±2°F) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.
10. Wipe the volumeter dry.
11. 33 Determine and record the mass of the volumeter, water, and specimen to the nearest 0.1 g. Designate this mass as E.

Calculations – Method B (Volumeter) 34

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement

M_n = new mass measurement

Bulk specific gravity (G_{mb}) and percent water absorbed:

35

$$G_{mb} = \frac{A}{B + D - E}$$

$$Percent\ Water\ Absorbed\ (by\ volume) = \frac{B - A}{B + D - E} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at 25 ±1°C (77 ±2°F), g

E = Mass of volumeter filled with specimen and water, g

Example:

36

$$G_{mb} = \frac{4833.6\ g}{4842.4\ g + 2924.4\ g - 5806.0\ g} = 2.465$$

$$\%\ Water\ Absorbed\ (by\ volume) = \frac{4842.4\ g - 4833.6\ g}{4842.4\ g + 2944.4\ g - 5806.0\ g} \times 100 = 0.45\%$$

Given:

A = 4833.6 g

B = 4842.4 g

D = 2924.4 g

E = 5806.0 g

Apparatus – Method C (Rapid Test for Method A or B)

- Oven: Capable of maintaining a temperature of 110 ±5°C (230 ±9°F) for drying the specimens to a constant mass.

See Methods A or B.

Note 2: This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure – Method C (Rapid Test for Method A or B)

1. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, A, as follows.
2. Determine and record mass of a large, flat-bottom container.
3. Place the specimen in the container.
4. Place in an oven at 110 ± 5 C (230 ± 9 F).
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm (¼ in.).
6. Determine and record the mass of the specimen. Designate this mass as M_p.
7. Return the specimen to the oven for at least 2 hours.
8. Determine and record the mass of the specimen. Designate this mass as M_n.
9. Determine percent change by subtracting the new mass determination, M_n, from the previous mass determination, M_p, dividing by the previous mass determination, M_p, and multiplying by 100.
10. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
11. Constant mass has been achieved; sample is defined as dry.

12. Cool in air to 25 ±5°C (77 ± 9°F).
13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.
14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. Designate this mass as A.

42 Calculations – Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

43 Report

- On forms approved by the agency
- Sample ID
- G_{mb} to the nearest 0.001
- Absorption to the nearest 0.01 percent
- The method performed

44

Tips!

- Use method approved by agency.
- Check for open or interconnecting voids and/or absorption over 2.00 percent.
- Check temperature of water in water bath.

REVIEW QUESTIONS

1. For how long must samples be submerged prior to determining immersed weight for Method A?
2. In determining the SSD mass of a specimen, how must the sample be dried?
3. At what temperature and for how long should core samples be dried?
4. How do methods A and B differ?

PERFORMANCE EXAM CHECKLIST

BULK SPECIFIC GRAVITY OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS
FOP FOR AASHTO T 166

Participant Name ______________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
Method A:		
1. Mass of dry sample determined.		
a. Sample dried to constant mass if required?	_____	_____
b. Cooled in air to 25 ±5°C (77 ±9°F)?	_____	_____
c. Dry mass determined to 0.1g?	_____	_____
2. Water at the overflow?	_____	_____
3. Balance zeroed?	_____	_____
4. Immersed weight determined.		
a. Water at 25 ±1°C (77 ±2°F)?	_____	_____
b. Immersed, shaken, on side, for 4 ±1 min.?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
5. Sample rapidly surface dried (within 5 sec.) with a damp towel and saturated surface dry (SSD) mass determined to 0.1 g (entire operation performed within 15 sec.)?	_____	_____
6. G_{mb} calculated to the nearest 0.001?	_____	_____
7. Absorption calculated to the nearest 0.01 percent	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
Method B:		
1. Specimen dried, cooled, and mass determined as in Method A?	_____	_____
2. Saturated surface-dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at 25 ±1°C (77 ±2°F)?	_____	_____
b. Sample rapidly dried (within 5 sec.) with damp towel ?	_____	_____
c. Specimen mass determined to 0.1 g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
3. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±2°F) determined?	_____	_____
4. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
5. Temperature of water brought to 25 ±1°C (77 ±2°F) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?	_____	_____
6. Volumeter wiped dry, and mass of volumeter and contents determined?	_____	_____
7. G_{mb} calculated to the nearest 0.001?	_____	_____
8. Absorption calculated to the nearest 0.01 percent?	_____	_____
Method C/A:		
1. Immersed weight determined.		
a. Water at 25 ±1°C (77 ±2°F)?	_____	_____
b. Immersed, shaken, on side, for 4 ±1 minutes?	_____	_____
c. Immersed weight determined to 0.1 g?	_____	_____
2. Sample rapidly surface dried with damp cloth (within 5 sec.)?	_____	_____
3. Saturated surface dry mass determined to 0.1 g?	_____	_____
4. Dry mass determined by:		
a. Heating in oven at 110 ± 5 C (230 ± 9 F)?	_____	_____
b. Breaking down to 6.3 mm (¼ in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?	_____	_____
d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g?	_____	_____
5. G_{mb} calculated to the nearest 0.001?	_____	_____
6. Absorption calculated to the nearest 0.01?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
Method C/B:		
1. Saturated surface-dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at 25 ±1°C (77 ±2°F)?	_____	_____
b. Sample rapidly dried with damp towel (within 5 sec.)?	_____	_____
c. Specimen mass determined to 0.1g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
2. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±2°F) determined to 0.1 g?	_____	_____
3. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
4. Temperature of water brought to 25 ±1°C (77 ±2°F) and volumeter covered, allowing some water to escape through the capillary pore of the tapered lid?	_____	_____
5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1 g?	_____	_____
6. Dry mass determined by:		
a. Heating in oven at 110 ± 5 C (230 ± 9 F)?	_____	_____
b. Breaking down to 6.3 mm (¼ in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?	_____	_____
d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g?	_____	_____
7. G_{mb} calculated to the nearest 0.001?	_____	_____
8. Absorption calculated to the nearest 0.01 percent?	_____	_____

Comments: First attempt: Pass_____Fail_______ Second attempt: Pass______Fail_____

____
____
____
____
____
____
____
____

Examiner Signature ________________________________WAQTC #:_______________

SAMPLING ASPHALT MATERIALS
FOP FOR AASHTO R 66

01

Significance

02

The quality of asphalt materials has a tremendous impact on a roadway project. The grade of binder selected is based on a number of factors, including local temperature extremes and characteristics of expected traffic. Using a grade of binder material other than that specified will have serious impacts on roadway performance and durability.

Scope

03

The procedure covers obtaining samples of liquid asphalt materials in accordance with AASHTO R 66-16. Sampling of solid and semi-solid asphalt materials – included in AASHTO R 66 – is not covered here.

Agencies may be more specific on exactly who samples, where to sample, and what type of sampling device to use.

Warning: Always use appropriate safety equipment and precautions for hot liquids.

04

Terminology

- Asphalt binder: Asphalt cement or modified asphalt cement that binds the aggregate particles into a dense mass.
- Asphalt emulsion: A mixture of asphalt binder and water.
- Cutback asphalt: Asphalt binder that has been modified by blending with a chemical solvent.

Containers

Metal cans

05

Sample containers must be new, and the inside may not be washed or rinsed. The outside may be wiped with a clean, dry cloth.

All samples shall be put in 1 L (1 qt) containers and properly identified on the outside of the container with contract number, date sampled, data sheet number, brand and grade of material, and sample number. Include lot and sublot numbers when appropriate.

Wide-mouth plastic jar

- 06 Asphalt binder and cutbacks: Use metal cans.
- 07 Emulsified asphalt: Use wide-mouth plastic jars with screw caps. Protect the samples from freezing since water is a part of the emulsion. The sample container should be completely filled to minimize a skin formation on the sample.

Note: The filled sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. If cleaning is necessary, use a clean dry cloth.

Procedure

Sampling liquid binder

1. 08 Coordinate sampling with contractor or supplier.
2. Allow a minimum of 4 L (1 gal) to flow before obtaining samples.
3. Obtain samples of:
    - 09 Asphalt binder from the line between the
      10 storage tank and the mixing plant while the plant is in operation, or from the delivery truck.
    - Cutback and emulsified asphalt from
      11 distributor spray bar or application device, or from the delivery truck before it is pumped into the distributor: Sample emulsified asphalt at delivery or before dilution.

Sampling from the spray bar

12 Report

- 13 On forms approved by the agency
- Sample ID
- Date
- Time
- Location
- Quantity represented

Tips! 14

- Remember to identify sample on outside of container.

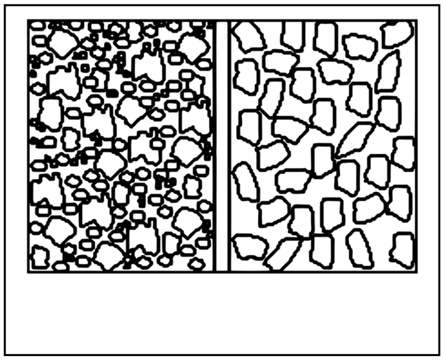
REVIEW QUESTIONS

1. Describe how liquid asphalt material is obtained at an asphalt mixture plant.

2. Describe how liquid asphalt material is obtained from a spray distributor.

3. Describe the containers used for sampling.

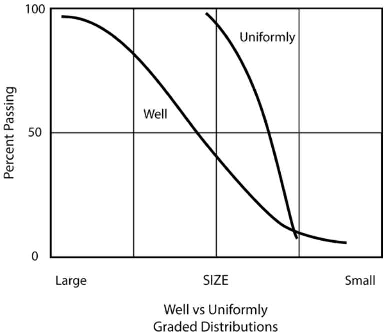
MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE FOP FOR AASHTO T 30



Well vs. uniformly graded

Significance

01 The amount and gradation of aggregate in asphalt mixtures are specified by the agency and relate to 02 strength, flexibility, and durability considerations. Mix designs are based on those specifications, as is mix production. To confirm that the amount and 03 gradation of aggregate in the finished product are correct, tests must be conducted. Compliance with the specification will help ensure a good roadway. Non-compliance may result in failure of the roadway. For these reasons, analysis of aggregate in asphalt mixtures is extremely important.



Gradation curves

Scope 04

This procedure covers mechanical analysis of 05 aggregate recovered from asphalt mix samples in accordance with AASHTO T 30-21. This FOP uses the aggregate recovered from the ignition furnace 06 used in AASHTO T 308. AASHTO T 30 was developed for analysis of extracted aggregate and thus includes references to extracted bitumen and filter element, which do not apply in this FOP. Sieve analyses determine the gradation or distribution of aggregate particles within a given sample to determine compliance with design and production standards.

Apparatus

Apparatus

- Balance or scale: capacity sufficient for the sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g and 07 conforming to AASHTO M 231
- Sieves, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical sieve shaker, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical Washing Apparatus (optional)
- Suitable drying equipment, meeting the requirements of FOP for AASHTO T 255.

- Containers and utensils: a pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.
- Wetting Agent: Any dispersing agent, such as dishwashing detergent, that will promote separation of the fine materials.

Sample Sieving

08

- In this procedure, it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the test sample, or a portion of the test sample, is placed on the top sieve.
- The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A; *Time Evaluation*.

Mass Verification

09 The aggregate sample mass, $M_{(T30)}$, determined in this method, shall agree with the mass of the aggregate remaining after ignition, M_f from the FOP for AASTHO T 308, within 0.1 percent. If the variation exceeds 0.1 percent, the results cannot be used for acceptance

Procedure

10

1. Determine and record the mass of the sample that was removed from the basket in the FOP for AASHTO T 308 to 0.1 g. Designate this mass as $M_{(T30)}$.
2. Verify the mass of the sample is within 0.1 percent by subtracting $M_{(T30)}$ from $M_{f(T308)}$ dividing by $M_{f(T308)}$ and multiplying by 100 (see Mass Verification Calculation and example).

   If the variation exceeds 0.1 percent, the sieve analysis results cannot be used for acceptance.

Separation of material

Pouring wash water over nested sieves

3. Nest a sieve, such as a 2.0 mm (No. 10) or 1.18 mm (No. 16), above the 75µm (No. 200) sieve.
4. Place the test sample in a container and cover with water. Add a wetting agent to the water to assure a thorough separation of the material finer than the 75µm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.
5. Agitate vigorously to ensure complete separation of the material finer than 75 µm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device. Maximum agitation is 10 min.

Note 1: When mechanical washing equipment is used, the introduction of water, agitating, and decanting may be a continuous operation. Use care not to overflow or overload the 75µm (No. 200) sieve.

6. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 µm (No. 200) sieve.
7. Add water to cover material remaining in the container, agitate, and repeat Step 6. Continue until the wash water is reasonably clear.
8. Remove the upper sieve, return material retained to the washed sample.
9. Rinse the material retained on the 75µm (No. 200) sieve until water passing through the sieve is reasonably clear and wetting agent is removed.
10. Return all material retained on the 75µm (No. 200) sieve to washed sample by rinsing into the washed sample.
11. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the “dry mass after washing.”

Small sieve shaker

16 12. Select sieves required by the specification and those necessary to avoid overloading. (See Annex B.) With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200).

13. Place the test sample, or a portion of the test sample, on the top sieve.

17 14. Place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 2: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

18 15. Determine and record the individual or cumulative mass retained on each sieve including the pan. Ensure that all material trapped in full openings of the sieves are removed and included in the mass retained.

Note 3: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

19 16. Perform the *Check Sum* calculation – Verify the *total mass after sieving* of material compared to the *dry mass after washing* is not more than 0.2 percent. Do not use test results for acceptance if the *Check Sum* result is more than 0.2 percent.

