Tech Brief

U.S. Department of Transportation
Federal Highway Administration

SUMMARY AND DISCLAIMERS

The purpose of this Tech Brief is to present an overview of sampling procedures for asphalt mixtures. The document is intended for highway agency and contractor engineers.

Except for the statutes and regulations cited, the contents of this document do not have the force and effect of law and are not meant to bind the States or the public in any way. This document is intended only to provide information regarding existing requirements under the law or agency policies.

American Concrete Institute (ACI) publications, ASTM International, and American Association of State Highway and Transportation Officials (AASHTO) standards are voluntary standards that are not required under Federal law. These standards, however, are commonly cited in Federal and State construction contracts and may be enforceable when included as part of the contract.

QUALITY ASSURANCE

ASPHALT MIXTURE SAMPLING

INTRODUCTION

State departments of transportation (State DOTs) invest heavily in highway infrastructure, including millions of lane miles of pavements. Asphalt pavements are expected to provide durable, smooth, and safe service over their design life. Agencies ensure they are spending funds responsibly by using specifications that cover construction practices and by generating acceptance procedures for the production of materials and construction of pavements.

Source: FHWA
Figure 1. Photo. Potential asphalt sampling locations.

Specifications should include materials sampling plans to identify:

- Quality characteristic(s) to be measured
- Frequency and location of sampling

Other aspects to be considered are:

- How a sample will be taken
- Size of the sample
- Handling and storage of the sample for testing

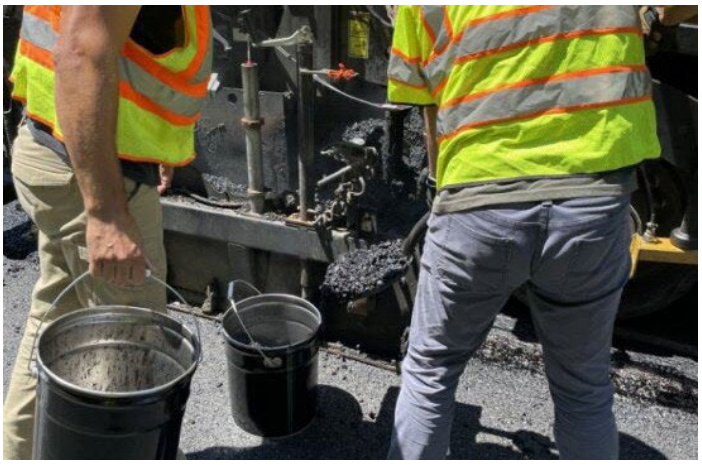
The specifications should identify the roles and responsibilities of State DOTs and contractors. The objective of this technical brief is to describe relevant procedures and standards used to support the sampling of asphalt pavement materials (Figure 1).

Source: FHWA
Figure 2. Photo of sampling location prior to the paver.

AGENCY ACCEPTANCE

Agency acceptance includes sampling, testing and inspection to determine the degree of compliance with the contract documents. Random sampling procedures are effective practices used so that the sample is representative of the overall quality of the material being evaluated in the acceptance decision. In addition to the use of random sampling procedures to support acceptance, sample security practices are essential to ensuring that fraud, abuse, and negligence in obtaining and handling samples does not jeopardize the integrity of the test results. Accepting substandard material can reduce service life, ultimately decreasing the overall pavement lifecycle.

To best represent the final in-place material, many agencies perform acceptance sampling after discharge from the hauling vehicle at an end-product location such as prior to the paver (e.g., out of the windrow) (Figure 2), at the paver (Figure 3), or behind the paver (Figure 4). While sampling at the plant or at the point of placement presents unique safety considerations both can be done safely with the proper training and precautions.



Source: FHWA
Figure 3. Photo of sampling location at the paver.

Source: FHWA
Figure 4. Photo of sampling location behind the paver.

CONTRACTOR RESPONSIBILITIES

Contractor responsibilities typically include those associated with producing and placing material to meet specifications, as well as the payment risks associated with sampling. The material producer usually prefers sampling as close as possible to the plant as they are in more control of the mixture and can use the information to inform plant production adjustments directly. However, that mixture may not represent the final product in the pavement due to placement practices.

