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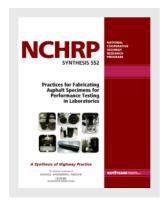
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#### NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

## NCHRP SYNTHESIS 552

# Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories

### A Synthesis of Highway Practice

Jo E. Sias

AND

Eshan V. Dave
University of New Hampshire
Durham, NH

Leslie Myers McCarthy VILLANOVA UNIVERSITY Villanova, PA

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## NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed, and implementable research is the most effective way to solve many problems facing state departments of transportation (DOTs) administrators and engineers. Often, highway problems are of local or regional interest and can best be studied by state DOTs individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation results in increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

Recognizing this need, the leadership of the American Association of State Highway and Transportation Officials (AASHTO) in 1962 initiated an objective national highway research program using modern scientific techniques—the National Cooperative Highway Research Program (NCHRP). NCHRP is supported on a continuing basis by funds from participating member states of AASHTO and receives the full cooperation and support of the Federal Highway Administration (FHWA), United States Department of Transportation, under Agreement No. 693JJ31950003.

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The needs for highway research are many, and NCHRP can make significant contributions to solving highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement, rather than to substitute for or duplicate, other highway research programs.

#### **NCHRP SYNTHESIS 552**

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Cover photo caption: Examples of asphalt concrete specimens fabricated for performance testing in the laboratory. *Top row (left to right)*: complex modulus test specimens, small and large diameter indirect tension test specimens, and direct tension cyclic fatigue specimen instrumented and mounted in machine. *Middle row*: small and large geometry specimens for complex modulus and direct tension cyclic fatigue testing. *Bottom row (left to right)*: semicircular bend specimen mounted in machine, flexural beam fatigue specimen, and disk-shaped compact tension test specimen mounted in machine.

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#### COOPERATIVE RESEARCH PROGRAMS

#### **CRP STAFF FOR NCHRP SYNTHESIS 552**

Christopher J. Hedges, Director, Cooperative Research Programs
Lori L. Sundstrom, Deputy Director, Cooperative Research Programs
Jo Allen Gause, Senior Program Officer
Deborah Irvin, Program Coordinator
Eileen P. Delaney, Director of Publications
Natalie Barnes, Associate Director of Publications

#### **NCHRP PROJECT 20-05 PANEL**

Joyce N. Taylor, Maine DOT, Augusta, ME (Chair)
Socorro "Coco" Briseno, California DOT (Retired), Sacramento, CA
Anita Bush, Nevada DOT, Carson City, NV
Joseph D. Crabtree, University of Kentucky, Lexington, KY
Mostafa "Moe" Jamshidi, Nebraska DOT, Lincoln, NE
Cynthia L. Jones, Ohio DOT, Columbus, OH
Jessie X. Jones, Arkansas DOT, Little Rock, AR
Brenda Moore, North Carolina DOT, Raleigh, NC
Ben Orsbon, South Dakota DOT, Pierre, SD
Randall R. "Randy" Park, Avenue Consultants, Bluffdale, UT
Brian Worrel, Iowa DOT, Ames, IA
Jack Jernigan, FHWA Liaison
Jim McDonnell, AASHTO Liaison
Stephen F. Maher, TRB Liaison

#### **TOPIC 50-14 PANEL**

Stacey D. Diefenderfer, Virginia DOT, Charlottesville, VA Gregory D. Johnson, Minnesota DOT, Maplewood, MN Rebecca S. McDaniel, Purdue University, West Lafayette, IN Ross A. Metcalfe, Montana DOT, Helena, MT Jesus A. Sandoval-Gil, Arizona DOT, Phoenix, AZ Brian M. Welch, Maine DOT, Bangor, ME David J. Mensching, FHWA Liaison Nelson H. Gibson, TRB Liaison

#### ABOUT THE NCHRP SYNTHESIS PROGRAM

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-05, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, Synthesis of Highway Practice.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

#### **FOREWORD**

By Jo Allen Gause Staff Officer Transportation Research Board

This synthesis documents procedures related to laboratory fabrication of asphalt performance test specimens at state departments of transportation (DOTs) and partner laboratories that conduct performance testing on behalf of DOTs. The synthesis provides examples of sampling procedures, as well as practices developed by DOTs and partner laboratories for improving consistency in fabricating performance test specimens.

Information for this study was gathered through a literature review, a survey of state DOTs, a survey of partner laboratories that complete asphalt testing for state DOTs, and follow-up interviews with selected agencies. Five case examples provide additional information on asphalt testing practices.

Jo E. Sias and Eshan V. Dave, University of New Hampshire, and Leslie Myers McCarthy, Villanova University, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on page iv. This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.





## CONTENTS

1	Summary
3 3 4 6 7	Chapter 1 Introduction  Background Objective of the Synthesis Study Approach Organization of the Report Definitions
9	<b>Chapter 2</b> Literature Review of Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories
9	Performance Tests for Asphalt Mixtures
12	Research on the Impact of Specimen Fabrication Practices on Performance Test Results
18	Summary of the Findings from the Literature: National and International Practices for Fabrication of Asphalt Specimens for Performance Tests in Laboratories
24	Chapter 3 State of the Practice
24	State of the Practice Related to the Use of Asphalt Laboratory Performance Tests
28	Specimen Fabrication Practices for Laboratory Asphalt Performance Testing
43	Challenges and Knowledge Gaps
48	Chapter Summary
19	Chapter 4 Case Examples
49	Arizona
51	Illinois
53	Maine
54	Montana
56	Texas
58	Chapter Summary
59	Chapter 5 Conclusions
59	- Chapter Summary and Key Findings
60	Identified Gaps in Knowledge and Future Research Needs
52	Abbreviations
54	References

68		Agency and Partner Laboratory Survey Questionnaires
133	Appendix B S	State Transportation Agency Survey Responses
166	<b>Appendix C</b> P	Partner Laboratory Survey Responses
197	Appendix D	List of Survey Respondents
199	P	Sample Documents that Exhibit Standard Procedures Used for Fabrication of Specimens for Performance Testing

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.