20 17. Calculate the total percentages passing, and the individual or cumulative percentages retained, to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the total mass of the initial dry sample.

Brushing sieve

18. Apply the Aggregate Correction Factor (ACF) to the calculated percent passing, as required in the FOP for AASHTO T 308 "Correction Factor," to obtain the reported percent passing.

19. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Calculations

Mass verification

21

$$Mass\ verification = \frac{\mathrm{M}_{\mathrm{f\,(T308)}} - \mathrm{M}_{\mathrm{(T30)}}}{\mathrm{M}_{\mathrm{f\,(T308)}}} \times 100$$

Where:

$\mathrm{M}_{\mathrm{f(T308)}}$ = Mass of aggregate remaining in the basket assembly remaining after ignition from the FOP for AASHTO T 308

$\mathrm{M}_{\mathrm{(T30)}}$ = Mass of aggregate sample obtained from the FOP for AASHTO T 308

Check Sum

22

$$check\ sum = \frac{dry\ mass\ after\ washing - mass\ after\ sieving}{dry\ mass\ after\ washing} \times 100$$

Percent Retained

Individual

23

$$\mathrm{IPR} = \frac{IMR}{M_{T30}} \times 100$$ 24

Cumulative

$$\mathrm{CPR} = \frac{CMR}{M_{T30}} \times 100$$

Where:

IPR = Individual Percent Retained

CPR = Cumulative Percent Retained

$\mathrm{M}_{\mathrm{T30}}$ = Total dry sample mass before washing

IMR = Individual Mass Retained

CMR = Cumulative Mass Retained

Percent Passing 25

Individual

$$PP = PCP - IPR$$

Cumulative

$$PP = 100 - CPR$$

Where:

PP = Calculated Percent Passing

PCP = Previous Calculated Percent Passing

Reported Percent Passing

$$RPP = PP + ACF$$ 26

Where:

RPP = Reported Percent Passing

ACF = Aggregate Correction Factor (if required)

Example

Mass verification

27

$$Mass\ verification = \frac{2422.5\ g - 2422.3\ g}{2422.5\ g} \times 100 = 0.01\%$$

Given:

$M_{f(T308)}$ = 2422.5 g

$M_{(T30)}$ = 2422.3 g

Dry mass of total sample, before washing (M_{T30}):	2422.3 g 28
Dry mass of sample, after washing out the 75 µm (No. 200) minus:	2296.2 g
Amount of 75 µm (No. 200) minus washed out (2422.3 – 2296.2 g):	126.1 g

Check sum

29

$$check\ sum = \frac{2296.2\ g - 2295.3\ g}{2296.2\ g} \times 100 = 0.04\%$$

This is not more than 0.2 percent therefore the results can be used for acceptance purposes.

Percent Retained for the 75 µm (No. 200) sieve 30

$$IPR = \frac{63.5\ g}{2422.3\ g} \times 100 = 2.6\% \quad or \quad CPR = \frac{2289.6\ g}{2422.3\ g} \times 100 = 94.5\%$$

Percent Passing using IPR and PCP for the 75 µm (No. 200) sieve

$$PP = 8.1\% - 2.6\% = 5.5\%$$

31

Percent Passing using CPR for the 75 µm (No. 200) sieve

$$PP = 100.0\% - 94.5\% = 5.5\%$$

32

Reported Percent Passing

$$RPP = 5.5\% + (-0.6\%) = 4.9\%$$

Individual
Gradation on All Sieves

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR by dividing IMR by *M* and multiplying by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from previous PP	Percent Passing (PP)	Agg. Corr. Factor from T 308 (ACF)	Reported Percent Passing*
19.0 (3/4)	0		0		100.0		100
12.5 (1/2)	346.9	$\frac{346.9}{2422.3} \times 100 =$	14.3	100.0 − 14.3 =	85.7		86
9.5 (3/8)	207.8	$\frac{207.8}{2422.3} \times 100 =$	8.6	85.7 − 8.6 =	77.1		77
4.75 (No. 4)	625.4	$\frac{625.4}{2422.3} \times 100 =$	25.8	77.1 − 25.8 =	51.3		51
2.36 (No. 8)	416.2	$\frac{416.2}{2422.3} \times 100 =$	17.2	51.3 − 17.2 =	34.1		34
1.18 (No. 16)	274.2	$\frac{274.2}{2422.3} \times 100 =$	11.3	34.1 − 11.3 =	22.8		23
0.600 (No. 30)	152.1	$\frac{152.1}{2422.3} \times 100 =$	6.3	22.8 − 6.3 =	16.5		17
0.300 (No. 50)	107.1	$\frac{107.1}{2422.3} \times 100 =$	4.4	16.5 − 4.4 =	12.1		12
0.150 (No. 100)	96.4	$\frac{96.4}{2422.3} \times 100 =$	4.0	12.1 − 4.0 =	8.1		8
0.075 (No. 200)	63.5	$\frac{63.5}{2422.3} \times 100 =$	2.6	8.1 − 2.6 =	5.5	-0.6 (5.5 − 0.6 =)	4.9
minus 75 µm (No. 200) in the pan	5.7						

Total mass after sieving = sum of sieves + mass in the pan = 2295.3 g

Dry mass of total sample, before washing (M_{T30}): 2422.3g

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Cumulative Gradation on All Sieves

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Agg. Corr. Factor from T 308 (ACF)	Reported Percent Passing*
19.0 (3/4)	0		0.0		100.0		100
12.5 (1/2)	346.9	$\frac{346.9}{2422.3} \times 100 =$	14.3	100.0 – 14.3 =	85.7		86
9.5 (3/8)	554.7	$\frac{554.7}{2422.3} \times 100 =$	22.9	100.0 – 22.9 =	77.1		77
4.75 (No. 4)	1180.1	$\frac{1180.1}{2422.3} \times 100 =$	48.7	100.0 – 48.7 =	51.3		51
2.36 (No. 8)	1596.3	$\frac{1596.3}{2422.3} \times 100 =$	65.9	100.0 – 65.9 =	34.1		34
1.18 (No. 16)	1870.5	$\frac{1870.5}{2422.3} \times 100 =$	77.2	100.0 – 77.2 =	22.8		23
0.600 (No. 30)	2022.6	$\frac{2022.6}{2422.3} \times 100 =$	83.5	100.0 – 83.5 =	16.5		17
0.300 (No. 50)	2129.7	$\frac{2129.7}{2422.3} \times 100 =$	87.9	100.0 – 87.9 =	12.1		12
0.150 (No. 100)	2226.1	$\frac{2226.1}{2422.3} \times 100 =$	91.9	100.0 – 91.9 =	8.1		8
0.075 (No. 200)	2289.6	$\frac{2289.6}{2422.3} \times 100 =$	94.5	100.0 – 94.5 =	5.5	-0.6 (5.5 – 0.6 =)	4.9
minus 75 µm (No. 200) in the pan	2295.3						
Total mass after sieving = 2295.3 g							
Dry mass of total sample, before washing (M_{T30}): 2422.3g							

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Report

- 39 On forms approved by the agency
- Sample ID
- Depending on the agency, this may include:
  - Individual mass retained on each sieve
  - Individual percent retained on each sieve
  - Cumulative mass retained on each sieve
  - Cumulative percent retained on each sieve 40
  - Aggregate Correction Factor for each sieve from AASHTO T 308
  - Calculated percent passing each sieve to 0.1 percent
  - Results on forms approved by the agency
- Percent passing to the nearest 1 percent, except 75 µm (No. 200) sieve to the nearest 0.1 percent.

Tips!

- 41 Do not lose any material when running the test.
- Remember to base calculations on the total mass of the initial dry sample.
- Check calculations, and sieves for damage or plugging, if results look “odd” or if the material suddenly goes out of spec.
- Save all material for rerunning.

Hand shaking

A2

ANNEX A
TIME EVALUATION

(Mandatory Information)

A3

The sieving time for each mechanical sieve shaker shall be checked at least annually to determine the time required for complete separation of the sample by the following method:

A4

1. Shake the sample over nested sieves for approximately 10 minutes.
2. Provide a snug-fitting pan and cover for each sieve and hold in a slightly inclined position in one hand.
3. Hand shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

A5

ANNEX B
OVERLOAD DETERMINATION

(Mandatory Information)

- For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m^2 (4 g/in^2) of sieving surface.
- For sieves with openings 4.75 mm (No. 4) and larger, the mass (in kg) shall not exceed the product of 2.5 x (sieve opening in mm) x (effective sieving area). See Table B1.

A6 Additional sieves may be necessary to keep from overloading the specified sieves. The sample may also be sieved in increments or sieves with a larger sieving area.

TABLE B1
Maximum Allowable Mass of Material Retained on a Sieve, g
Nominal Sieve Size, mm (in.)
Exact size is smaller (see AASHTO T 27)

Sieve Size mm (in.)		**203 mm (8 in.) dia.**	**254 mm (10 in.) dia.**	**305 mm (12 in.) dia.**
		Sieving Area m^2 (in^2)		
		0.0285 (44.2)	**0.0457 (70.8)**	**0.0670 (103.5)**
50	(2)	3600	5700	8400
37.5	(1 1/2)	2700	4300	6300
25.0	(1)	1800	2900	4200
19.0	(3/4)	1400	2200	3200
16.0	(5/8)	1100	1800	2700
12.5	(1/2)	890	1400	2100
9.5	(3/8)	670	1100	1600
6.3	(1/4)	440	720	1100
4.75	(No. 4)	330	540	800
-4.75	(-No. 4)	200	320	470

REVIEW QUESTIONS

1. What is the maximum mass that can be retained on a 4.75 mm (No. 4) sieve with a 12 in. diameter without overloading?

2. Describe how sieves should be cleaned.

3. What should be done to protect the 75 µm (No. 200) sieve during washing?

4. Once a washed sample is placed in the oven and dried to a constant mass, what is the next step?

5. For how long should material be sieved on the shaker?

6. How much unexplained sample mass after sieve analysis may be lost before you would have to rerun an aggregate sample?

PERFORMANCE EXAM CHECKLIST

MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE FOP FOR AASHTO T 30

Participant Name ______________________________ Exam Date ______________

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Total dry mass determined to 0.1 g?	_____	_____
2. Dry mass agrees with sample mass after ignition (M_f) from AASHTO T 308 within 0.1 percent?	_____	_____
3. Sample placed in container and covered with water?	_____	_____
4. Wetting agent added?	_____	_____
5. Contents of container agitated vigorously?	_____	_____
6. Wash water poured through proper nest of two sieves?	_____	_____
7. Washing continued until wash water is reasonably clear and no wetting agent remaining?	_____	_____
8. Retained material returned to washed sample?	_____	_____
9. Washed material coarser than 75 µm (No. 200) dried to constant mass at 110 ±5°C (230 ±9°F)?	_____	_____
10. Sample cooled to room temperature?	_____	_____
11. Dry mass after washing determined to 0.1 g?	_____	_____
12. Material sieved on specified sieves?	_____	_____
13. Mass of each fraction of aggregate, including minus 75 µm (No. 200), determined and recorded to 0.1 g?	_____	_____
14. Total mass of material after sieving agrees with mass before sieving to within 0.2 percent?	_____	_____
15. Percent passing each sieve determined correctly to the nearest 0.1 percent?	_____	_____
16. Aggregate correction factor applied, if applicable?	_____	_____
17. Percent passing on each sieve reported correctly to the nearest 1 percent and nearest 0.1 percent on the 75 µm (No. 200)?	_____	_____

Comments: First attempt: Pass_____Fail_______ Second attempt: Pass______Fail_____

____

____

____

Examiner Signature _______________________________WAQTC #:_____________

APPENDIX A
FIELD OPERATING PROCEDURES – SHORT FORMS

Chapter	**Section**
11	FOP for AASHTO R 97 Sampling Asphalt Mixtures
12	FOP for AASHTO R 47 Reducing Samples of Asphalt Mixtures to Testing Size
13	FOP for AASHTO T 329 Moisture Content of Asphalt Mixtures by Oven Method
14	FOP for AASHTO T 308 Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method
15	FOP for AASHTO T 209 Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
16	FOP for AASHTO T 166 Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
17	FOP for AASHTO R 66 Sampling Asphalt Materials
18	FOP for AASHTO T 30 Mechanical Analysis of Extracted Aggregate
19	FOP for AASHTO T 255 Total Evaporable Moisture Content of Aggregate by Drying

SAMPLING ASPHALT MIXTURES
FOP FOR AASHTO R 97

Scope

This procedure covers sampling asphalt mixtures from plants, haul units, and roadways in accordance with AASHTO R 97-19. Sampling is as important as testing. Use care to obtain a representative sample. Avoid segregation and contamination of the material during sampling.

This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Apparatus

- Shovel or Metal Scoops, or Other Equipment: square-head metal shovels at least 125 mm (5.5 in.) wide.
- Sample containers: such as cardboard boxes, metal cans, stainless steel bowls, or other agency-approved containers
- Sampling plate: thick metal plate, minimum 8 gauge, sized to accommodate sample requirements, with a wire attached to one corner long enough to reach from the center of the paver to the outside of the farthest auger extension. A minimum of one hole 6 mm (0.25 in.) in diameter must be provided in a corner of the plate.
- Cookie cutter sampling device: formed steel angle with two 100 mm by 150 mm by 9 mm (4 in. by 6 in. by 3/8 in.) handles, sized to accommodate sample requirements. Minimum 50 mm (2 in.) smaller than the sampling plate when used together.