With the transfer of control from the production facility to the transportation and laydown, additional samples are taken closer to, or at, the job site. At the job site, issues can arise due to material quality, construction practices, or sampling practices. For example, placement segregation can occur. Inconsistent delivery of material to the paving operation or inclement weather can interrupt or stop the paving operation, leading to pavement quality and ride concerns. Defects can be avoided by employing proper repair practices after samples are removed. Proper repair practices are covered in the sampling standards discussed below.
Repaired locations must maintain a homogeneous surface that does not allow for weather intrusion. Sampling the mixture provides evidence that the contractor is giving the owner an acceptable product that will produce the expected product service life. The results of those tests indicate the difference between full payment, incentive payment, and disincentive payment per the specifications. Proper quality control (QC) and process control sampling and testing can aid in reducing the risk of contractors by helping them ensure that they are consistently producing material that meets specification requirements.

STANDARDS AND SPECIFICATIONS

Agencies use materials specifications that are either internal to the agency or from another organization. These organizations could include the American Association of State Highway and Transportation Officials (AASHTO), ASTM International, or another entity. These are voluntary standards that are not required under Federal Law. These standards are, however, commonly cited in Federal and State construction contracts and may be enforceable when included as part of the contract. Specifications often reference voluntary standards and guidance documents prepared as consensus documents by various organizations.

The standards typically referenced by State DOTs' specifications for sampling asphalt include AASHTO R 97, "Standard Practice for Sampling Asphalt Mixtures" (AASHTO 2019), or ASTM D979, "Standard Practice for Sampling Asphalt Mixtures" (ASTM 2022). These standards prescribe a methodology that supports acquiring a sample to determine compliance with the requirements of the agency specifications.

Regardless of the purpose of testing, prior to sampling, the material to be tested should be inspected for uniformity. Any observed anomalies regarding uniformity should be documented in the test/sample report remarks section to bring attention to possible materials concerns. Sampling locations should be selected using a random sampling procedure or a stratified random sampling procedure meeting the definitions of AASHTO R 10, "Standard Practice for Definition of Terms Related to Quality and Statistics as Used in Highway Construction" (AASHTO 2022).

ASPHALT PROPERTIES USED FOR ACCEPTANCE

Properties of asphalt materials and mixtures used for acceptance vary by agency, although several properties are commonly used. A list of these properties, along with examples of the standards typically used for tests to determine these properties are provided in Table 1. Materials tests are typically performed during production. Care must be taken in collecting these material and mixture samples to ensure that the samples reflect the actual product in the field.
Information provided in Table 1 shows examples of tests commonly used by many State DOTs. However, there are other tests, and variations of test methods currently in use by different agencies.

Source: FHWA
Figure. 5 Photo. Asphalt sample in laboratory, prior to testing.