Performance testing of asphalt mixtures is becoming more widespread as agencies move toward performance-related specifications for asphalt-mixture design and construction and evaluate the potential benefits of new materials and products on asphalt-mixture performance. Standard specifications or guidance documents exist for conducting performance tests, but there is little to no guidance on the appropriate methodologies for fabricating the test specimens. Various research studies have shown that different specimen fabrication methods can significantly affect measured performance properties. This has substantial impact if performance properties are used as criteria in the design, evaluation, and acceptance of asphalt mixtures. However, general guidance on the best approaches to fabricating specimens that includes the collection of component materials, mixing and reheating protocols, laboratory conditioning, compaction, and coring/cutting have not been developed or documented in a manner that agencies can use to identify appropriate practices. As performance testing transitions to common practice in the design and evaluation of asphalt mixtures, guidelines on the specimen fabrication process will be needed.

This synthesis documents state highway agency procedures with respect to laboratory fabrication of asphalt performance test specimens. The synthesis provides examples of sampling procedures used for materials and specific procedures and practices that states and partner laboratories have developed for improved consistency in fabricating performance test specimens, as well as common challenges faced and knowledge gaps that have been identified.

The information for this synthesis was gathered through a comprehensive literature review, a survey of state departments of transportation (DOTs), a survey of partner laboratories that complete asphalt performance testing for state DOTs, and subsequent interviews of personnel from five states selected for further study. Forty-one state DOTs (40 states and the District of Columbia) responded to the survey, attaining a survey response rate of 80%. After reviewing documentation in the literature and the detailed survey responses, the states of Arizona, Illinois, Maine, Montana, and Texas were selected for further review through interviews. Twenty-nine partner laboratories responded to the survey. The following observations were made based on the survey data, detailed interviews, and literature review.

- Most states are either fabricating asphalt specimens for performance testing in house or having the work done at partner laboratories. However, states use a range of mixture sampling and splitting procedures for collecting material for specimen fabrication.
- Existing ASTM or AASHTO standards are followed as written or with some modification for the performance testing but usually do not provide appropriately detailed guidance with respect to specimen fabrication.

- 2 Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories
  - Loose-mix conditioning is commonly adopted, but various protocols are used for shortand long-term conditioning between agency and partner laboratories.
  - Most performance test specimens are compacted to a target air void content of 7% using gyratory compactors. The allowable tolerance is typically higher for agencies than partner laboratories, and meeting air void requirements is reported as the most common challenge in specimen fabrication, with average rejection rates of 10% to 15%.
  - There are minimal restrictions in place at DOT laboratories with respect to maximum allowable storage times during the performance-test specimen-fabrication process. Partner laboratories more commonly use maximum storage time limits; however, the reason for choice of specific maximum allowable storage times is typically not documented. A majority of entities do not have specific protocols to prepare specimens for storage.
  - Partner laboratories and agencies with more experience with performance testing have established protocols and specific guidance for fabricating specimens to maintain consistency, but these protocols and guidance vary widely.



#### CHAPTER 1

## Introduction

This chapter introduces background information on practices related to the fabrication of asphalt-mixture specimens for performance testing. The survey and interview processes and organization of the report will also be described.

#### **Background**

Performance testing of asphalt mixtures is becoming more widespread for a variety of reasons and with a variety of testing devices. The tests results are sensitive to the procedures used in preparation of the specimens. Guidelines exist for conducting the tests; however, they do not all provide uniform or comprehensive direction for fabricating test specimens. Additionally, many state highway agencies are relatively new to fabrication of performance test specimens and are in various stages of gaining experience. There are few detailed ruggedness studies that identify critical sources of variability with respect to specimen fabrication procedures. Numerous research efforts have addressed some aspects of the specimen fabrication process on performance test results, but typically only have examined one aspect of specific tests and usually as a side objective of the main study. Therefore, individual laboratories tend to follow their own procedures, or no specific procedure, where the standards are not specific.

#### **Objective of the Synthesis**

The objective of this synthesis was to document procedures related to laboratory fabrication of asphalt performance test specimens at state highway agencies and partner laboratories that conduct performance testing on behalf of state highway agencies. For the purpose of this synthesis, fabrication begins with a mixture and results in a prepared test specimen. Other information about specimen fabrication to be gathered included aspects such as

- Purpose of the testing (e.g., mix design, quality assurance, or research);
- Methodologies used by state DOTs and targeted partner asphalt testing laboratories;
- Tests performed and standards or procedures used;
- Equipment used (e.g., for splitting, charging mold, compaction, coring, or cutting);
- Short- and long-term aging procedures;
- Laboratory testing sequencing and time limitations (e.g., maximum shelf life or operational disruptions);
- Rejection rate of specimens produced (after cutting and coring) that never get tested; and
- Research, common issues encountered, and solutions developed.

The synthesis also includes suggestions for future research, based on existing gaps identified through the literature review, surveys, and case example interviews. The synthesis provides a

reference to transportation agencies and other entities regarding existing practices for fabrication of performance test specimens.

#### **Study Approach**

A multifaceted approach was taken to document the various activities that have been conducted in recent years by both agencies and partner lab entities with respect to specimen fabrication for asphalt performance testing and related procedures. There is a need to quantify these efforts and collect examples of practices that are reported to be effective to facilitate the exchange of information and to help other agencies and industry partners. The approach to this study included a literature review, a survey of U.S. state and Canadian provincial transportation agencies, a survey of partner laboratories that conduct performance testing for state highway agencies, and interviews with transportation agencies in states identified as having existing practices for dealing with asphalt performance testing. The following sections provide more detail on each step in the approach.