  Example: Sampling plate 380 mm (15 in.) square and a cookie cutter sampling device 330 mm (13 in.) square.
- Mechanical sampling device: a permanently attached device that allows a sample receptacle to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation.
- Agency approved release agent: a non-stick product that prevents the asphalt mixture from sticking to the apparatus and does not contain solvents or petroleum-based products that could affect asphalt binder properties.

Sample Size

Sample size depends on the test methods specified by the agency for acceptance. Check agency requirement for the size required.

Procedure

General

- Select sample locations using a random or stratified random sampling procedure, as specified by the agency. The material shall be tested to determine variations. The supplier/contractor shall provide equipment for safe and appropriate sampling, including sampling devices on plants when required.
- Ensure the container(s) and sampling equipment are clean and dry before sampling.
- For dense graded mixture samples use cardboard boxes, stainless steel bowls or other agency-approved containers.
- For hot open graded mixture samples use stainless steel bowls. Cardboard boxes can used if the sample has cooled to the point that asphalt binder will not migrate from the aggregate.

Attached Sampling Devices

These are normally permanently attached devices that allow a sample container to pass perpendicularly through the entire stream of material. Operation may be manual, pneumatic, or hydraulic and allow the sample container to pass through the stream twice without overfilling. A sampling device may also divert the entire stream into container.

1. Lightly coat the container attached to the sampling device with an agency-approved release agent or preheat it, or both, to approximately the same discharge temperature of the mix.
2. Pass the container twice, once in each direction, through the material perpendicularly without overfilling the container.
3. Transfer the asphalt mixture to an agency-approved container without loss of material.
4. Repeat until proper sample size has been obtained.
5. Combine the increments to form a single sample.

Conveyor Belts

1. Avoid sampling at the beginning or end of an asphalt mixture production run due to the potential for segregation.
2. Stop the belt containing asphalt mixture.
3. Set the sampling template into the asphalt mixture on the belt, avoiding intrusion by adjacent material.
4. Remove the asphalt mixture from inside the template, including all fines, and place in a sample container.
5. Repeat, obtaining equal size increments, until proper sample size has been obtained.
6. Combine the increments to form a single sample.

Haul Units

1. Visually divide the haul unit into approximately four equal quadrants.
2. Identify one sampling location in each quadrant.
3. Dig down and remove approximately 0.3 m (1 ft.) of material to avoid surface segregation. Obtain each increment from below this level.
4. Combine the increments to form a sample of the required size.

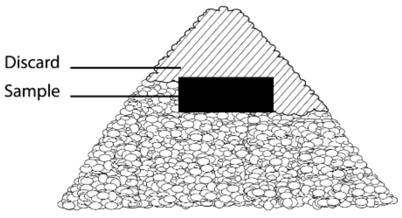
Paver Auger

1. Obtain samples from the end of the auger using a square head shovel.
2. Place the shovel in front of the auger extension, with the shovel blade flat upon the surface to be paved over.
3. Allow the front face of the auger stream to cover the shovel with asphalt mixture, remove the shovel before the auger reaches it by lifting as vertically as possible.
4. Place asphalt mixture in a sample container.
5. Repeat until proper sample size has been obtained.
6. Combine the increments to form a sample of the required size.

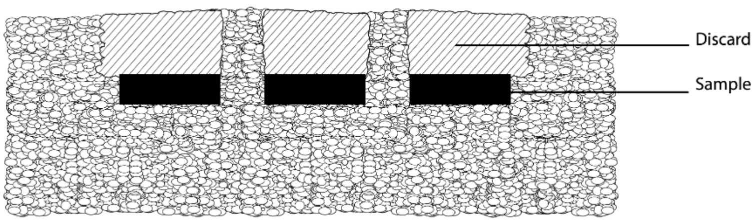
Note 1: First full shovel of material may be discarded to preheat and 'butter' the shovel.

Windrow

1. Obtain samples from the windrow of a transport unit. Avoid the beginning or the end of the windrow section.
2. Visually divide the windrow into approximately three equal sections.
3. Remove approximately 0.3 m (1 ft) from the top of each section.
4. Fully insert the shovel into the flat surface as vertically as possible, exclude the underlying material, roll back the shovel and lift the material slowly out of the windrow to avoid material rolling off the shovel.
5. Place in a sample container.
6. Repeat, obtaining equal size increments, in each of the remaining thirds.
7. Combine the increments to form a sample of the required size.



Windrow cross section



Windrow side view

Roadway before Compaction

There are two conditions that will be encountered when sampling asphalt mixtures from the roadway before compaction. The two conditions are:

- Laying asphalt mixture on grade or untreated base material requiring Method 1.
- Laying asphalt mixture on existing asphalt or laying a second lift of asphalt mixture allowing Method 2.

SAFETY:

Sampling is performed behind the paving machine, in front of the breakdown roller. For safety, the breakdown roller must remain at least 3 m (10 ft.) behind the sampling operation until the sample has been obtained and the hole filled with loose asphalt mixture.

Method 1 requires a plate to be placed in the roadway in front of the paving operation. There is always concern with moving, operating equipment. It is safest to stop the paving train while a plate is installed in front of the paver. When this is not possible the following safety rules must be followed.

1. The plate placing operation must be at least 3 m (10 ft.) in front of the paver or pickup device. The technician placing the plate must have eye contact and communication with the paving machine operator. If eye contact cannot be maintained at all times, a third person must be present to provide communication between the operator and the technician.
2. No technician is to be between the asphalt supply trucks and the paving machine. The exception to this rule is if the supply truck is moving forward creating a windrow, in which case the technician must be at least 3 m (10 ft.) behind the truck.

If at any time the Engineer feels that the sampling technique is creating an unsafe condition, the operation is to be halted until it is made safe, or the paving operation will be stopped while the plate is being placed.

Method 1 - Obtaining a Sample on Grade or Untreated Base (Plate Method)

1. Following the safety rules detailed above, the technician is to:
    a. Smooth out a location in front of the paver at least 0.5 m (2 ft.) inside the edge of the mat.
    b. Lay the plate down diagonally with the direction of travel, keeping it flat and tight to the base with the lead corner facing the paving machine.

    Note 2: The plate may be secured by driving a nail through the hole in the lead corner of the plate.
2. Pull the wire, attached to the outside corner of the plate, taut past the edge of the asphalt mixture mat and secure it. Let the paving operation pass over the plate and wire.
3. Using the exposed end of the wire, pull the wire up through the fresh asphalt mixture to locate the corner of the plate.

  a. Plate only:
    i. Using a small square head shovel, scoop, or both, remove the full depth of the asphalt mixture from the plate. Take care to prevent sloughing of adjacent material.
    ii. Place asphalt mixture, including any material adhering to the plate and scoop or shovel in a sample container.
    iii. Remove the sample cutter from the roadway. The hole made from the sampling must be filled by the contractor with loose asphalt mixture.
  b. "Cookie Cutter":
    i. Place the "cookie cutter" sample device, just inside the end of the wire; align the cutter over the plate. Press "cookie cutter" device down through the asphalt mixture to the plate.
    ii. Using a small square tipped shovel or scoop, or both, carefully remove all the asphalt mixture from inside of the cutter and place in a sample container.
    iii. Remove the sample cutter and the plate from the roadway. The hole made from the sampling must be filled by the contractor with loose asphalt mixture.

Method 2 - Obtaining a Sample on Asphalt Surface (Non-plate Method)

1. After the paving machine has passed the sampling point, immediately place the "cookie cutter" sampling device on the location to be sampled.
2. Push the cutter down through the asphalt mixture until it is flat against the underlying asphalt mat.
3. Using a small square tipped shovel, scoop, or both, carefully remove all the asphalt mixture from inside of the cutter and place in a sample container.
4. Remove the cutter from the roadway. The hole made from the sampling must be filled by the contractor with loose asphalt mixture.

Stockpiles

Remove at least 0.1 m (4 in.) from the surface before sampling; mixtures in a stockpile may develop an oxidized crust.

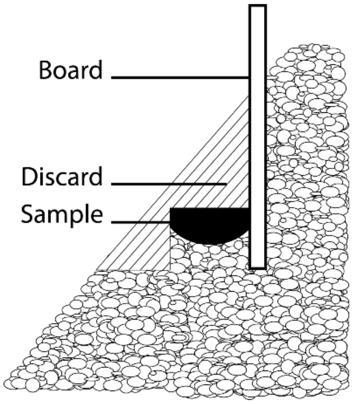
Method 1 – Loader

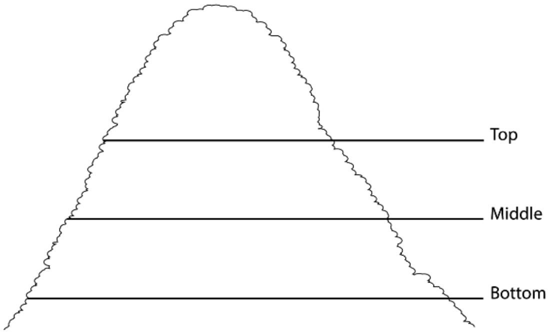
1. Direct the loader operator to enter the stockpile with the bucket at least 0.3 m (1 ft) above ground level without contaminating the stockpile.
2. Obtain a full loader bucket of the asphalt mixture; tilt the bucket back and up.
3. Form a small sampling pile at the base of the stockpile by gently rolling the asphalt mixture out of the bucket with the bucket just high enough to permit free flow of the mixture. Repeat as necessary.
4. Create a flat surface by having the loader "back-drag" the small pile.

5. Obtain approximately equal increments from at least three randomly selected locations on the flat surface at least 0.3 m (1 ft) from the edge.
6. Fully insert the shovel, exclude the underlying material, roll back the shovel and lift the asphalt mixture slowly out of the pile to avoid mixture rolling off the shovel.
7. Combine the increments to form a sample.

Method 2 – Stockpile Face

1. Create horizontal surfaces with vertical faces in the top, middle, and bottom third of the stockpile with a shovel or a loader if one is available.
2. Shove a flat board against the vertical face behind the sampling location to prevent sloughing of asphalt mixture. Discard the sloughed mixture to create the horizontal surface.
3. Obtain the sample from the horizontal surface as close as possible to the intersection of the horizontal and vertical faces.
4. Obtain at least one sample increment of equal size from each of the top, middle, and bottom thirds of the pile.
5. Combine the increments to form a single sample.





Identification and Shipping

1. Identify sample containers as required by the agency.
2. Ship samples in containers that will prevent loss, contamination, or damage.

Report

- On forms approved by the agency
- Sample ID
- Date
- Time
- Location
- Quantity represented

REDUCING SAMPLES OF ASPHALT MIXTURES TO TESTING SIZE
FOP FOR AASHTO R 47

Scope

This procedure covers sample reduction of asphalt mixtures to testing size in accordance with AASHTO R 47-23. The reduced portion is to be representative of the original sample.

Apparatus

- Thermostatically controlled oven capable of maintaining a temperature of at least 110°C (230°F) or high enough to heat the material to a pliable condition for splitting.
- Non-contact temperature measuring device.
- Metal spatulas, trowels, metal straightedges, drywall taping knives, or a combination thereof; for removing asphalt mixture samples from the quartering device, cleaning surfaces used for splitting, etc.
- Square-tipped, flat-bottom scoop, shovel, or trowel for mixing asphalt mixture before quartering.
- Miscellaneous equipment including hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans.
- Sheeting: Non-stick heavy paper or other material as approved by the agency.
- Agency-approved release agent, free of solvent or petroleum-based material that could affect asphalt binder.
- Mechanical Splitter Type B (Riffle): having a minimum of eight equal-width chutes discharging alternately to each side with a minimum chute width of at least 50 percent larger than the largest particle size. A hopper or straight-edged pan with a width equal to or slightly smaller than the assembly of chutes in the riffle splitter to permit uniform discharge of the asphalt mixture through the chutes without segregation or loss of material. Sample receptacles of sufficient width and capacity to receive the reduced portions of asphalt mixture from the splitter without loss of material.
- Quartering Template: formed in the shape of a 90- degree cross with equal sides that exceed the diameter of the flattened cone of material sufficient to allow complete separation of the quartered sample. The height of the sides must be sufficient to extend above the thickness of the flattened cone of the sample to be quartered. Manufactured of metal that will withstand heat and use without deforming.
- Non-stick mixing surface that is hard, heat-resistant, clean, level, and large enough to permit asphalt mixture samples to be mixed without contamination or loss of material.

Sampling

Obtain samples according to the FOP for AASHTO R 97.

Sample Preparation

The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily. Do not exceed either the temperature or time limits specified in the test method(s) to be performed.

Selection of Procedure (Method)

Refer to agency requirements when determining the appropriate method(s) of sample reduction. In general, the selection of a particular method to reduce a sample depends on the initial size of the sample vs. the size of the sample needed for the specific test to be performed. It is recommended that, for large amounts of material, the initial reduction be performed using a mechanical splitter. This decreases the time needed for reduction and minimizes temperature loss. Further reduction of the remaining asphalt mixture may be performed by a combination of the following methods, as approved by the agency.

The methods for reduction are:

- Mechanical Splitter Type B (Riffle) Method
- Quartering and Sectoring Methods
  - Quartering
  - Sectoring
- Incremental Method

Procedure

When heating of the equipment is desired, it shall be heated to a temperature not to exceed the maximum mixing temperature of the job mix formula (JMF).