Table 1: Asphalt Material and Mixture Properties and Test Methods - Examples

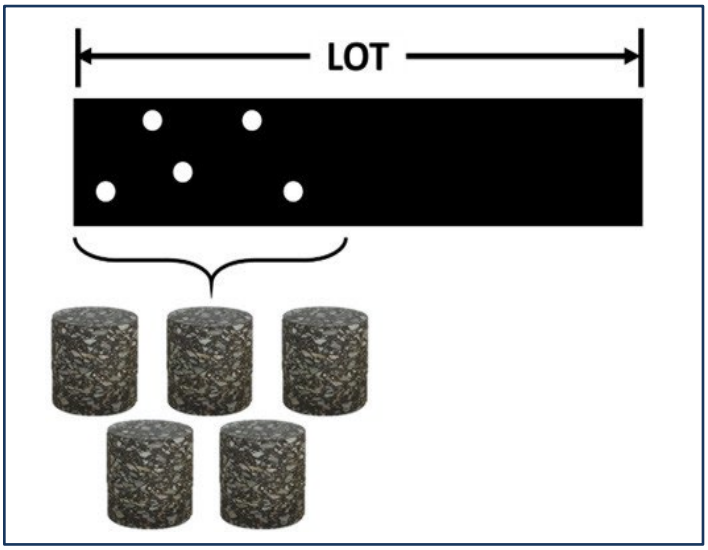
Type of Material	Property or Characteristic	Standard(s)
Asphalt Mixtures	Asphalt content	• AASHTO T 308, "Standard Method of Test for Determining the Asphalt Binder Content of Asphalt Mixtures by the Ignition Method" (AASHTO 2022) • ASTM D6307, "Standard Test Method for Asphalt Content of Asphalt Mixture by Ignition Method" (ASTM 2019)
Component Materials	Aggregate gradation	• AASHTO T 30, "Standard Method of Test for Mechanical Analysis of Extracted Aggregate" (AASHTO 2021) • ASTM D5444, "Standard Test Method for Mechanical Size Analysis of Extracted Aggregate" (ASTM 2023)
Asphalt Mixtures (Volumetrics)	Theoretical maximum specific gravity (Gmm)	• AASHTO T 209, "Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Asphalt Mixtures" (AASHTO 2023) • ASTM D2041, "Standard Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures" (ASTM 2019)
Asphalt Mixtures (Volumetrics)	Bulk specific gravity of compacted asphalt mixture (Gmb)	• AASHTO T 166, "Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Asphalt Mixtures using Saturated Surface Dry Specimens" (AASHTO 2022) • ASTM D2726, "Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures" (ASTM 2021)
Asphalt Mixtures (Volumetrics)	Air voids	• AASHTO T 312, "Standard Method of Test for Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor" (AASHTO 2022) • ASTM D6925 , "Standard Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor" (ASTM 2023)
Asphalt Mixtures (Volumetrics)	Voids in mineral aggregate (VMA)	• ASTM D6995, "Standard Test Method for Determining Field VMA Based on the Maximum Specific Gravity of an Asphalt Mixture (Gmm)" (ASTM 2021)
Asphalt Mixtures	Rutting resistance	• AASHTO T 324, "Standard Method of Test for Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures" (AASHTO 2023)

Note: Each standard listed in Table 1 is voluntary, and its use is not a Federal Requirement

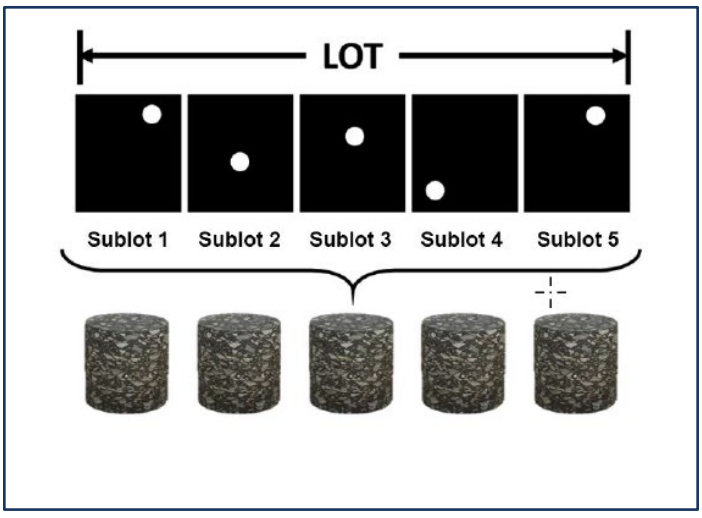
Source: FHWA
Figure 6. Photo. Asphalt sampling in the constructed mat behind the paver.