#### **Literature Review**

A comprehensive literature review of sources both in the United States and internationally was used to establish current practice and emerging trends related to the fabrication of performance specimens for asphalt laboratory testing. The research team consulted a number of resources, including the Transport Research International Documentation (TRID), general web searches, FHWA and DOT internal reports, journal publications, conference proceedings, transportation agency specifications and standards, and resources of professional associations. Particular attention focused on summarizing practices for fabrication of asphalt specimens for performance testing in laboratories used nationally and internationally; specimen fabrication practices used by agencies, private/commercial testing laboratories, university testing laboratories, non-DOT agencies (e.g., federal agencies, Canadian provincial transportation agencies, tollways, or local agencies), or other international agencies; and research on the impacts of specimen fabrication practices on performance test results.

#### Survey of State Highway and Provincial Transportation Agency Laboratories

The primary intent of the survey was to establish the current state of the practice for state transportation agencies with respect to the use of laboratory performance tests for asphalt mixtures and whether testing is conducted in house, by partner (consultant, university, or federal agency) laboratories, or both. In addition, the survey addressed specific details associated with the specimen fabrication process and collected information on the process flow of the fabrication process, along with time constraints and challenges associated with each step. Finally, the survey solicited the identities of partner lab entities engaged in the fabrication of performance test specimens, as well as knowledge gaps and ideas for future research topics.

The survey consisted of 27 questions and was sent to members of the AASHTO Committee on Materials and Pavements, with a recommendation for distribution to the agency's materials engineers to complete the survey. The agency survey was sent to contacts in each of the state DOTs, the District of Columbia, and the 11 Canadian provincial transportation agencies. Eighty percent (40/50) of all state DOTs and the District of Columbia responded to the agency survey and are included in the survey analysis.

The agency survey questions are included in Appendix A and the results are in Appendix B of this report. The map in Figure 1 shows the state highway agencies in the United States that

Figure 1. Location of state highway agencies completing survey and interviewed for case examples.

completed the agency survey, along with specific agencies that were selected to serve as case examples, to be presented in Chapter 4 of this report.

#### **Survey of Partner Laboratories**

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The partner laboratory survey consisted of 25 questions (included in Appendix A) and was sent to contacts at laboratories that conduct performance testing for state highway agencies that were identified in the literature review or from the responses gathered as part of the agency survey. There were 29 responses that were completed and included in the survey analysis (responses are documented in Appendix C). The map in Figure 2 shows the geographic distribution of organizations that completed the survey.

A list of the agencies and partner laboratories that completed the survey is included in the analysis in Appendix D.

#### **Interviews of Transportation Practitioners for Case Examples**

Based on the survey responses, five states were selected for additional data gathering on practices used related to the fabrication of performance test specimens for asphalt paving mixtures. Several criteria were considered in the selection of the case example agencies to be interviewed. The criteria included (1) agencies that reported they have substantially moved into the development or use of asphalt performance testing and (2) the geographical distribution of states, in order to reflect a national perspective and varying climatic conditions (which influences the types of pavement distresses that agencies are designing against).

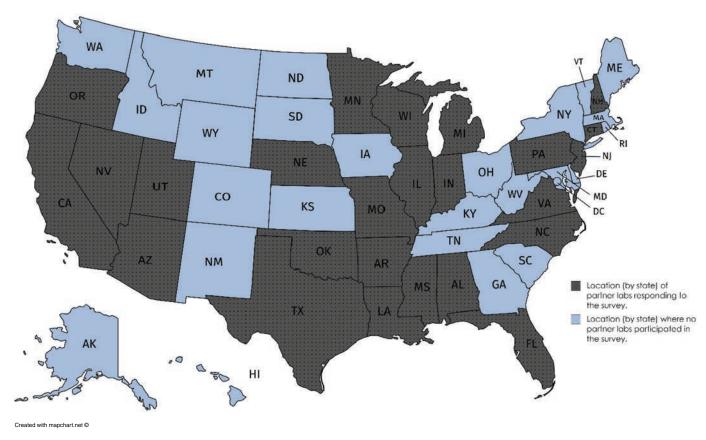


Figure 2. Location of partner labs that the completed survey.

At least one representative from each of the organizations was interviewed over the phone to gather their input on issues and practices in their state or province related to practices for fabricating asphalt performance test specimens. A sampling of documents obtained as examples of current practice are included in Appendix E.

#### Organization of the Report

This synthesis report is organized into five chapters. The balance of Chapter 1 presents the report's structure and defines key terms. The report structure is summarized with brief explanations of each chapter's content.

Chapter 2 introduces the details published in the literature and in online sources related to practices for fabricating asphalt specimens for laboratory performance testing throughout the United States and internationally. There is a section that introduces performance test procedures and equipment used for asphalt mixtures and includes information on tests for various types of asphalt mixtures. A section on the specimen fabrication procedures that are used for asphalt mixtures is presented. The chapter concludes with a discussion on research that is under way that is related to the impact of specimen fabrication protocols on performance test results of asphalt mixtures.

Chapter 3 provides the state of the practice reported by the state DOTs and other organizations on the procedures that are used to fabricate specimens for performance testing of asphalt mixtures in the laboratory. An overview of the various procedures that are used is presented, based on the survey responses from state DOTs as well as partner laboratories. It provides the

state of the practice in terms of the use of asphalt laboratory performance tests and in regard to which performance tests are conducted and for what purpose [mix design approval, quality assurance (QA), research]. It also summarizes the extent to which agencies conduct testing in-house or contract with outside laboratories to conduct the testing. Specific practices used by state DOTs and other laboratories to fabricate performance test specimens are identified, along with information related to compaction, cutting and coring, age conditioning, storage time limitations, the required equipment used, and so forth. The chapter concludes with a discussion on rejection rates and reasons, and other challenges identified with fabricating specimens are summarized.