Mechanical Splitter Type B (Riffle) Method

1. Clean the splitter and apply a light coating of agency-approved release agent to the surfaces that will come in contact with asphalt mixture (hopper or straight-edged pan, chutes, receptacles).
2. Place two empty receptacles under the splitter.
3. Carefully empty the asphalt mixture from the agency-approved container(s) into the hopper or straight-edged pan without loss of material. Uniformly distribute from side to side of the hopper or pan.
4. Discharge the asphalt mixture at a uniform rate, allowing it to flow freely through the chutes.
5. Any asphalt mixture that is retained on the surface of the splitter shall be removed and placed into the appropriate receptacle.
6. Reduce the remaining asphalt mixture as needed by this method or a combination of the following methods as approved by the agency.

7. Using one of the two receptacles containing asphalt mixture, repeat the reduction process until the asphalt mixture contained in one of the two receptacles is the appropriate size for the required test.
8. After each split, remember to clean the splitter hopper and chute surfaces if needed.
9. Retain and properly identify the remaining unused asphalt mixture sample for further testing if required by the agency.

Quartering and Sectoring Methods

1. If needed, apply a light coating of agency-approved release agent to quartering template.
2. Place the sample from the agency approved container(s) into a conical pile on a hard, "non-stick," clean, level surface where there will be neither a loss of material nor the accidental addition of foreign material. The surface can be made non-stick by the application of an agency-approved release agent, or sheeting.
3. Mix the material thoroughly by turning the entire sample over a minimum of four times with a flat-bottom scoop; or by alternately lifting each corner of the sheeting and pulling it over the sample diagonally toward the opposite corner, causing the material to be rolled. Create a conical pile by either depositing each scoop or shovelful of the last turning on top of the preceding one or lifting both opposite corners.
4. Flatten the conical pile to a uniform diameter and thickness where the diameter is four to eight times the thickness. Make a visual observation to ensure that the material is homogeneous.
5. Divide the flattened cone into four equal quarters using the quartering template or straightedges assuring complete separation.
6. Reduce to appropriate sample mass by quartering or sectoring.

Quartering

   a. Remove diagonally opposite quarters, including all the fine material, and place in a container to be retained.
   b. Remove the quartering template, if used.
   c. Combine the remaining quarters.
   d. If further reduction is necessary, repeat Quartering Method Steps 3 through 6.
   e. Repeat until appropriate sample mass is obtained. The final sample must consist of the two remaining diagonally opposite quarters.
   f. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Sectoring

a. Using a straightedge, obtain a sector by slicing through a quarter of the asphalt mixture from the center point to the outer edge of the quarter.

b. Pull or drag the sector from the quarter with two straight edges or hold one edge of the straightedge in contact with quartering device.

c. Remove an approximately equal sector from the diagonally opposite quarter and combine.

d. If necessary, repeat until the appropriate sample mass has been obtained.

e. Continue sectoring with the unused portion of the asphalt mixture until samples have been obtained for all required tests.

f. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

Incremental Method

1. Cover a hard, clean, level surface with sheeting. This surface shall be large enough that there will be neither a loss of material nor the accidental addition of foreign material.
2. Place the sample from the agency approved container(s) into a conical pile on that surface.
3. Mix the material thoroughly by turning the entire sample over a minimum of four times:
   a. Use a flat-bottom scoop; or
   b. Alternately lift each corner of the sheeting and pull it over the sample diagonally toward the opposite corner, causing the material to be rolled.
4. Create a conical pile by either depositing each scoop or shovelful of the last turning on top of the preceding one or lifting both opposite corners.
5. Grasp the sheeting and roll the conical pile into a cylinder (loaf), then flatten the top. Make a visual observation to determine that the material is homogenous.
6. Remove one quarter of the length of the loaf and place in a container to be saved by either:
   a. Pull sheeting over edge of counter and drop material into container.
   b. Use a straightedge at least as wide as the full loaf to slice off material and place into container.
7. Obtain an appropriate sample mass for the test to be performed; by either:
   a. Pull sheeting over edge of counter and drop cross sections of the material into container until proper sample mass has been obtained.
   b. Use a straightedge at least as wide as the full loaf to slice off cross sections of the material until proper sample mass has been obtained and place into container.

Note 1: When reducing the sample to test size it is advisable to take several small increments, determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size, use the sample as reduced for the test.

8. Repeat Step 7 until all the samples for testing have been obtained or until the final quarter of the original loaf is reached.

9. Retain and properly identify the remaining unused portion of the asphalt mixture sample for further testing if required by the agency.

MOISTURE CONTENT OF ASPHALT MIXTURES BY OVEN METHOD
FOP FOR AASHTO T 329

Scope

This procedure covers the determination of moisture content of asphalt mixtures in accordance with AASHTO T 329-22.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

Constant mass – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: 2 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Forced draft, ventilated, or convection oven: Capable of maintaining the temperature surrounding the sample at 163 ±14°C (325 ±25°F).
- Container: Clean, dry, not affected by heat and of sufficient size to contain a test sample without danger of spilling.
- Thermometer or other suitable device with a temperature range of 50 to 200°C (122 to 392°F) and readable to the nearest 2°C (4°F).

Sample

The test sample shall be obtained in accordance with the FOP for AASHTO R 97 and reduced in accordance with the FOP for AASHTO R 47. The size of the test sample shall be a minimum of 1000 g.

Procedure

1. Preheat the oven to the Job Mix Formula (JMF) mixing temperature range. If the mixing temperature is not supplied, a temperature of 163 ±14ºC (325 ±25ºF) is to be used.
2. Determine and record the mass of the container, including release media, to the nearest 0.1 g.

   Note 1: When using paper or other absorptive material to line the container ensure it is dry before determining initial mass of container.

3. Place the wet sample in the container.
4. Determine and record the temperature of the sample to the nearest 2°C (4°F).
5. Determine and record the mass of the sample and container to the nearest 0.1 g.
6. Determine and record the wet mass (M_i) of the sample by subtracting the container mass determined in Step 2 from the mass of the sample and container determined in Step 5.

7. Place the sample and container in the oven and dry for 90 ±5 min.
8. Determine the mass of sample and container.
9. Determine and record the mass of the sample by subtracting the container mass determined in Step 2 from the mass of the sample and container determined in Step 8.
10. Return sample and container to the oven and dry for 30 ±5 min.
11. Determine the mass of sample and container.
12. Determine and record the mass of the sample by subtracting the container mass determined in Step 2 from the mass of the sample and container determined in Step 11.
13. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.
14. Continue drying, performing Steps 10 through 13, until there is less than 0.05 percent change after additional drying time.
15. Cool the sample and container to ±9°C (±15°F) of the temperature determined in Step 4.
16. Determine and record the dry mass of the sample and container to the nearest 0.1 g.
17. Determine and record the mass of dry sample (M_f) by subtracting the mass of the container determined in Step 2 from the dry mass of the sample and container determined in Step 16.

Note 2: Moisture content and the number of samples in the oven will affect the rate of drying at any given time. Placing wet samples in the oven with nearly dry samples could affect the drying process.

Calculations

Constant Mass:

Calculate constant mass using the following formula:

$$\% \, Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement

M_n = new mass measurement

Example:

Mass of container and release media:	232.6 g
Initial mass of sample and container:	1367.5 g
Initial mass of sample (M_i):	1367.5 g – 232.6 g = 1134.9 g

Mass of sample and container after first drying cycle: 1361.8 g

Mass, M_p, of sample: 1361.8 g – 232.6 g = 1129.2 g

Mass of sample and container after second drying cycle: 1360.4 g

Mass, M_n, of sample: 1360.4 g – 232.6 g = 1127.8 g

$$\% \, Change = \frac{1129.2 \, g - 1127.8 \, g}{1129.2 \, g} \times 100 = 0.12\%$$

0.12 percent is not less than 0.05 percent, so continue drying the sample.

Mass of sample and container after third drying cycle: 1359.9 g

Mass, M_n, of sample: 1359.9 g – 232.6 g = 1127.3 g

$$\% \, Change = \frac{1127.8 \, g - 1127.3 \, g}{1127.8 \, g} \times 100 = 0.04\%$$

0.04 percent is less than 0.05 percent, so constant mass has been reached.

Moisture Content:

Calculate the moisture content, as a percent, using the following formula.

$$Moisture \; Content = \frac{M_i - M_f}{M_f} \times 100$$

Where:

M_i = initial, wet mass

M_f = final, dry mass

Example:

M_i = 1134.9 g

M_f = 1127.3 g

$$Moisture \; Content = \frac{1134.9 \, g - 1127.3 \, g}{1127.3 \, g} \times 100 = 0.674, \text{report } 0.67\%$$

Report

- On forms approved by the agency
- Sample ID
- Moisture content to the nearest 0.01 percent

DETERMINING THE ASPHALT BINDER CONTENT OF ASPHALT MIXTURES BY THE IGNITION METHOD
FOP FOR AASHTO T 308

Scope

This procedure covers the determination of asphalt binder content of asphalt mixtures by ignition of the binder in accordance with AASHTO T 308-22.

Overview

The sample is heated in a furnace at 538°C (1000°F) or less; samples may be heated by convection or direct infrared irradiation (IR). The aggregate remaining after burning can be used for sieve analysis using the FOP for AASHTO T 30.

Some agencies allow the use of recycled asphalt mixtures. When using recycled asphalt mixtures, check with the agency for specific correction procedures.

Asphalt binder in the asphalt mixture is ignited in a furnace. Asphalt binder content is calculated as the percentage difference between the initial mass of the asphalt mixture and the mass of the residual aggregate, with the asphalt binder correction factor, and moisture content subtracted. The asphalt binder content is expressed as a percent of moisture-free mix mass.

Two methods, A and B, are presented.

Apparatus

Note 1: The apparatus must be calibrated for the specific mix design. See "Correction Factors" at the end of this FOP.

The apparatus for Methods A and B is the same except that the furnace for Method A requires an internal balance.

- Ignition Furnace: A forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining the temperature between at least 530 and 545°C (986 and 1013°F) and have a temperature control accurate within ±5°C (±9°F).

  For Method A, the furnace will be equipped with an internal scale thermally isolated from the furnace chamber and accurate to 0.1 g. The scale shall be capable of determining the mass of a 3500 g sample in addition to the sample baskets. A data collection system will be included so that mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the sample and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive minutes. Perform lift test according to manufacturer's instructions weekly during use, if applicable. The furnace shall be designed to permit the operator to change the ending mass loss percentage from both 0.01 percent to 0.02 percent.

For both Method A and Method B, the furnace chamber dimensions shall be adequate to accommodate a 3500 g sample. The furnace door shall be equipped so that it cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided and the furnace shall be vented so that no emissions escape into the laboratory. The furnace shall have a fan to pull air through the furnace to expedite the test and to eliminate the escape of smoke into the laboratory.

- Sample Basket Assembly: consisting of sample basket(s), catch pan, and basket guards. Sample basket(s) will be of appropriate size allowing samples to be thinly spread and allowing air to flow through and around the sample particles. Sets of two or more baskets shall be nested. A catch pan: of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught. Basket guards will completely enclose the basket and be made of screen mesh, perforated stainless steel plate, or other suitable material.
- Thermometer, or other temperature measuring device, with a temperature range of 10 - 260°C (50-500°F).
- Oven capable of maintaining 110 ±5°C (230 ±9°F).
- Balance or scale: Capacity sufficient for the sample mass and conforming to the requirements of M 231, Class G2.
- **Safety equipment**: Safety glasses or face shield, high temperature gloves, long sleeved jacket, a heat resistant surface capable of withstanding 650°C (1202°F), a protective cage capable of surrounding the sample baskets during the cooling period, and a particle mask for use during removal of the sample from the basket assembly.
- Miscellaneous equipment: A container larger than the sample basket(s) for transferring sample after ignition, large flat pan, spatulas, bowls, and wire brushes.

Sampling

1. Obtain samples of asphalt mixture in accordance with the FOP for AASHTO R 97.
2. If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan in an oven at 110 ±5°C (230 ±9°F) until workable.
3. Reduce asphalt mixture samples in accordance with the FOP for AASHTO R 47.
4. Test sample size shall conform to the mass requirement shown in Table 1.

Note 2: When the mass of the test specimen exceeds the capacity of the equipment used or for large samples of fine mixes, the test specimen may be divided into suitable increments, tested, and the results appropriately combined through a weighted average for calculation of the asphalt binder content.

Table 1

Nominal Maximum Aggregate Size* mm (in.)	Minimum Mass Specimen g	Maximum Mass Specimen g
37.5 (1 ½)	4000	4500
25.0 (1)	3000	3500
19.0 (3/4)	2000	2500
12.5 (1/2)	1500	2000
9.5 (3/8)	1200	1700
4.75 (No. 4)	1200	1700

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

General

1. For the convection-type furnace, preheat the ignition furnace to 538 ± 5°C (1000 ± 9°F) or to the temperature determined in the Correction Factors Annex of this method. Manually record the furnace temperature (set point) before the initiation of the test if the furnace does not record automatically. For the direct IR irradiation-type furnace, use the same burn profile as used during the correction factor determination.

Procedure – Method A (Internal Balance)

1. Dry the sample to constant mass, according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.
2. Determine and record the mass of the sample basket assembly to the nearest 0.1 g.
3. Evenly distribute the sample in the sample basket assembly, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.
4. Determine and record the total mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g.
5. Calculate the initial mass of the sample by subtracting the mass of the sample basket from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as (M_i).
6. Record the correction factor or input into the furnace controller for the specific asphalt mixture.

7. Input the initial mass of the sample (M_i) into the ignition furnace controller. Verify that the correct mass has been entered.
8. Verify the furnace scale is reading zero, if not, reset to zero.

CAUTION: Operator should wear safety equipment – high temperature gloves, face shield, fire-retardant shop coat – when opening the door to load or unload the sample.

9. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Close the chamber door and verify that the sample mass displayed on the furnace scale equals the total mass of the sample and sample basket assembly recorded in Step 5 within ±5 g.

Note 3: Differences greater than 5 g or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall.

Note 4: Furnace temperature will drop below the set point when the door is opened but will recover when the door is closed, and ignition begins. Sample ignition typically increases the temperature well above the set point – relative to sample size and asphalt binder content.

10. Initiate the test by pressing the start button. This will lock the sample chamber and start the combustion blower.

Safety note: Do not attempt to open the furnace door until the asphalt binder has been completely burned off.

11. Allow the test to continue until the stable light and audible stable indicator indicate that the change in mass does not exceed 0.01 percent for three consecutive minutes. Press the stop button. This will unlock the sample chamber and cause the printer to print out the test results.

Note 5: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

12. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 minutes).
13. Determine and record the mass of the sample and sample basket assembly after ignition to the nearest 0.1 g.
14. Calculate the mass of the sample by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as M_f.
15. Use the asphalt binder content percentage from the printed ticket. Subtract the moisture content and the correction factor if not entered into the furnace controller from the printed ticket asphalt binder content and report the difference as the corrected asphalt binder content.

    Asphalt binder content percentage can also be calculated using the formula from "Method B" Step 16.

Calculation

Corrected asphalt binder content:

$$P_b = BC - MC - C_f{}^*$$

*If correction factor is not entered into the furnace controller

where:

P_b = the corrected asphalt binder content as a percent by mass of the asphalt mixture

BC = asphalt binder content shown on printed ticket

MC = moisture content of the companion asphalt mixture sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried before initiating the procedure, MC=0)

C_f = correction factor as a percent by mass of the asphalt mixture sample

Procedure – Method B (External Balance)

1. Dry the sample to constant mass, according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.
2. Determine and record the mass of the sample basket assembly to the nearest 0.1 g.
3. Place the sample basket(s) in the catch pan. Evenly distribute the sample in the sample basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.
4. Determine and record the mass of the sample and sample basket assembly at room temperature to the nearest 0.1 g.
5. Calculate the initial mass of the sample by subtracting the mass of the sample basket from the mass of the sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as (M_i).
6. Record the correction factor for the specific asphalt mixture.
7. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Burn the asphalt mixture sample in the furnace for 45 minutes or the length of time determined in the “Correction Factors” section.
8. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample and allow it to cool to room temperature (approximately 30 min).

9. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
10. Calculate the sample mass by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g.
11. Place the sample basket assembly back into the furnace.
12. Burn the sample for at least 15 minutes after the furnace reaches the set temperature.
13. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 min.).
14. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
15. Calculate the mass of the sample by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g.
16. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.
17. If the percent change exceeds 0.01 percent of the previous sample mass, repeat Steps 11 through 16 until the percent change does not exceed 0.01 percent.

    Note 6: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

18. Determine and record the mass of the sample and sample basket assembly to the nearest 0.1 g.
19. Calculate the final sample mass by subtracting the mass of the sample basket assembly and sample and sample basket assembly and record to the nearest 0.1 g. Designate this mass as M_f.
20. Calculate the asphalt binder content of the sample.

Calculations

Constant Mass

Calculate %change:

$$\% \, Change = \frac{M_p - M_n}{M_p} \times 100$$

where:

M_p = sample mass after ignition

M_n = sample mass after 15 min. additional ignition

Example

Initial mass of sample and basket	= 5292.7 g
Mass of basket assembly	= 2931.5 g
M_i	= 2361.2 g
Sample mass and basket after first ignition	= 5154.4 g
Sample mass after first ignition	= 2222.9 g
Sample mass and basket after additional 15 min ignition	= 5154.2 g

Constant mass

Sample mass after additional 15 min ignition = 2222.7 g

$$\%change = \frac{2222.9\ g - 2222.7\ g}{2222.9\ g} \times 100 = 0.009\%$$

%change is not greater than 0.01 percent, so $\mathbf{M_f}$ = 2222.7 g

Percent asphalt binder (P_b)

Calculate the asphalt binder content of the sample as follows:

$$P_b = \frac{M_i - M_f}{M_i} \times 100 - MC - C_f$$

where:

P_b = the corrected asphalt binder content as a percent by mass of the asphalt mixture sample

M_f = the final sample mass after ignition, g

M_i = the initial mass of the asphalt mixture sample before ignition, g

MC= moisture content of the companion asphalt mixture sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried before initiating the procedure, MC = 0).

C_f = correction factor as a percent by mass of the asphalt mixture sample

Example

Correction factor = 0.42%

Moisture content = 0.04%

Initial mass of sample and basket = 5292.7 g

Mass of basket assembly = 2931.5 g

M_i = 2361.2 g

M_f = 2222.7 g

$$P_b = \frac{2361.2\ g - 2222.7\ g}{2361.2\ g} \times 100 - 0.04\% - 0.42\% = 5.41\%$$

P_b= 5.41%

Gradation

1. Empty contents of the basket(s) into a container, being careful to capture all material. Use a small wire brush to ensure all residual fines are removed from the baskets.

   Note 7: Particle masks are a recommended safety precaution.

2. Perform the gradation analysis in accordance with the FOP for AASHTO T 30.

Report

- On forms approved by the agency
- Sample ID
- Method of test (A or B)
- Corrected asphalt binder content, P_b, to the nearest 0.01 percent or per agency standard
- Correction factor, C_f, to the nearest 0.01 percent
- Temperature compensation factor (Method A only)
- Total percent loss
- Sample mass
- Moisture content to the nearest 0.01%
- Test temperature

Attach the original printed ticket with all intermediate values (continuous tape) to the report for furnaces with internal balances.

ANNEX – CORRECTION FACTORS

ASPHALT BINDER AND AGGREGATE

(Mandatory Information)

Asphalt binder content results may be affected by the type of aggregate in the mixture and by the ignition furnace. Asphalt binder and aggregate correction factors must, therefore, be established by testing a set of correction specimens for each Job Mix Formula (JMF) mix design. Each ignition furnace will have its own unique correction factor determined in the location where testing will be performed.

This procedure must be performed before any acceptance testing is completed, and repeated each time there is a change in the mix ingredients or design. Any changes greater than 5 percent in stockpiled aggregate proportions should require a new correction factor.

All correction samples will be prepared by a central / regional laboratory unless otherwise directed.

Asphalt binder correction factor: A correction factor must be established by testing a set of correction specimens for each Job Mix Formula (JMF). Certain aggregate types may result in unusually high correction factors (> 1.00 percent). Such mixes should be corrected and tested at a lower temperature as described below.

Aggregate correction factor: Due to potential aggregate breakdown during the ignition process, a correction factor will need to be determined for the following conditions:

a. Aggregates that have a proven history of excessive breakdown

b. Aggregate from an unknown source.

This correction factor will be used to adjust the acceptance gradation test results obtained according to the FOP for AASHTO T 30.

Procedure

1. Obtain samples of aggregate in accordance with the FOP for AASHTO R 90.
2. Obtain samples of asphalt binder in accordance with the FOP for AASHTO R 66.

   Note 8: Include other additives that may be required by the JMF.

3. Prepare an initial, or "butter," mix at the design asphalt binder content. Mix and discard the butter mix before mixing any of the correction specimens to ensure accurate asphalt content.
4. Prepare two correction specimens at the JMF design asphalt binder content. Aggregate used for correction specimens shall be sampled from material designated for use on the project. An agency approved method will be used to combine aggregate. An additional "blank" specimen shall be batched and tested for aggregate gradation in accordance with the FOP for AASHTO T 30. The gradation from the "blank" shall fall within the agency specified mix design tolerances.
5. Place the freshly mixed specimens directly into the sample basket assembly. If mixed specimens are allowed to cool before placement in the sample basket assembly, the

specimens must be dried to constant mass according to the FOP for AASHTO T 329. Do not preheat the sample basket assembly.

6. Test the specimens in accordance with Method A or Method B of the procedure.
7. Once both correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed ignition furnace tickets, if available.
8. Calculate the difference between asphalt binder contents of the two specimens:
    a. If the difference between the asphalt binder contents of the two specimens does not exceed 0.15 percent, use these two results to determine the correction factor.
    b. If the difference between the asphalt binder contents of the two specimens exceeds 0.15 percent, repeat with two more specimens and, from the four results, discard the high and low results. Determine the correction factor from the two remaining results.
9. Calculate the difference between the actual and measured asphalt binder contents to 0.01 percent. The asphalt binder correction factor, C_f, is the average of the differences expressed as a percent by mass of asphalt mixture.
10. If the asphalt binder correction factor exceeds 1.00 percent, the test temperature must be lowered to 482 ± 5°C (900 ± 9°F) and new samples must be burned. If the correction factor is the same or higher at the lower temperature, it is permissible to use the higher temperature. The temperature for determining the asphalt binder content of asphalt mixture samples by this procedure shall be the same temperature determined for the correction samples.
11. For the direct IR irradiation-type burn furnaces, the **default** burn profile should be used for most materials. The operator may select burn-profile Option 1 or Option 2 to optimize the burn cycle. The burn profile for testing asphalt mixture samples shall be the same burn profile selected for correction samples.

    Option 1 is designed for aggregate that requires a large asphalt binder correction factor (greater than 1.00 percent) – typically very soft aggregate (such as dolomite).

    Option 2 is designed for samples that may not burn completely using the **default** burn profile.
12. Perform a gradation analysis on the residual aggregate in accordance with the FOP for AASHTO T 30, if required. The results will be utilized in developing an “Aggregate Correction Factor” and should be calculated and reported to 0.1 percent.
13. From the gradation results subtract the percent passing for each sieve, for each sample, from the percent passing each sieve of the “Blank” specimen gradation results from Step 4.
14. Determine the average difference of the two values. If the difference for any single sieve exceeds the allowable difference of that sieve as listed in Table 2, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by the FOP for AASHTO T 30. If the 75 µm (No. 200) is the only sieve outside the limits in Table 2, apply the aggregate correction factor to only the 75 µm (No. 200) sieve.

Table 2
Permitted Sieving Difference

Sieve	Allowable Difference
Sizes larger than or equal to 2.36 mm (No.8)	± 5.0%
Sizes larger than to 75 µm (No.200) and smaller than 2.36 mm (No.8)	± 3.0%
Sizes 75 µm (No.200) and smaller	± 0.5%

Examples:

Sieve Size mm (in.)	Correction Factor Blank Sample % Passing	Correction Factor Sample #1 % Passing	Correction Factor Sample #2 % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
19.0 (3/4)	100	100	100	0/0	0.0	
12.5 (1/2)	86.3	87.4	86.4	-1.1/-0.1	-0.6	
9.5 (3/8)	77.4	76.5	78.8	+0.9/-1.4	-0.3	
4.75 (No. 4)	51.5	53.6	55.9	-2.1/-4.4	-3.3	
2.36 (No. 8)	34.7	36.1	37.2	-1.4/-2.5	-2.0	
01.18 (No. 16)	23.3	25.0	23.9	-1.7/-0.6	-1.2	
0.600 (No. 30)	16.4	19.2	18.1	-2.8/-1.7	-2.3	
0.300 (No. 50)	12.0	11.1	12.7	+0.9/-0.7	+0.1	
0.150 (No. 100)	8.1	9.9	6.3	-1.8/+1.8	0.0	
75 µm (No. 200)	5.5	5.9	6.2	-0.4/-0.7	-0.6	**- 0.6**

In this example, all gradation test results performed on the residual aggregate (FOP for AASHTO T 30) would have an aggregate correction factor applied to the percent passing the 75 µm (No. 200) sieve. The correction factor must be applied because the average difference on the 75 µm (No. 200) sieve is outside the tolerance from Table 2.

In the following example, aggregate correction factors would be applied to each sieve because the average difference on the 4.75 mm (No. 4) is outside the tolerance from Table 2.

Sieve Size mm (in.)	Correction Factor Blank Sample % Passing	Correction Factor Sample #1 % Passing	Correction Factor Sample #2 % Passing	Difference 1 / 2	Avg. Diff.	Sieves to adjust
19.0 (3/4)	100	100	100	0/0	0.0	0.0
12.5 (1/2)	86.3	87.4	86.4	-1.1/-0.1	-0.6	**-0.6**
9.5 (3/8)	77.4	76.5	78.8	+0.9/-1.4	-0.3	**-0.3**
4.75 (No. 4)	51.5	55.6	57.9	-4.1/-6.4	-5.3	**-5.3**
2.36 (No. 8)	34.7	36.1	37.2	-1.4/-2.5	-2.0	**-2.0**
01.18 (No. 16)	23.3	25.0	23.9	-1.7/-0.6	-1.2	**-1.2**
0.600 (No. 30)	16.4	19.2	18.1	-2.8/-1.7	-2.3	**-2.3**
0.300 (No. 50)	12.0	11.1	12.7	+0.9/-0.7	+0.1	**+0.1**
0.150 (No. 100)	8.1	9.9	6.3	-1.8/+1.8	0.0	0.0
75 µm (No. 200)	5.5	5.9	6.2	-0.4/-0.7	-0.6	**-0.6**

THEORETICAL MAXIMUM SPECIFIC GRAVITY (G_{mm}) AND DENSITY OF ASPHALT MIXTURES
FOP FOR AASHTO T 209

Scope

This procedure covers the determination of the maximum specific gravity (G_{mm}) of uncompacted asphalt mixtures in accordance with AASHTO T 209-23. Two methods using different containers – bowl and pycnometer / volumetric flask– are covered.

Specimens prepared in the laboratory shall be cured according to agency standards.