RANDOM SAMPLING

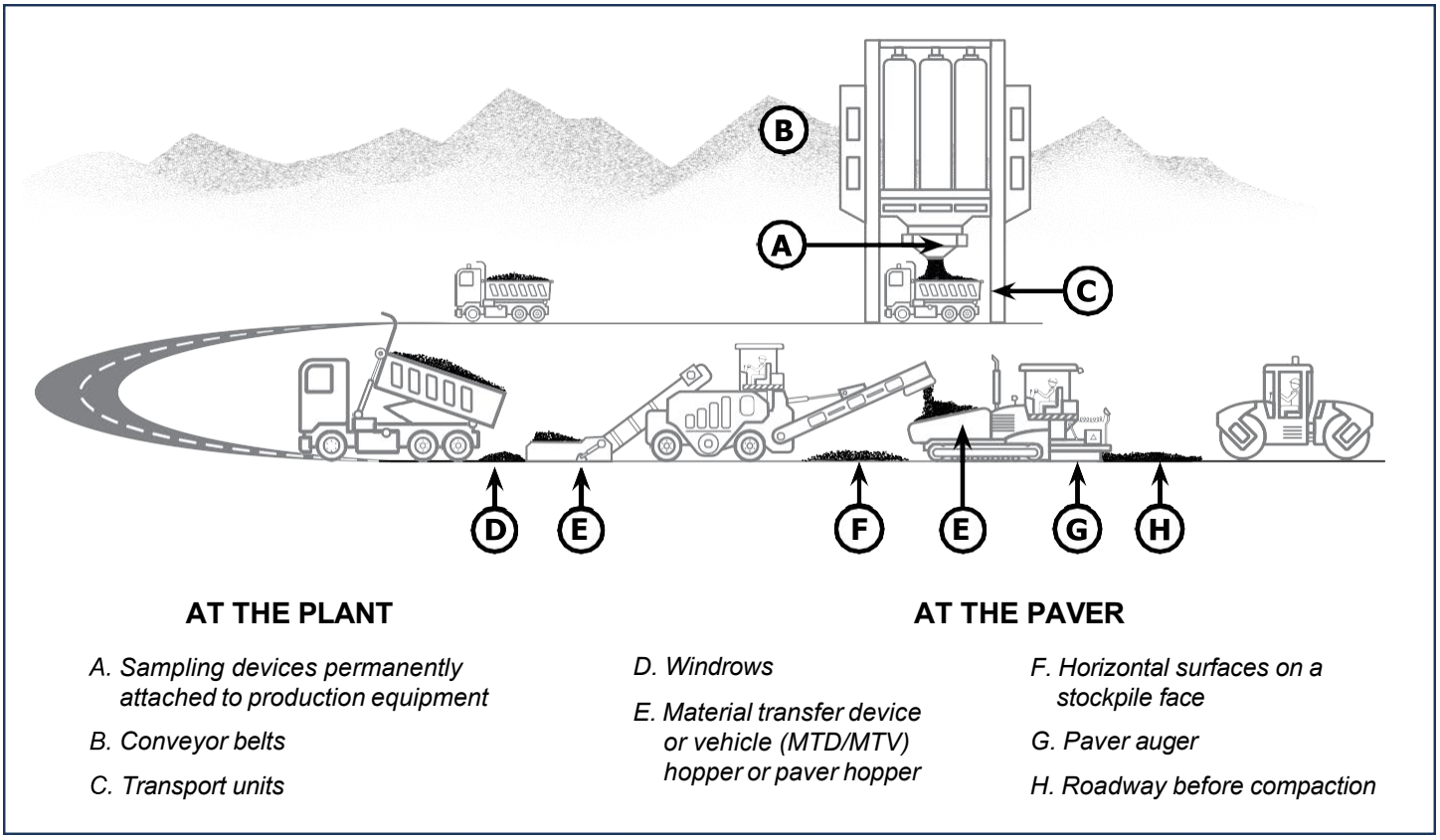
Random sampling must be employed when performing QC and agency verification sampling and testing (23 CFR 637.205(e)). Random sampling is critical to ensure the integrity of the acceptance decision (Figure 6). In random sampling approaches, the random sample represents the entire output over a defined lot or sublot. Each portion of the material or constructed product has an equal probability of being selected for sampling and testing (Figure 7). In stratified random sampling approaches, the lot(s) are divided into sublots. Sample location(s) are then randomly determined within each sublot. This approach prevents unintentional or intentional sampling bias by ensuring samples are distributed throughout the lot (Figure 8). Sampling plans should indicate how random samples will be identified, the use of stratified sublot intervals, the number of sublots per lot, and sampling frequencies.