Chapter 4 examines the specific examples of specimen fabrication practices reported in case example interviews with selected agencies. The specific examples also summarize practices with respect to sampling of material, achieving air void tolerances, and storage of material and specimens. The majority of the information presented in this chapter was collected through the detailed interviews with personnel in various agencies in each of the five states selected for further study.

Chapter 5 provides a summary of the key findings and conclusions of the project, including agency use of performance testing and purpose and information on whether testing is done in-house or contracted to an outside laboratory. It also presents findings and conclusions related to procedures used for fabricating asphalt-mixture specimens for performance testing along with performance testing time and equipment availability. A discussion of challenges related to specimen fabrication, including impacts on performance test results and rejection rates, is presented. The chapter concludes by outlining apparent knowledge gaps stemming from the agency's and partner's laboratory surveys and case example interviews. Suggestions for future research on the impact of specimen fabrication protocols on performance test results are also presented.

The documented practices are drawn from the literature review and results of the agency and partner laboratory surveys, along with case example interviews. These chapters are followed by references and five appendices. Appendix A includes a copy of the agency and partner laboratory survey questions. Appendix B and Appendix C present the agency and partner laboratories survey results, respectively. Appendix D includes a list of the agencies and other organizations that completed the surveys. Appendix E presents links to sample documents that are examples of practices that were shared by agencies in response to the surveys and interviews.

#### **Definitions**

Some key terms are defined that pertain to the synthesis scope. Additional terms are defined within the context of their relevant sections. A list of abbreviations is also included in the report.

Asphalt Mixtures: The term asphalt mixtures is intended to represent any dense-graded hot-mix asphalt (HMA), warm-mix asphalt (WMA), or stone-matrix asphalt (SMA) mixture that is produced at a plant or in the laboratory. This term includes mixtures that have been modified with the use of recycled materials (e.g., reclaimed asphalt pavement, recycled asphalt shingles, crumb rubber from recycled tires, and so forth). This term does not include maintenance mixtures (e.g., cold-mix asphalt, seal coats, and the like), in-place recycled mixtures (e.g., hot-in-place recycled asphalt, cold-in-place recycled asphalt, and so forth), or specialized surface mixtures (e.g., open-graded friction courses or gap-graded thin bonded overlays).

Laboratory Asphalt-Mixture Performance Tests: Laboratory asphalt-mixture performance tests are defined as any laboratory test procedure for mechanical characterization of asphalt

mixtures to determine a fundamental engineering or empirical property (e.g., resilient modulus, creep properties, and cracking properties) that can predict pavement performance and/or appear in primary performance-prediction relationships. Examples of performance-prediction relationships include models that can be used to predict pavement stress, distress, or performance from combinations of predictors that represent traffic, environmental, roadbed, and structural conditions. Pavement performance in this definition is in the context of asphalt-mixture durability and resistance to traffic and climate-induced distresses.

**Specimen Fabrication for Performance Testing:** Specimen fabrication for this survey is defined as the comprehensive process by which loose asphalt mixture (made in a laboratory or sampled from a plant) is made into the finalized test specimen that is ready for mechanical characterization. The steps for fabrication include, but are not limited to, reheating, compaction, conditioning (e.g., laboratory aging or moisture), cutting, coring, air void determination, and gluing of loading platens or gage brackets.

**Partner Laboratories:** These are organizations that conduct asphalt-mixture performance tests for state highway agencies and include federal agency laboratories (e.g., FHWA), state-agency-affiliated research laboratories [e.g., Virginia Transportation Research Council (VTRC)] along with consultant and university laboratories.



## Literature Review of Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories

This chapter presents results of the literature review of practices for fabricating specimens for performance testing in laboratories and covers a discussion of various asphalt performance tests and a review of the impact of specimen fabrication practices on performance test results. Topics addressed as part of the specimen fabrication practices include sampling location, mixture type, conditioning protocol (aging and moisture), laboratory compaction methods, specimen parameters (specimen size and geometry or specimen air voids), shelf life, and anisotropy. The information presented in this chapter was gathered from published technical papers and reports as well as several DOT manuals for specimen fabrication. The NCHRP has also funded research projects that cut across some of the specimen fabrication practices; these were extensively reviewed and are presented as part of this chapter.

#### **Performance Tests for Asphalt Mixtures**

In this subsection, the most common asphalt-mixture performance tests currently employed by both agency and partner laboratories are briefly discussed.

#### Stiffness and Viscoelastic Characterization

Dynamic (Complex) Modulus Testing (E\*) (AASHTO T 342)

The dynamic (complex) modulus test is used to characterize the viscoelastic properties of asphalt mixtures using an asphalt-mixture performance tester (AMPT). In recent years, its use is becoming more widespread as it is implemented as a reliable method for characterizing stiffness and load resistance properties of asphalt mixtures and is used as an input in mechanistic-empirical pavement design. The dynamic modulus is determined by applying sinusoidal axial loads to cylindrical test specimens at varying frequencies and temperatures. These test specimens are typically 100 mm (4 in.) in diameter and 150 mm (6 in.) in height. However, more recently there has also been use of smaller cylindrical specimens having a diameter and height of  $38 \times 135$  mm ( $1.5 \times 5.3$  in.),  $50 \times 135$  mm ( $2 \times 5.3$  in.),  $38 \times 110$  mm ( $1.5 \times 4.3$  in.), or  $50 \times 110$  mm ( $2 \times 4.3$  in.) (Diefenderfer et al. 2015). The specimens are cored out of laboratory-compacted samples, with a saw used to shave off the ends (or faces) to ensure they are smooth and parallel. The specimen can also be fabricated from field cores, and for this the smaller cylindrical specimens are typically used because pavement lift thicknesses are usually less than 100 mm (4 in.).