Apparatus

- Balance or scale: 10,000 g capacity, readable to 0.1 g, meeting AASHTO M 231, Class G2
- Container: A glass, metal, or plastic bowl, pycnometer or volumetric flask between 2000 and 10,000 mL as required by the minimum sample size requirements in Table 1 sample and capable of withstanding full vacuum applied
- Pycnometer / volumetric flask cover: A glass plate or a metal or plastic cover with a vented opening
- Vacuum lid: A transparent lid with a suitable vacuum connection, with a vacuum opening to be covered with a fine wire mesh
- Vacuum pump or water aspirator: Capable of evacuating air from the container to a residual pressure of 3.4 kPa (25 mm Hg)
- Vacuum measurement device: Residual pressure manometer or vacuum gauge, capable of measuring residual pressure down to 3.4 kPa (25 mmHg) or less and readable to at least 0.2 kPa (2 mmHg)
- Suspension apparatus: Suitable apparatus and holder to permit determining the mass of the sample while suspended below the balance. The wire suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length for Bowl Method.
- Water bath: A constant-temperature water bath (optional for Pycnometer or Volumetric Flask Method)
- Thermometers: Thermometric devices accurate to 0.25°C (0.5°F) and with a temperature range of at least 20 to 45°C (68 to 113°F).
- Bleeder valve to adjust vacuum
- Automatic vacuum control unit (optional)
- Timer
- Towel

Standardization

Use a container that has been standardized according to the Annex. The container shall be standardized periodically in conformance with procedures established by the agency.

Test Sample Preparation

1. Obtain samples in accordance with the FOP for AASHTO R 97 and reduce according to the FOP for AASHTO R 47.
2. Test sample size shall conform to the requirements of Table 1. Samples larger than the capacity of the container may be tested in two or more increments. Results will be combined by calculating the weighted average ($G_{mm\ (avg)}$.). If the increments have a specific gravity difference greater than 0.013, the test must be re-run.
3. Plant-produced samples may be short-term conditioned according to AASHTO R 30 as specified by the agency.

Note 1: Short-term conditioning at the specified temperature is especially important when absorptive aggregates are used. This short-term conditioning will ensure the computation of realistic values for the amount of asphalt absorbed by the aggregate and void properties of the mix. Plant-produced asphalt mixtures should be evaluated to make sure short-term conditioning has taken place during production and delivery.

Table 1

Test Sample Size for G_{mm}

Nominal Maximum* Aggregate Size mm (in.)	Minimum Mass g
37.5 or greater (1½)	4000
19 to 25 (3/4 to 1)	2500
12.5 or smaller (1/2)	1500

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained.

Procedure – General

Two procedures – bowl and pycnometer / volumetric flask – are covered. The first 11 steps are the same for both.

1. Separate the particles of the sample, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 6.3 mm (1/4 in.). If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven only until it is pliable enough for separation.
2. Cool the sample to room temperature.
3. Determine and record the mass of the dry container to the nearest 0.1 g.
4. Place the sample in the container.
5. Determine and record the mass of the dry container and sample to the nearest 0.1 g.

6. Determine and record the mass of the sample by subtracting the mass determined in Step 3 from the mass determined in Step 5. Designate this mass as “A.”
7. Add sufficient water at approximately 25° C (77° F) to cover the sample by about 25 mm (1 in.).

Note 1: The release of entrapped air may be facilitated by the addition of a wetting agent. Check with the agency to see if this is permitted and, if it is, for a recommended agent.

8. Place the lid on the container and attach the vacuum line. To ensure a proper seal between the container and the lid, wet the O-ring or use a petroleum gel.
9. Remove entrapped air by subjecting the sample to a partial vacuum of 4.0 ±0.6 kPa (30 ±5 mmHg) residual pressure for 15 ±1 minutes.
10. Agitate the container and sample, either continuously by mechanical device or manually by vigorous shaking at 2-minute intervals. This agitation facilitates the removal of air.
11. Release the vacuum. Increase the pressure to atmospheric pressure in 10 to 15 seconds if the vacuum release is not automated. Turn off the vacuum pump and remove the lid. When performing the pycnometer / volumetric flask method, complete steps 12B through 16B within 10 ±1 minute.

Procedure – Bowl

12A. Fill the water bath to overflow level with water at 25 ±1°C (77 ±2°F) and allow the water to stabilize.

13A. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.

14A. Suspend and immerse the bowl and sample in water at 25 ±1°C (77 ±2°F) for 10 ±1 minute.

15A. Determine and record the submerged weight of the bowl and sample to the nearest 0.1 g. Designate as “C.”

Procedure – Pycnometer or Volumetric Flask

12B. Immediately fill the pycnometer / volumetric flask with water without reintroducing air.

13B. Stabilize the temperature of the pycnometer / volumetric flask and sample so that the final temperature is within 25 ±1°C (77 ±2°F).

14B. Finish filling the pycnometer / volumetric flask with water that is 25 ±1°C (77 ±2°F), place the cover or a glass plate on the pycnometer / volumetric flask, and eliminate all air.

Note 2: When using a metal pycnometer and cover, place the cover on the pycnometer and push down slowly, forcing excess water out of the hole in the center of the cover. Use care when filling the pycnometer to avoid reintroducing air into the water.

15B. Towel dry the outside of the pycnometer / volumetric flask and cover.

16B. Determine and record the mass of the pycnometer / volumetric flask, cover, de-aired water, and sample to the nearest 0.1 g. within 10 ±1 minute of completion of Step 11. Designate this mass as "E."

Procedure – Mixtures Containing Uncoated Porous Aggregate

If the pores of the aggregates are not thoroughly sealed by an asphalt binder film, they may become saturated with water during the vacuuming procedure, resulting in an error in G_{mm} and theoretical maximum density. To determine if this has occurred, complete the general procedure and then:

1. Carefully drain water from sample through a towel held over the top of the container to prevent loss of material.
2. Spread sample in a flat shallow pan and place before an electric fan to remove surface moisture.
3. Determine the mass of the sample when the surface moisture appears to be gone.
4. Continue drying and determine the mass of the sample at 15-minute intervals until less than a 0.5 g loss is found between determinations.
5. Record the mass as the saturated surface dry mass to the nearest 0.1 g. Designate this mass as "A_{SSD}."
6. Calculate, as indicated below, G_{mm} using "A" and "A_{SSD}," and compare the two values.

Calculation

Calculate the G_{mm} to three decimal places as follows:

Bowl Procedure

$$G_{mm} = \frac{A}{A + B - C} \qquad or \qquad G_{mm} = \frac{A}{A_{SSD} + B - C}$$

(for mixes containing uncoated aggregate materials)

Where:

A = mass of dry sample in air, g

A_{SSD} = mass of saturated surface dry sample in air, g

B = standardized submerged weight of the bowl, g (see Annex)

C = submerged weight of sample and bowl, g

Example:

$$G_{mm} = \frac{1432.7\ g}{1432.7\ g + 286.3\ g - 1134.9\ g} = 2.453 \quad or$$

$$G_{mm} = \frac{1432.7\ g}{1434.2\ g + 286.3\ g - 1134.9\ g} = 2.447$$

Given:

A = 1432.7 g

A_{SSD} = 1434.2 g

B = 286.3 g

C = 1134.9 g

Pycnometer / Volumetric Flask Procedure

$$G_{mm} = \frac{A}{A + D - E} \qquad or \qquad G_{mm} = \frac{A}{A_{SSD} + D - E}$$

(for mixtures containing uncoated materials)

Where:

A = mass of dry sample in air, g

A_{SSD} = mass of saturated surface-dry sample in air, g

D = standardized mass of pycnometer / volumetric flask filled with water at 25°C (77°F), g, (See Annex)

E = mass of pycnometer / volumetric flask filled with water and the test sample at test temperature, g

Example (two increments of a large sample):

$$G_{mm_1} = \frac{2200.3\ g}{2200.3\ g + 7502.5\ g - 8812.0\ g} = 2.470$$

$$G_{mm_2} = \frac{1960.2\ g}{1960.2\ g + 7525.5\ g - 8690.8\ g} = 2.466$$

Given:

Increment 1	Increment 2
A_1 = 2200.3 g	A_2 = 1960.2 g
D_1 = 7502.5 g	D_2 = 7525.5 g
E_1 = 8812.0 g	E_2 = 8690.8 g

Variation = 2.470 - 2.466 = 0.004, which is < 0.013

Allowable variation is: 0.013. The values may be used.

Weighted average

For large samples tested a portion at a time, calculate the $G_{mm\ (avg)}$ by multiplying the dry mass of each increment by its G_{mm}, add the results together (Σ) and divide by the sum (Σ) of the dry masses.

$$G_{mm(avg)} = \frac{\sum\left(A_x \times G_{mm_x}\right)}{\sum A_x}$$

or

$$G_{mm(avg)} = \frac{\left(A_1 \times G_{mm_1}\right) + \left(A_2 \times G_{mm_2}\right)}{A_1 + A_2}\ etc.$$

Where:

A_x = mass of dry sample increment in air, g

G_{mmx} = theoretical maximum specific gravity of the increment

Example:

$$G_{mm(avg)} = \frac{(2200.3\ g \times 2.470) + (1960.2\ g \times 2.466)}{2200.3\ g + 1960.2\ g} = \frac{10{,}268.6}{4160.5\ g} = 2.468$$

Theoretical Maximum Density

To calculate the theoretical maximum density at 25°C (77°F) use one of the following formulas. The density of water at 25°C (77°F) is 997.1 kg/ m^3 in Metric units or 62.245 lb/ft^3 in English units.

Theoretical maximum density kg/m^3 = G_{mm} × 997.1 kg/ m^3

2.468 × 997.1 kg/ m^3 = 2461 kg/ m^3

or

Theoretical maximum density lb/ft^3 = G_{mm} × 62.245 lb/ft^3

2.468 × 62.245 lb/ft^3 = 153.6 lb/ft^3

Report

- On forms approved by the agency
- Sample ID
- G_{mm} to the nearest 0.001
- Theoretical maximum density to the nearest 1 kg/m^3 (0.1 lb/ft^3)

ANNEX – STANDARDIZATION OF BOWL AND PYCNOMETER OR VOLUMETRIC FLASK

(Mandatory Information)

Bowl – Standardization

1. Fill the water bath to overflow level with 25 ±1°C (77 ±2°F) water and allow the water to stabilize.
2. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
3. Suspend and completely immerse the bowl for 10 ±1 minute.
4. Determine and record the submerged weight of the bowl to the nearest 0.1 g.
5. Refill the water bath to overflow level.
6. Perform Steps 2 through 5 two more times for a total of three determinations.
7. If the range of the three determinations is less than or equal to 0.3 g., average the determinations. Designate as “B.”
8. If the range of the three determinations is greater than 0.3 g., take corrective action and perform the standardization procedure again.

Bowl – Check

1. Fill the water bath to overflow level 25 ±1°C (77 ±2°F) water and allow the water to stabilize.
2. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath. Immerse the suspension apparatus sufficiently to cover both it and the bowl.
3. Suspend and completely immerse the bowl for 10 ±1 minute.
4. Determine and record the submerged weight of the bowl to the nearest 0.1 g.
5. If this determination is within 0.3 g of the standardized value, use the standardized value for “B.”
6. If it is not within 0.3 g, take corrective action and perform the standardization procedure again.
7. For labs that check the bowl standardization frequently (such as daily), calculate the moving average and range of the last three mass determinations. Designate the average of the last three masses as “B.”
8. If the moving range exceeds 0.3 g at any time, take corrective action and perform the standardization procedure again.

Pycnometer or Volumetric Flask – Standardization

1. Fill the pycnometer / volumetric flask with water at approximately 25°C (77°F).
2. Place the metal or plastic cover, or a glass plate on the pycnometer / volumetric flask and eliminate all air. (See Note 2.)
3. Stabilize the pycnometer / volumetric flask at 25 ± 1ºC (77 ± 2ºF) for 10 ± 1 min.
4. Towel dry the outside of the pycnometer / volumetric flask and cover.
5. Determine and record the mass of the pycnometer / volumetric flask, water, and cover or plate to the nearest 0.1 g.
6. Perform Steps 2 through 5 two more times for a total of three determinations.
7. If the range of the three determinations is less than or equal to 0.3 g, average the three determinations. Designate as "D."
8. If the range of the determinations is greater than 0.3 g., take corrective action and perform the "Pycnometer or Volumetric Flask – Standardization" again.

Pycnometer or Volumetric Flask – Check

1. Fill the pycnometer / volumetric flask with water at approximately 25°C (77°F).
2. Place the metal or plastic cover or a glass plate on the pycnometer / volumetric flask and eliminate all air. (See Note 2.)
3. Stabilize the pycnometer / volumetric flask at 25 ± 1ºC (77 ± 2ºF) for 10 ± 1 min.
4. Towel dry the outside of the pycnometer / volumetric flask and cover.
5. Determine and record the mass of the pycnometer / volumetric flask, water, and cover or plate.
6. If this determination is within 0.3 g of the standardized value, use the standardized value for "D."
7. If it is not within 0.3 g, perform the standardization procedure again.

BULK SPECIFIC GRAVITY (G_{mb}) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS
FOP FOR AASHTO T 166

Scope

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted asphalt mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-22. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both, AASHTO T 275 or AASHTO T 331 should be performed.

Overview

- Method A: Suspension
- Method B: Volumeter
- Method C: Rapid test for A or B

Test Specimens

Test specimens may be either laboratory-molded or sampled from asphalt mixture pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one- and one-half times the maximum size.