Source: FHWA
Figure 7. Graphic. Asphalt sampling locations, randomized.



Source: FHWA
Figure 8. Graphic. Asphalt sampling locations, stratified within sublots.



Source: FHWA

Figure 9 A-H. Graphic. The graphic shows possible sampling locations at the plant and at the paver.

SAMPLING LOCATIONS

Samples can be taken at various points in the material production and laydown operation, with the location selected based on the test, specification requirements, and the ultimate use of the sample for QC and/or acceptance purposes. AASHTO R 97 (AASHTO 2019) and ASTM D979 (ASTM 2022) provide information on the apparatus used for obtaining samples and the procedure to obtain samples from several locations at the material production facility or at the job site.

Safety concerns must be addressed to support a safe working environment. Spotters, alarms, and eye contact with paver and roller operators are a few examples of important safety considerations. All sampling and testing must be executed by qualified sampling and testing personnel (23 CFR 637.209(b))

Procedures are outlined for sampling from:

A. Sampling devices permanently attached to production equipment
B. Conveyor belts
C. Transport units
D. Windrows
E. Material transfer device or vehicle (MTD/MTV) hopper or paver hopper
F. Horizontal surfaces on a stockpile face
G. Paver augers
H. Roadways before compaction

Sampling at flat surfaces created by a loader is also addressed.

The sample should represent the materials in place on the roadway, and therefore, many agencies specify that the sample must be obtained from the roadway near the point of placement. Sampling at the point of placement allows the agency to capture and monitor all sources of variability in production and placement. Sampling from a point within the laydown process allows an agency to manage unannounced random sampling with fewer staff which can reduce the potential for fraud from biased materials production (at the mat). Acceptance sampling of asphalt mixtures after placement provides an opportunity for the State DOTs to ensure the end product is acceptable instead of relying upon tests of unplaced mixture, which may or may not reflect the quality of the final constructed pavement.

Sampling from a plant via an automatic sampler at the plant while midstream in the production process **(Figure 9-A)** or from a delivery belt **(Figure 9-B)** is more suited to support the contractor's QC rather than agency acceptance.

Depending upon the State DOTs' quality assurance (QA) program, sampling at the plant can give the State DOTs the opportunity to witness and monitor the producer performing the testing to prevent fraudulent actions (such as changing samples) and to ensure testing competency. However, drawbacks to sampling at the plant can include the producer knows approximately when the sample will be taken and requires additional State DOT personnel to be present at the plant and away from the site. In addition, this sampling approach may not capture potential adverse mixture impacts due to prolonged silo storage or haul complications. The contractor may change their practices when the State DOT is present so that the sample is no longer representative of the lot.

Although widely used, sampling from the hauling vehicle at the plant (Figure 9-C) does not capture all production and placement variability that can impact the final in-place pavement. Issues such as haul time and segregation from material handling can impact the material's properties and these changes are not captured by testing materials sampled at this location.

There is a potential for higher variability in materials experiencing longer silo storage times or haul distances, particularly with highly absorptive aggregates and high RAP mixes. Methods used for loading and tarping, haul distances, and ambient temperature can also impact the properties and characteristics of asphalt mixtures.

Finally, maintaining staff at the production plant to properly manage unannounced and unpredictable random sampling may be challenging for some agencies.

Sampling ahead of the paver from a windrow of material (Figure 9-D) includes visually dividing the windrow from the haul unit into approximately three equal sections. Approximately 0.3m (1 foot) of material is removed from the top of the windrow, and the sample is taken in three increments from the material beneath the removed portion, in the center of the windrow laterally. The three increments are combined to form a sample of the required size. This approach requires the least amount of rework, but it is only viable when a pickup device or material transfer device/vehicle (MTD/ MTV) is being used for the material transfer into the paver.