#### Resilient Modulus Testing

The resilient modulus ( $M_R$ ) test (ASTM D7369) is used to characterize the stiffness and load resistance properties of asphalt mixtures. It is the primary test employed by most state DOTs still utilizing the AASHTO 1993 pavement design, evaluation, and analysis. This test is conducted by applying a repeated haversine compressive load of a fixed magnitude, load duration, and cyclic duration to the vertical diameter of a cylindrical testing specimen, and the resilient (recoverable) deformation of the specimen is measured in the vertical and horizontal directions. The specimen dimensions are  $101.6 \pm 3.8 \text{ mm}$  (4 in.) or  $152.4 \pm 9 \text{ mm}$  (6 in.) in diameter and between 38.1 mm (1.5 in.) and 63.5 mm (2.5 in.) in thickness. It is conducted at a test temperature of  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 2^{\circ}\text{F}$ ).

#### Cracking

#### Direct Tension Cyclic Fatigue Test

The direct tension cyclic fatigue (DTCF) test (AASHTO TP 107) is used to characterize the fatigue behavior of asphalt mixtures by determining the damage characteristic relationship using Simplified Viscoelastic Continuum Damage (S-VECD) theory. The testing is conducted at a temperature based on the binder performance grade (PG) given as

Test temperature (°C) = 
$$\left[\frac{\text{high PG temperature} + \text{low PG temperature}}{2} - 3\right]$$
(1)

The test is conducted by applying repeated tensile loads at 10 Hz under different strain amplitudes to cylindrical specimens typically 100 mm (4 in.) in diameter and 130 mm (5 in.) in height but can also be done on a small specimen geometry (SSG) that is 38 mm (1.5 in.) in diameter and 110 mm (4.3 in.) tall. Test specimen fabrication requires coring the required dimension from laboratory-compacted samples or field cores and gluing of platens to both ends of the specimen.

#### Flexural Beam Fatigue Test

The flexural beam fatigue (FBF) test (AASHTO T 321) is used to evaluate the fatigue life of asphalt mixtures under cyclic haversine four-point flexural loading at different strain levels. The frequency of the loading ranges from 5 to 10 Hz. Testing is conducted at a temperature of  $20.0\pm0.5^{\circ}$ C ( $68.0\pm1^{\circ}$ F). Test specimens are beams 380 mm (15 in.) long by 50 mm (2 in.) thick by 63 mm (2.5 in.) wide. These beam specimens are sawed from laboratory or field-compacted asphalt mixtures.

#### Cracking Tolerance Index Test

The cracking tolerance index or CTIndex (formerly known as IDEAL-CT) test (ASTM D 8225) is used to characterize the cracking tolerance of asphalt mixtures. It is run at intermediate temperature [25°C (77°F) or PG intermediate temperature] on a cylindrical specimen of 150 mm (6 in.) diameter and 62 mm (2.5 in.) height at a loading rate of 50 mm/min (2 in./min). Mixtures with nominal maximum aggregate size (NMAS)  $\geq$  25 mm and a height of 95 mm (3.75 in.) is specified. It is a simple test that requires no instrumentation, cutting, gluing, drilling, or notching of specimens. The standard suggests that all the specimens should be compacted to the same level of air voids (e.g.,  $7 \pm 0.5\%$ ).

#### Superpave Indirect Tensile Strength and Creep Test

The Superpave indirect tensile (IDT) strength and creep test (AASHTO T 322) is used to determine the tensile creep compliance at different loading times, tensile strengths, and

Poisson's ratios of asphalt mixtures. The tensile creep and strength have been used to estimate thermal cracking potential. It can also be used to determine potential for moisture damage where moisture-conditioned and unconditioned specimens are evaluated to obtain the tensile strength ratio (TSR). It is conducted using cylindrical specimens that are typically laboratory fabricated or field cores. For laboratory-compacted specimens, a minimum specimen height of 50 mm (2 in.) is required for specimens with a nominal diameter of 100 mm (4 in.), and a minimum specimen height of 75 mm (3 in.) is required for specimens with a nominal diameter of 150 mm (6 in.). For field cores, a minimum height of 38 mm (1.5 in.) is specified for specimens with a nominal diameter of 100 mm (4 in.).

#### Texas Overlay Test

The Texas Overlay test (TxOT) (TxDOT Designation: TEX-248-F) is used to evaluate the resistance of asphalt mixtures to fatigue or reflective cracking. The goal of the test is to obtain the critical fracture energy and cracking resistance index which are used to characterize cracking resistance. This test is conducted by applying repeated direct tension load to cylindrical-laboratory-molded or field-cored specimens that are trimmed perpendicular to the top surface on two parallel sides. The test is performed at a constant temperature of  $25 \pm 0.5$  °C ( $77 \pm 1$ °F). The cylindrical specimen is specified to have diameter of 150 mm (6 in.) and height of  $115 \pm 5$  mm ( $4.5 \pm 0.2$  in.) before trimming. The actual test specimens after trimming are required to be  $76 \pm 0.5$  mm ( $3 \pm 0.02$  in.) wide and  $38 \pm 0.5$  mm ( $1.5 \pm 0.02$  in.) high. The test also requires that test specimens are glued at the bottom to a metal plate before being mounted on the tester. A repeated tensile load is applied until the maximum load is reduced by 93% of the maximum load during the first cycle, indicating that cracking has developed and the specimen is considered failed.

#### Disk-Shaped Compact Tension Test

The disk-shaped compact tension (DCT) test (ASTM D 7313) is used to determine the fracture resistance of asphalt mixtures at cold in-service temperatures of  $10^{\circ}\text{C}$  ( $50^{\circ}\text{F}$ ) or below. The disk-shaped test specimens are prepared from 150 mm (6 in.) diameter samples compacted in the laboratory or from field cores. The test specimen is fabricated to have a thickness of  $50\pm5$  mm ( $2\pm0.2$  in.), a  $62.5\pm5$  mm ( $2.5\pm0.25$  in.) notch along the diameter of the specimen not wider than 1.5 mm (0.06 in.), a flat surface cut at  $90\pm5^{\circ}$  to the notch, and two  $25\pm1.0$  mm ( $1\pm0.04$  in.) loading holes on opposite sides of the notch. The test is conducted by loading the specimens in tension to evaluate fracture energy.