Terminology

Constant Mass: The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus – Method A (Suspension)

- Balance or scale: 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale and equipped with an overflow outlet for maintaining a constant water level.
- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of 52 ± 3°C (126 ±5°F) for drying the specimens to a constant mass.

- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 15 to 45°C (59 to 113°F) and, graduated in 0.1°C (0.2°F) subdivisions.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

Procedure – Method A (Suspension)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
    a. Oven method
        i. Initially dry overnight at 52 ±3°C (125 ±5°F).
        ii. Determine and record the mass of the specimen. Designate this mass as M_p.
        iii. Return the specimen to the oven for at least 2 hours.
        iv. Determine and record the mass of the specimen. Designate this mass as M_n.
        v. Determine percent change by subtracting the new mass determination, M_n, from the previous mass determination, M_p, dividing by the previous mass determination M_p, and multiplying by 100.
        vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
        vii. Constant mass has been achieved; sample is defined as dry.

    Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

    b. Vacuum dry method according to the FOP for AASHTO R 79.
2. Cool the specimen in air to 25 ±5°C (77 ±9°F), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Fill the water bath to the overflow level with water at 25 ±1°C (77 ±2°F) and allow the water to stabilize.
4. Zero or tare the balance with the suspension apparatus attached, ensuring that the suspension apparatus is completely submerged and not touching the sides or the bottom of the water bath.
5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for 4 ±1 minutes.
6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as C.
7. Remove the sample from the water and quickly surface dry with a damp cloth towel within 5 sec.

8. Zero or tare the balance.
9. Immediately determine and record the mass of the saturated surface-dry (SSD) specimen to nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen. Do not exceed 15 sec. performing Steps 7 through 9.

Calculations – Method A (Suspension)

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B - C}$$

$$Percent\ Water\ Absorbed\ (by\ volume) = \frac{B - A}{B - C} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water at 25 ±1°C (77 ±2°F), g

Example:

$$G_{mb} = \frac{4833.6\ g}{4842.4\ g - 2881.3\ g} = 2.465$$

$$\%\ Water\ Absorbed\ (by\ volume) = \frac{4842.4\ g - 4833.6\ g}{4842.4\ g - 2881.3\ g} \times 100 = 0.45\%$$

Given:

A = 4833.6 g
B = 4842.4 g
C = 2881.3 g

Apparatus – Method B (Volumeter)

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: For immersing the specimen in water, capable of maintaining a uniform temperature at 25 ± 1°C (77 ± 2°F).
- Thermometer: Range of 15 to 45°C (59 to 113°F) and graduated in 0.1°C (0.2°F) subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of 52 ± 3°C (126 ± 5°F). for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

Procedure – Method B (Volumeter)

Method B is not acceptable for use with specimens that have more than 6 percent air voids.

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
   a. Oven method:
      i. Initially dry overnight at 52 ±3°C (125 ±5°F).
      ii. Determine and record the mass of the specimen. Designate this mass as M_p.
      iii. Return the specimen to the oven for at least 2 hours.
      iv. Determine and record the mass of the specimen. Designate this mass as M_n.
      v. Determine percent change by subtracting the new mass determination, M_n, from the previous mass determination, M_p, dividing by the previous mass determination, M_p, and multiplying by 100.
      vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
      vii. Constant mass has been achieved; sample is defined as dry.

   Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

   b. Vacuum dry method according to the FOP for AASHTO R 79.
2. Cool the specimen in air to 25 ±5°C (77 ±9°F), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Immerse the specimen in the temperature-controlled water bath at 25 ±1°C (77 ±2°F) for at least 10 minutes.
4. At the end of the ten-minute period, fill the volumeter with distilled water at 25 ±1°C (77 ±2°F) making sure some water escapes through the capillary bore of the tapered lid.
5. Wipe the volumeter dry. Determine the mass of the volumeter and water to the nearest 0.1 g. Designate this mass as D.
6. Remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 sec.
7. Immediately determine and record the mass of the SSD specimen to the nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.
8. Place the specimen in the volumeter and let stand 60 sec.
9. Bring the temperature of the water to 25 ±1°C (77 ±2°F) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.
10. Wipe the volumeter dry.

11. Determine and record the mass of the volumeter, water, and specimen to the nearest 0.1 g. Designate this mass as E.

Calculations – Method B (Volumeter)

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B + D - E}$$

$$Percent\ Water\ Absorbed\ (by\ volume) = \frac{B - A}{B + D - E} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at 25 ±1°C (77 ±2°F), g

E = Mass of volumeter filled with specimen and water, g

Example:

$$G_{mb} = \frac{4833.6\ g}{4842.4\ g + 2924.4\ g - 5806.0\ g} = 2.465$$

$$\%\ Water\ Absorbed\ (by\ volume) = \frac{4842.4\ g - 4833.6\ g}{4842.4\ g + 2924.4\ g - 5806.0\ g} \times 100 = 0.45\%$$

Given:

A = 4833.6 g
B = 4842.4 g
D = 2924.4 g
E = 5806.0 g

Apparatus – Method C (Rapid Test for Method A or B)

- Oven: Capable of maintaining a temperature of 110 ±5°C (230 ±9°F) for drying the specimens to a constant mass.

See Methods A or B.

> ***Note 2:*** This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure – Method C (Rapid Test for Method A or B)

1. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, A, as follows.
2. Determine and record mass of a large, flat-bottom container.
3. Place the specimen in the container.
4. Place in an oven at 110 ± 5 C (230 ± 9 F).
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm (¼ in.).
6. Determine and record the mass of the specimen. Designate this mass as M_p.
7. Return the specimen to the oven for at least 2 hours.
8. Determine and record the mass of the specimen. Designate this mass as M_n.

9. Determine percent change by subtracting the new mass determination, M_n, from the previous mass determination, M_p, dividing by the previous mass determination, M_p, and multiplying by 100.
10. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
11. Constant mass has been achieved; sample is defined as dry.
12. Cool in air to 25 ±5°C (77 ±9°F).
13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.
14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. Designate this mass as A.

Calculations – Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

Report

- On forms approved by the agency
- Sample ID
- G_{mb} to the nearest 0.001
- Absorption to the nearest 0.01 percent
- Method performed.

SAMPLING ASPHALT MATERIALS
FOP FOR AASHTO R 66

Scope

This procedure covers obtaining samples of liquid asphalt materials in accordance with AASHTO R 66-16. Sampling of solid and semi-solid asphalt materials – included in AASHTO R 66 – is not covered here.

Agencies may be more specific on exactly who samples, where to sample, and what type of sampling device to use.

Warning: Always use appropriate safety equipment and precautions for hot liquids.

Terminology

- Asphalt binder: Asphalt cement or modified asphalt cement that binds the aggregate particles into a dense mass.
- Asphalt emulsion: A mixture of asphalt binder and water.
- Cutback asphalt: Asphalt binder that has been modified by blending with a chemical solvent.

Containers

Sample containers must be new, and the inside may not be washed or rinsed. The outside may be wiped with a clean, dry cloth.

All samples shall be put in 1 L (1 qt) containers and properly identified on the outside of the container with contract number, date sampled, data sheet number, brand and grade of material, and sample number. Include lot and sublot numbers when appropriate.

- Emulsified asphalt: Use wide-mouth plastic jars with screw caps. Protect the samples from freezing since water is a part of the emulsion. The sample container should be completely filled to minimize a skin formation on the sample.
- Asphalt binder and cutbacks: Use metal cans

Note: The sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. If cleaning is necessary, use a clean dry cloth.

Procedure

1. Coordinate sampling with contractor or supplier.
2. Allow a minimum of 4 L (1 gal) to flow before obtaining samples.
3. Obtain samples of:
    - Asphalt binder from the line between the storage tank and the mixing plant while the plant is in operation, or from the delivery truck.
    - Cutback and emulsified asphalt from distributor spray bar or application device; or from the delivery truck before it is pumped into the distributor. Sample emulsified asphalt at delivery or before dilution.

Report

- On standard agency forms
- Sample ID
- Date
- Time
- Location
- Quantity represented

MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE FOP FOR AASHTO T 30

Scope

This procedure covers mechanical analysis of aggregate recovered from asphalt mix samples in accordance with AASHTO T 30-21. This FOP uses the aggregate recovered from the ignition furnace used in AASHTO T 308. AASHTO T 30 was developed for analysis of extracted aggregate and thus includes references to extracted bitumen and filter element, which do not apply in this FOP.

Sieve analyses determine the gradation or distribution of aggregate particles within a given sample to determine compliance with design and production standards.

Apparatus

- Balance or scale: Capacity sufficient for the sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g and conforming to AASHTO M 231.
- Sieves, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical sieve shaker, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical Washing Apparatus (optional).
- Suitable drying equipment, meeting the requirements of the FOP for AASHTO T 255.
- Containers and utensils: A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water.
- Wetting Agent: Any dispersing agent, such as dishwashing detergent, that will promote separation of the fine materials.

Sample Sieving

- In this procedure, it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the test sample, or a portion of the test sample, is placed on the top sieve.
- The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A; *Time Evaluation*.

Mass Verification

The aggregate sample mass, $M_{(T30)}$, determined in this method, shall agree with the mass of the aggregate remaining after ignition, M_f from the FOP for AASTHO T 308, within 0.1 percent. If the variation exceeds 0.1 percent, the results cannot be used for acceptance.

Procedure

1. Determine and record the mass of the sample that was removed from the basket in the FOP for AASHTO T 308 to 0.1 g. Designate this mass as $M_{(T30)}$.
2. Verify the mass of the sample is within 0.1 percent by subtracting $M_{(T30)}$ from $M_{f(T308)}$ dividing by $M_{f(T308)}$ and multiplying by 100 (see *Mass Verification Calculation* and example).

   If the variation exceeds 0.1 percent, the sieve analysis results cannot be used for acceptance.
3. Nest a sieve, such as a 2.0 mm (No. 10) or 1.18 mm (No. 16), above the 75µm (No. 200) sieve.
4. Place the test sample in a container and cover with water. Add a wetting agent to the water to assure a thorough separation of the material finer than the 75µm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.
5. Agitate vigorously to ensure complete separation of the material finer than 75µm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device. Maximum agitation is 10 min.

Note 1: When mechanical washing equipment is used, the introduction of water, agitating, and decanting may be a continuous operation. Use care not to overflow or overload the 75µm (No. 200) sieve.

6. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 µm (No. 200) sieve.
7. Add water to cover material remaining in the container, agitate, and repeat Step 6. Continue until the wash water is reasonably clear.
8. Remove the upper sieve, return material retained to the washed sample.
9. Rinse the material retained on the 75 µm (No. 200) sieve until water passing through the sieve is reasonably clear and wetting agent is removed.
10. Return all material retained on the 75 µm (No. 200) sieve to the washed sample by rinsing into the washed sample.
11. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the "dry mass after washing."
12. Select sieves required by the specification and those necessary to avoid overloading. (See Annex B.) With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200).
13. Place the test sample, or a portion of the test sample, on the top sieve.
14. Place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 2: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

15. Determine and record the individual or cumulative mass retained for each sieve including the pan. Ensure that all material trapped in full openings of the sieves are removed and included in the mass retained.

Note 3: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

16. Perform the *Check Sum* calculation – Verify the *total mass after sieving* of material compared to the *dry mass after washing* is not more than 0.2 percent. Do not use test results for acceptance if the *Check Sum* result is more than 0.2 percent.
17. Calculate the total percentages passing, and the individual or cumulative percentages retained, to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the total mass of the initial dry sample.
18. Apply the Aggregate Correction Factor (ACF) to the calculated percent passing, as required in the FOP for AASHTO T 308 "Correction Factor," to obtain the reported percent passing.
19. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Calculations

Mass verification

$$Mass\ verification = \frac{\mathrm{M}_{\mathrm{f\,(T308)}} - \mathrm{M}_{\mathrm{(T30)}}}{\mathrm{M}_{\mathrm{f\,(T308)}}} \times 100$$

Where:

$\mathrm{M}_{\mathrm{f(T308)}}$ = Mass of aggregate remaining in the basket assembly after ignition from the FOP for AASHTO T 308

$\mathrm{M}_{\mathrm{(T30)}}$ = Mass of aggregate sample obtained from the FOP for AASHTO T 308

Check Sum

$$check\ sum = \frac{dry\ mass\ after\ washing - total\ mass\ after\ sieving}{dry\ mass\ after\ washing} \times 100$$

Percent Retained

Individual

$$\text{IPR} = \frac{IMR}{M_{T30}} \times 100$$

Cumulative

$$\text{CPR} = \frac{CMR}{M_{T30}} \times 100$$

Where:

IPR = Individual Percent Retained
CPR = Cumulative Percent Retained
M_{T30} = Total dry sample mass before washing
IMR = Individual Mass Retained
CMR = Cumulative Mass Retained

Percent Passing

Individual

$$PP = PCP - IPR$$

Cumulative

$$PP = 100 - CPR$$

Where:

PP = Calculated Percent Passing
PCP = Previous Calculated Percent Passing

Reported Percent Passing

$$RPP = PP + ACF$$

Where:

RPP = Reported Percent Passing

ACF = Aggregate Correction Factor (if applicable)

Example

Mass verification

$$Mass\ verification = \frac{2422.5\ g\ -\ 2422.3\ g}{2422.5\ g} \times\ 100\ = 0.01\%$$

Given:

$M_{f(T308)}$ = 2422.5 g

$M_{(T30)}$ = 2422.3 g

Dry mass of total sample, before washing (M_{T30}):	2422.3 g
Dry mass of sample, after washing out the 75 µm (No. 200) minus:	2296.2 g
Amount of 75 µm (No. 200) minus washed out (2422.3 g – 2296.2g):	126.1 g

Check sum

$$check\ sum = \frac{2296.2\ g - 2295.3\ g}{2296.2\ g} \times 100 = 0.0\%$$

This is not more than 0.2 percent therefore the results can be used for acceptance purposes.