Sampling from the material transport device/vehicle hopper or the paver hopper (Figure 9-E) approach avoids sampling from the hot mat, but the sampling process might result in the segregation of the mixture. Sampling from the hopper currently requires the removal of surface material, and then taking the sample from the middle third of the hopper with a shovel.

Sampling from a stockpile (Figure 9-F) can be performed at several different locations such as: behind the haul vehicle using the end dump, from the hopper using a loader/skid steer, or from the MTV using the dump conveyor. In any of these cases, one option would be to use a loader/skid steer to flatten the pile to take the sample increments after digging down a foot. Another option is to use a hand shovel to bench in layers around the pile. Then, at the top, middle, and bottom thirds, take a sample from the vertical and horizontal intersection of each bench created.

Sampling from the paver screed auger (Figure 9-G) is convenient but raises concerns about staging the sampling receptacles in a readily accessible manner. This process requires coordination between the sampler, paver operator, and screed operator, as this process is constantly moving while the person responsible for taking the sample is positioning receptacles.

Roadway sampling before compaction (Figure 9-H) is when samples are removed from an area subjected to traffic; future pavement distress can be avoided when the area is properly backfilled and compacted. When using a plate to sample, a "cookie cutter" is recommended to limit the impact to the pavement area and to create edges suitable for proper patching techniques. Also, a cookie cutter is usually needed when working with thin lifts. Multiple locations in the immediate area of the initial sample location may be needed to yield sufficient material for testing as well as to alleviate undue influence of the underlying surface due to the thin material lift.

Sampling from a flat surface created by a loader is allowed by only some State DOTs and is included in this document for informational purposes only. A small loader such as skid-steer is used to obtain a sample in a manner that would mirror the paving process; the skid-steer could "back drag" the remaining material, allowing it to be paved over. This methodology is not a common practice; safety concerns and timeliness may discourage the use of this practice.

Source: FHWA
Figure 10. Photo: Smooth paved road.

REPRESENTING IN PLACE MATERIAL

Random sampling represents the quality of material across an entire lot in an unbiased manner which provides the basis for compliance evaluation for acceptance. The agency is solely responsible for acceptance, even though other entities are impacted.

Samples should comply with agency specifications. Samples are typically collected within each sublot. Several sublots are then combined to create lots that are used to determine acceptance. For proper payment, the samples should best represent the quality of material that has been constructed and is in place on the roadway.

CLOSING

Asphalt sampling is one of the keys to a long-lasting, functional roadway. Use of proper sampling and testing procedures helps support quality materials and construction.

Specifications rely on procedures and practices outlined in industry and/or agency standards and guidance documents to support sampling and testing approaches. Random sampling leads to test results representing the entire output over a defined lot or sublot. Each portion of material or constructed product has an equal probability of being selected for sampling and testing.

Sampling locations for asphalt mixtures include locations at the production facility, in front of the paver, at the paver, or behind the paver. Sampling locations behind the paver most closely represent the quality of the final in-place product. Due to limited personnel, current workforce challenges can lead to a sampling process at the roadway rather than the plant. Different information about the mixture can be determined from material sampled at different locations. Care needs to be taken so that results are not subject to sampling issues which can lead to results that may not represent the material in the final pavement mat.

No matter the sampling procedure used, it is imperative for agencies to have detailed sampling procedures to reduce variability in sampling practices. Following designated standards and sampling practices can help agencies evaluate asphalt mixtures to ensure the roadways perform as expected over the entire design life.

Pavements are a critical component of our highway system. To protect the public's investment and to provide a safe and efficient means of travel, agencies need to ensure that paving materials are of acceptable quality and that pavements are constructed to meet specification criteria.

REFERENCES

The sampling and testing standards listed below are voluntary standards and are not required under Federal Law or regulations.

AASHTO. (2022). AASHTO R 10, "Standard Practice for Definition of Terms Related to Quality and Statistics as Used in Highway Construction." American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. (2019). AASHTO R 97, "Standard Practice for Sampling Asphalt Mixtures." American Association of State Highway and Transportation Officials, Washington, DC.

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