#### Semicircular Bend Test

The semicircular bend (SCB) test (AASHTO TP 124, ASTM D8044, AASHTO TP 105) has been used to measure cracking resistance of asphalt mixtures both at intermediate temperatures following the AASHTO TP 124 or ASTM D8044 procedures and low temperatures following the AASHTO TP 105 procedure. All procedures have similar specimen geometry, fabricated by cutting laboratory-prepared or field core disks in half and notching parallel to the loading and vertical axis. However, the specimen thickness and notch length vary based on the specific procedure. The test methods involve loading the semicircular specimen to failure at a constant rate of deformation under three-point bending.

#### Rutting, Moisture Susceptibility, and Durability

#### Asphalt Pavement Analyzer Test

The asphalt pavement analyzer (APA) test (AASHTO T 340) is used to evaluate permanent deformation (rutting), fatigue cracking, and moisture susceptibility of asphalt mixtures. There is

also an APA junior that is a smaller version of the APA. The APA apparatus applies 8,000 repetitive linear wheel loads of  $445 \pm 422$  N ( $100 \pm 5$  lb) to test specimens via a hose at a pressure of  $690 \pm 35$  kPa ( $100 \pm 5$  psi). It has an environment-controlled chamber that can be used for testing in dry or submerged conditions; the test is typically conducted at the PG high temperature. The test is conducted at the same time on three rectangular slabs with dimensions of 75 mm  $\times$  125 mm  $\times$  300 mm (3 in.  $\times$  5 in.  $\times$  11.8 in.) or six cylindrical specimens 150 mm (6 in.) diameter and 75 mm (3 in.) height which can be fabricated from field cores or laboratory-compacted samples. Average rut depth is reported.

#### Repeated Load Permanent Deformation Flow Number Test

The repeated load permanent deformation (RLPD) flow number test (AASHTO T 378) is conducted using the AMPT and is used to evaluate rutting performance of asphalt mixtures. This test involves application of a specific stress level in a haversine waveform for 0.1 second, followed by a rest or dwell period of 0.9 second to obtain the permanent strain. The test is typically conducted at the high pavement temperature selected by the agency. The flow number is defined as the number of load cycles corresponding to the minimum rate of change of permanent axial strain. Test specimens are typically fabricated to be 100 mm (4 in.) in diameter and 150 mm (6 in.) in height, but can also be done on an SSG that is 38 mm (1.5 in.) in diameter and 110 mm (4.3 in.) tall. These test specimens can be produced from roadway cores or laboratory-compacted samples.

#### Hamburg Wheel Tracking Test

The Hamburg Wheel Tracking (HWT) test (AASHTO T 324) is used to test asphalt mixtures for rutting and moisture susceptibility. The test is typically conducted on specimens submerged in a water bath at temperatures ranging from 40 to  $50^{\circ}$ C (104 to  $122^{\circ}$ F). The apparatus applies repetitive loads ( $52 \pm 2$  passes per minute) of  $705 \pm 4.5$  N ( $158 \pm 1.0$  lb) to slab or cylindrical specimens using a steel wheel. Slab specimens 320 mm (13 in.) long and 260 mm (10.25 in.) wide and thickness ranging from 38 mm (3 in.) to 100 mm (4 in.) may be used. Alternatively, two cylindrical specimens may be fabricated to have diameter of 150 mm (6 in.) and thickness ranging from 38 mm (3 in.) to 100 mm (4 in.). The cylindrical specimens are required to be cut at the edges along a secant line so that they can be joined together with no space between the cut edges. The test concludes after either 20,000 passes or when a maximum rut depth (established a priori) is reached.

#### Cantabro Test

The Cantabro test (Tex-245-F, AASHTO TP 108-14, ASTM D 7064-08), as specified by the Texas DOT, is used to evaluate abrasion loss of asphalt specimens using the Los Angeles Abrasion Machine. The significance of the test is to determine the durability of a mixture and strength of bond between binder and aggregates. It is conducted by rotating the compacted specimen of diameter 150 mm (6 in.) and height  $115 \pm 5$  mm (4.5  $\pm$  0.2 in.) for 300 revolutions and measuring the mass of material before and after. This test is conducted at a test temperature of  $25 \pm 1^{\circ}$ C (77  $\pm$  2°F) on specimens fabricated from laboratory-compacted specimens.

#### Research on the Impact of Specimen Fabrication Practices on Performance Test Results

In this subsection, literature on the impact of various specimen fabrication practices relating to sampling, specimen fabrication methods, conditioning procedures, compaction methods, test specimen parameters, and shelf life are summarized.

#### Sampling

State DOTs employ various sampling techniques for quality assurance. The goal is to get an uncontaminated, representative sample of the final product in the field. Hassan (2002) performed a forensic study for Colorado DOT and found that differences of no more than 3% existed in asphalt content of samples obtained from different locations (at the plant with a tube sampler, at the point of delivery, and behind the paver) and that none of these differences were statistically significant. Turner and West (2006) evaluated the effect of sampling locations (truck by shovel, truck by robotic device, behind the spreader, and cores) on asphalt content, gradation, and percent air voids. Results showed that there is no significant statistical difference in the gradation and percent air voids due to sampling location. A difference was noted for percent asphalt content; however, segregation was observed in the samples obtained from the truck by using a shovel resulting in finer gradation, higher asphalt content, and lower-percent air voids. The study also indicated that samples obtained using the remote truck sampling device had similar properties to samples obtained behind the paver. Elseifi (2007) evaluated the quality control/quality assurance (QC/QA) sampling practices of six highway agencies and determined that sampling behind the paver provides a sample that is more representative of the final product, and many of the states are able to sample at this location without much difficulty.