Percent Retained for the 75 µm (No. 200) sieve

$$IPR = \frac{63.5\ g}{2422.3\ g} \times 100 = 2.6\%$$

$$or$$

$$CPR = \frac{2289.6\ g}{2422.3\ g} \times 100 = 94.5\%$$

Percent Passing using IPR and PCP for the 75 µm (No. 200) sieve

$$PP = 8.1\% - 2.6\% = 5.5\%$$

Percent Passing using CPR for the 75 µm (No. 200) sieve

$$PP = 100.0\% - 94.5\% = 5.5\%$$

Reported Percent Passing

$$RPP = 5.5\% \ + (-0.6\%) = 4.9\%$$

Individual
Gradation on All Sieves

Sieve Size mm (in.)	Individual Mass Retained g (IMR)	Determine IPR by dividing IMR by *M* and multiplying by 100	Individual Percent Retained (IPR)	Determine PP by subtracting IPR from Previous PP	Percent Passing (PP)	Agg. Corr. Factor from T 308 (ACF)	Reported Percent Passing*
19.0 (3/4)	0		0		100.0		100
12.5 (1/2)	346.9	$\frac{346.9}{2422.3} \times 100 =$	14.3	100.0 – 14.3 =	85.7		86
9.5 (3/8)	207.8	$\frac{207.8}{2422.3} \times 100 =$	8.6	85.7 – 8.6 =	77.1		77
4.75 (No. 4)	625.4	$\frac{625.4}{2422.3} \times 100 =$	25.8	77.1 – 25.8 =	51.3		51
2.36 (No. 8)	416.2	$\frac{416.2}{2422.3} \times 100 =$	17.2	51.3 – 17.2 =	34.1		34
1.18 (No. 16)	274.2	$\frac{274.2}{2422.3} \times 100 =$	11.3	34.1 – 11.3 =	22.8		23
0.600 (No. 30)	152.1	$\frac{152.1}{2422.3} \times 100 =$	6.3	22.8 – 6.3 =	16.5		17
0.300 (No. 50)	107.1	$\frac{107.1}{2422.3} \times 100 =$	4.4	16.5 – 4.4 =	12.1		12
0.150 (No. 100)	96.4	$\frac{96.4}{2422.3} \times 100 =$	4.0	12.1 – 4.0 =	8.1		8
0.075 (No. 200)	63.5	$\frac{63.5}{2422.3} \times 100 =$	2.6	8.1 – 2.6 =	5.5	-0.6 (5.5 – 0.6 =)	4.9
minus 75 µm (No. 200) in the pan	5.7						
Total mass after sieving = sum of sieves + mass in the pan = 2295.3 g							
Dry mass of total sample, before washing (M_{T30}): 2422.3g							

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Cumulative
Gradation on All Sieves

Sieve Size mm (in.)	Cumulative Mass Retained g (CMR)	Determine CPR by dividing CMR by M and multiplying by 100	Cumulative Percent Retained (CPR)	Determine PP by subtracting CPR from 100.0	Percent Passing (PP)	Agg. Corr. Factor from T 308 (ACF)	Reported Percent Passing*
19.0 (3/4)	0		0.0		100.0		100
12.5 (1/2)	346.9	$\frac{346.9}{2422.3} \times 100 =$	14.3	$100.0 - 14.3 =$	85.7		86
9.5 (3/8)	554.7	$\frac{554.7}{2422.3} \times 100 =$	22.9	$100.0 - 22.9 =$	77.1		77
4.75 (No. 4)	1180.1	$\frac{1180.1}{2422.3} \times 100 =$	48.7	$100.0 - 48.7 =$	51.3		51
2.36 (No. 8)	1596.3	$\frac{1596.3}{2422.3} \times 100 =$	65.9	$100.0 - 65.9 =$	34.1		34
1.18 (No. 16)	1870.5	$\frac{1870.5}{2422.3} \times 100 =$	77.2	$100.0 - 77.2 =$	22.8		23
0.600 (No. 30)	2022.6	$\frac{2022.6}{2422.3} \times 100 =$	83.5	$100.0 - 83.5 =$	16.5		17
0.300 (No. 50)	2129.7	$\frac{2129.7}{2422.3} \times 100 =$	87.9	$100.0 - 87.9 =$	12.1		12
0.150 (No. 100)	2226.1	$\frac{2226.1}{2422.3} \times 100 =$	91.9	$100.0 - 91.9 =$	8.1		8
0.075 (No. 200)	2289.6	$\frac{2289.6}{2422.3} \times 100 =$	94.5	$100.0 - 94.5 =$	5.5	-0.6 $(5.5 - 0.6 =)$	4.9
minus 75 µm (No. 200) in the pan	2295.3						
Total mass after sieving = 2295.3 g							
Dry mass of total sample, before washing (M_{T30}): 2422.3g							

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Report

- On forms approved by the agency
- Sample ID
- Depending on the agency, this may include:
  - Individual mass retained on each sieve
  - Individual percent retained on each sieve
  - Cumulative mass retained on each sieve
  - Cumulative percent retained on each sieve
  - Aggregate Correction Factor for each sieve from AASHTO T 308
  - Calculated percent passing each sieve to 0.1 percent
- Percent passing to the nearest 1 percent, except 75 µm (No. 200) sieve to the nearest 0.1 percent.

ANNEX A TIME EVALUATION

(Mandatory Information)

The minimum time requirement should be evaluated for each shaker at least annually by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.
2. Provide a snug-fitting pan and cover for each sieve and hold in a slightly inclined position in one hand.
3. Hand-shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.

ANNEX B OVERLOAD DETERMINATION

(Mandatory Information)

- For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m^2 (4 g/in^2) of sieving surface.
- For sieves with openings 4.75 mm (No. 4) and larger, the mass (in kg) shall not exceed the product of 2.5 x (sieve opening in mm) x (effective sieving area). See Table B1.

Additional sieves may be necessary to keep from overloading the specified sieves. The sample may also be sieved in increments or sieves with a larger surface area.

TABLE B1
Maximum Allowable Mass of Material Retained on a Sieve, g
Nominal Sieve Size, mm (in.)
Exact size is smaller (see AASHTO T 27)

Sieve Size mm (in.)		**203 mm (8 in.) dia.**	**254 mm (10 in.) dia.**	**305 mm (12 in.) dia.**
		Sieving Area m^2 (in^2)		
		0.0285 (44.2)	**0.0457 (70.8)**	**0.0670 (103.5)**
50	(2)	3600	5700	8400
37.5	(1 1/2)	2700	4300	6300
25.0	(1)	1800	2900	4200
19.0	(3/4)	1400	2200	3200
16.0	(5/8)	1100	1800	2700
12.5	(1/2)	890	1400	2100
9.5	(3/8)	670	1100	1600
6.3	(1/4)	440	720	1100
4.75	(No. 4)	330	540	800
-4.75	(-No. 4)	200	320	470

TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING FOP FOR AASHTO T 255

Scope

This procedure covers the determination of moisture content of aggregate in accordance with AASHTO T 255-22. It may also be used for other construction materials.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

Constant mass – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: Capacity sufficient for the principal sample mass, accurate to 0.1 percent of sample mass or readable to 0.1 g, meeting the requirements of AASHTO M 231.
- Containers: clean, dry, and capable of being sealed
- Suitable drying containers
- Microwave safe container with ventilated lids
- Heat source: thermostatically controlled, capable of maintaining 110 ± 5°C (230 ± 9°F).
  - Forced draft oven (preferred)
  - Ventilated oven
  - Convection oven
- Heat source, uncontrolled, for use when allowed by the agency, will not alter the material being dried, and close control of the temperature is not required.
  - Infrared heater, hot plate, fry pan, or any other device/method allowed by the agency
  - Microwave oven (900 watts minimum)
- Hot pads or gloves
- Utensils such as spoons

Sample Preparation

Obtain a representative sample according to the FOP for AASHTO R 90 in its existing condition. If necessary, reduce to moisture content sample size according to the FOP for AASHTO R 76.

The moisture content sample size is based on Table 1 or other information that may be specified by the agency.

TABLE 1
Sample Sizes for Moisture Content of Aggregate

Nominal Maximum Size* mm (in.)	Minimum Sample Mass g (lb)
150 (6)	50,000 (110)
100 (4)	25,000 (55)
90 (3 1/2)	16,000 (35)
75 (3)	13,000 (29)
63 (2 1/2)	10,000 (22)
50 (2)	8000 (18)
37.5 (1 1/2)	6000 (13)
25.0 (1)	4000 (9)
19.0 (3/4)	3000 (7)
12.5 (1/2)	2000 (4)
9.5 (3/8)	1500 (3.3)
4.75 (No. 4)	500 (1.1)

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Immediately seal or cover moisture content samples to prevent any change in moisture content or follow the steps in “Procedure.”

Procedure

Determine all sample masses to the nearest 0.1 percent of the sample mass or to the nearest 0.1 g.

When determining the mass of hot samples or containers or both, place and tare a buffer between the sample container and the balance. This will eliminate damage to or interference with the operation of the balance or scale.

1. Determine and record the mass of the container (and lid for microwave drying).
2. Place the wet sample in the container.
3. Determine and record the total mass of the container and wet sample.

   a. For oven(s), hot plates, infrared heaters, etc.: Spread the sample in the container.
   b. For microwave oven: Heap sample in the container; cover with ventilated lid.
4. Determine and record the wet mass of the sample (M_W) by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 3.
5. Place the sample in one of the following drying apparatuses:
   a. Controlled heat source (oven): at 110 ±5°C (230 ±9°F).
   b. Uncontrolled heat source (Hot plate, infrared heater, or other heat sources as allowed by the agency): Stir frequently to avoid localized overheating.
6. Dry until sample appears moisture free.
7. Determine mass of sample and container.
8. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 7.
9. Return sample and container to the heat source for the additional time interval.
   a. Controlled (oven): 30 minutes
   b. Uncontrolled (Hot plate, infrared heater, or other heat sources as allowed by the agency): 10 minutes
   c. Uncontrolled (Microwave oven): 2 minutes

Caution: Some minerals in the sample may cause the aggregate to overheat, crack and explode, altering the aggregate gradation.

10. Determine mass of sample and container.
11. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 10.
12. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p), dividing by the previous mass determination (M_p), and multiplying by 100.
13. Continue drying, performing Steps 9 through 12, until there is less than a 0.10 percent change after additional drying time.
14. Constant mass has been achieved; sample is defined as dry.
15. Allow the sample to cool. Determine and record the total mass of the container and dry sample.
16. Determine and record the dry mass of the sample (M_D) by subtracting the mass of the container determined in Step 1 from the mass of the container and sample determined in Step 15.
17. Determine and record percent moisture (w) by subtracting the final dry mass determination (M_D) from the initial wet mass determination (M_W), dividing by the final dry mass determination (M_D), and multiplying` by 100.

TABLE 2
Methods of Drying

Heat Source	Specific Instructions	Drying intervals to achieve constant mass (minutes)
Controlled: Forced Draft Oven (preferred), Ventilated Oven, or Convection Oven	110 ±5°C (230 ±9°F)	30
Uncontrolled:		
Hot plate, Infrared heater, or any other device/method allowed by the agency	Stir frequently	10
Microwave	Heap sample and cover with ventilated lid	2

Calculation

Constant Mass:

Calculate constant mass using the following formula:

$$\%\,Change = \frac{M_p - M_n}{M_p} \times 100$$

where:

M_p = previous mass measurement

M_n = new mass measurement

Example:

Mass of container:	1232.1 g
Mass of container after first drying cycle:	2637.2 g
Mass, M_p, of possibly dry sample:	2637.2 g - 1232.1 g = 1405.1 g
Mass of container and sample after second drying cycle:	2634.1 g
Mass, M_n, of sample:	2634.1 g - 1232.1 g = 1402.0 g

$$\%\,Change = \frac{1405.1\text{ g} - 1402.0\text{ g}}{1405.1\text{ g}} \times 100 = 0.22\%$$

0.22 percent is not less than 0.10 percent, so continue drying

Mass of container and sample after third drying cycle:	2633.0 g
Mass, M_n, of sample:	2633.0 g - 1232.1 g = 1400.9 g

$$\%\,Change = \frac{1402.0\text{ g} - 1400.9\text{ g}}{1402.0\text{ g}} \times 100 = 0.08\%$$

0.08 percent is less than 0.10 percent, so constant mass has been reached.

Moisture Content:

Calculate the moisture content, w, as a percent, using the following formula:

$$w = \frac{M_W - M_D}{M_D} \times 100$$

where:

w = moisture content, percent
M_W = wet mass
M_D = dry mass

Example:

Mass of container:	1232.1 g
Mass of container and wet sample:	2764.7 g
Mass, M_W, of wet sample:	2764.7 g - 1232.1 g = 1532.6 g
Mass of container and dry sample (COOLED):	2633.5 g
Mass, M_D, of dry sample:	2633.5 g - 1232.1 g = 1401.4 g

$$w = \frac{1532.6\text{ g} - 1401.4\text{ g}}{1401.4\text{ g}} \times 100 = \frac{131.7\text{ g}}{1401.4\text{ g}} = 9.40\%\text{ report } 9.4\%$$

Report

- On forms approved by the agency
- Sample ID
- M_W, wet mass
- M_D, dry mass
- Moisture content to the nearest 0.1 percent