#### **Production and Compaction Types**

To conduct performance testing on asphalt mixtures, there are different methods employed to fabricate specimens. The ideal method for obtaining a sample representative of field properties is fabrication of specimens from field cores. However, this method is not generally applicable especially when the purpose of testing precedes construction. It is therefore important to fabricate specimens using other methods. Alternative specimen fabrication methods include laboratory mixed laboratory compacted (LMLC), plant mixed laboratory compacted (PMLC), and reheated plant mixed laboratory compacted (RPMLC). Researchers have attempted to study the effect of the various fabrication methods to identify their effect on performance test results as well as to determine which method most closely represents field mixture properties. Johnson et al. (2010) showed that laboratory-produced mixtures containing reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS) are generally stiffer than the corresponding plant-produced mixture as a result of a better blending of the recycled and virgin binders occurring in the laboratory. Mogawer et al. (2012) evaluated plant-produced mixtures containing RAP and showed that RPMLC were significantly stiffer than PMLC. However, with increase in RAP content, the PMLC specimens had a higher increase in stiffness as compared to RPMLC specimens. Rahbar-Rastegar and Daniel (2019) compared the measured properties and cracking behavior of PMLC and LMLC specimens, observing that either fabrication method could produce higher stiffness depending on the plant where the mixture is produced. There was, however, no distinct trend in the cracking behavior. Jacques (2016) showed that specimens fabricated from field cores have lower air void content compared with plant- and laboratory-produced mixtures. Ranking the fabrication methods in terms of mixture stiffness, it was observed that the field cores and RPMLC had the highest stiffness, followed by the LMLC and then the PMLC. Daniel et al. (2018) also observed that there is a difference in the viscoelastic and fatigue properties of LMLC, PMLC, and RPMLC, and the magnitude of the difference is dependent on RAP content and binder performance grade. In the NCHRP Project 09-48, these differences in volumetric and mechanical properties of mixture type were quantified, and conversion factors were recommended. Mechanistic-empirical (M-E) design models were further employed to show that the predicted performance is significantly affected by mixture type (Mohammad et al. 2016).

#### **Conditioning Procedures**

#### Aging

The effects of aging on asphalt mixtures and its implication on cracking performance have been established. Earlier efforts to simulate mixture aging in the laboratory led to the development of the AASHTO R30 standard specification. Researchers have studied the effect of the standard short-term aging protocols of 2 hours at compaction temperature or 4 hours at  $135^{\circ}$ C ( $275^{\circ}$ F) for HMA and 2 hours at  $116^{\circ}$ C ( $240^{\circ}$ F) for warm-mix materials, in an attempt to compare with short-term aging that occurs during production in plant. In a study by Yin et al. (2015), the effect was evaluated through volumetric analysis and performance evaluation by  $M_R$ ,  $E^*$ , and HWT tests. It was observed that the short-term aging protocols were able to simulate the asphalt aging and absorption that occur during plant production and construction. *NCHRP Report 815: Short-Term Laboratory Conditioning of Asphalt Mixtures* also reviewed and confirmed that the current short-term aging protocols are able to simulate plant conditions (Newcomb et al. 2015). Lolly (2013) showed that elevated short-term aging temperature (by  $25^{\circ}$ F) and time (2 and 4 hours) increase the stiffness of the asphalt mixtures measured in terms of dynamic modulus and IDT strength, with increased aging time having more effect.

Over the years, researchers have also attempted to study several existing laboratory long-term aging protocols. The current standard protocol is performed on compacted shortterm aged specimens by placing them in a forced draft oven at  $85^{\circ}\text{C} \pm 3^{\circ}\text{C}$  ( $185^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ) for  $120 \pm 0.5$  h to represent 7 to 10 years of aging in the field. There have, however, been issues observed regarding this standard procedure related to distortion in the specimen geometry and volumetrics as well as an aging gradient in the specimen (Elwardany et al. 2017). As an alternative, researchers have recommended the long-term aging of loose mixtures (Arega et al. 2013, Partl et al. 2013). In the extensive study by Elwardany et al. (2017), the possibility of employing a pressure aging vessel in place of oven aging was explored. It was observed that the application of pressure deformed the compacted specimens. The study also compared the practical implication of aging loose mixtures as opposed to compacted specimen; results showed that there is an advantage in terms of efficiency and specimen integrity. The Asphalt Institute recommends long-term aging loose mixture in the oven for 24 h at 135°C (275°F). However, recent studies have shown that aging asphalt mixtures at temperatures higher than 100°C (212°F) causes changes in the chemistry of the binder and therefore does not adequately reflect field aging (Rad et al. 2017). Findings from the NCHRP Project 9-54 study led to the recommendation for loose mix aging in the oven at 95°C (203°F) (Kim et al. 2018). Rahbar-Rastegar et al. (2018) investigated how mixture properties change with four different long-term aging protocols on loose mixtures and 5 days at 85°C (185°F) on compacted samples. Longer aging protocols of 12 days at 95°C (203°F) and 24 h at 135°C (275°F) produced mixtures with similar rheological properties but different fracture properties. Zhang et al. (2019) evaluated the three loose-mix long-term aging protocols; the study showed that the protocols of 24 h at 135°C (275°F) and 95°C (203°F) for 12 days resulted in similar changes in both rheological and fatigue properties.

#### Moisture Conditioning

Moisture-induced damage has been identified as one the challenging distresses that lead to premature failure in asphalt pavements. To determine the susceptibility of mixtures to moisture-related damage, laboratory conditioning and testing typically follows the established and accepted modified Lottman procedure (AASHTO T 283). However, as a result of inconsistencies in identifying moisture-susceptible mixtures, there are other applicable moisture conditioning procedures. Earlier research to study different moisture conditioning procedures was done by Coplantz and Newcomb (1988), in which four procedures on compacted specimens were evaluated: full vacuum saturation only, full vacuum saturation with one freeze-thaw cycle, 55 to 80% vacuum saturation with one freeze-thaw cycle, and 55 to 80%

vacuum saturation with multiple freeze—thaw cycles. The study reported that there was no evidence of moisture damage to mixtures subjected to only vacuum saturation; however, damage became more severe with an increase in number of freeze—thaw cycles even with lower saturation levels.

Alam et al. (1998), in an attempt to modify the Strategic Highway Research Program Environmental Conditioning System (ECS) (AASHTO TP 34) procedure, evaluated various parameters that could affect the severity of conditioning. It was observed that there was no difference between the ECS saturation and static immersion saturation and that the severity of the conditioning process could be controlled by changing the confining pressure or the chamber temperature. NCHRP Project 9-34 showed that the ECS conditioning procedure is the most promising when evaluated with  $E^*$  test as compared with the TSR or HWT, when compared with field performance (Solaimanian et al. 2007).

In NCHRP Project 9-13, the AASHTO T 283 conditioning procedure was evaluated for its compatibility with Superpave® mix design; specimens were prepared using the Superpave gyratory compactor (SGC) (at 100 mm (4 in.) and 150 mm (6 in.) diameter), Marshall hammer, and Hveem kneading compactor. Results showed that there was no difference in TSR after conditioning with or without freeze—thaw. The study also showed that saturation level (55, 75, or 90%) has a minor effect on the moisture-induced damage (Epps et al. 2000). Sebaaly et al. (2001) reported similar findings that the AASHTO T 283 procedure with or without freeze—thaw had no significant difference in terms of induced damage. Moaveni and Abuawad (2012) compared the modified Illinois DOT and AASHTO T 283 moisture conditioning methods; the study showed that the AASHTO T 283 conditioning resulted in more severe damage as a result of the freeze and thaw cycle included in the procedure. Amelian et al. (2014) employed digital image analysis on specimens subject to the boiling water test and demonstrated a good correlation between these results and TSR and dynamic modulus (|E\*|) ratio after AASHTO T 283 moisture conditioning but not retained Marshall stability.

Figueroa and Reyes (2016) showed that moisture-induced sensitivity test (MIST) conditioning resulted in greater strength reduction as compared with AASHTO T 283 because of vacuum pressure included in the procedure to simulate realistic dynamic load effect. Vishal et al. (2018) also compared the AASHTO T 283 to MIST conditioning for 3,500 cycles at two different temperatures (40°C (104°F) and 60°C (14°F)) and two different pressures (40 psi and 70 psi). In this study, it was observed that the moisture damage done using the AASHTO T 283 conditioning process was similar to the MIST conditioning process at a temperature of 60°C, 40 psi pressure, and 3,500 conditioning cycles.

#### **Laboratory Compaction Method**

In order to simulate field compaction in the laboratory, several laboratory compaction methods and devices have been employed over the years. Several researchers have investigated the existing compaction methods and reported that they produced specimens with significantly different properties and varying trends when correlated with field core properties (Consuegra et al. 1989; Sousa et al. 1991; Button et al. 1994; Khan et al. 1998; Khosla and Sadasivam, 2002; Mbarki et al. 2012; Azari 2014). Additionally, efforts have been made to evaluate the SGC, which is currently the most popular laboratory compaction method. Harvey et al. (2000) showed that laboratory specimens compacted from reheated field mix using the SGC have much greater resistance to permanent shear deformation than do field cores taken from the locations where the field mix was sampled. Epps et al. (2000) evaluated Hveem, Marshall, and SGC compaction methods for specimens of 100 mm (4 in.) in diameter subject to dry and conditioned IDT tests. They found that there were significant differences between the compaction methods for some of the study mixtures.

Solaimanian et al. (1999) evaluated six models of SGC (Rainhart, Troxler, Updated ITC, Test Quip, Pine, and ITC) based on the AASHTO PP 35 procedure and found that all the compactors produce similar results within the 1% air void tolerance level at the design gyration level. As part of the NCHRP Project 9-29 study, five Superpave gyratory compactors (Interlaken, Pine AFGC125X, Pine AFG1, Servopac, and Pine AFGB1A) were compared to determine their effect on  $|E^*|$  and flow number test. Results showed that the effect was insignificant (Bonaquist 2011). Prowell et al. (2003) observed a strong trend between the internal angle of gyration measured by the Dynamic Angle Validation Kit (DAVK) and the resulting compacted sample density for a wide range of SGCs. For all the SGC brands and models evaluated, results showed on average that a change in 0.1 degree of internal angle will result in a change of 0.010 in bulk specific gravity of the mi  $(G_{\rm mb})$  or a difference in air voids of 0.4%. DeVol et al. (2007), in a similar study, compared calibration of SGCs using external angle versus internal angle of gyration; average air voids (target of 4.0%) of 3.81% with a standard deviation of 0.54% were observed via external angle, while the internal angle resulted in average air voids of 3.98% with a standard deviation of 0.50%.

#### **Specimen Parameters**

Specimen parameters (e.g., geometry, size, and air void content) with some tolerance level are typically specified in performance tests. Practically, in fabricating specimens, failure in meeting the specified tolerance level has resulted in rejected specimens. Several studies have been done to determine the necessity of adhering to these specified parameter tolerance levels in different performance tests for consistency in obtained results.

#### Specimen Size and Geometry

Harvey et al. (2000) compared variance of the repeated simple shear test at constant height (RSST-CH) results for cylindrical specimens 150 mm (6 in.) and 200 mm (8 in.) in diameter versus cylinders 150 mm (6 in.) and 200 mm (8 in.) in diameters that were trimmed along the length in the direction of shearing to obtain specimens that were almost prismatic in shape. It was observed that neither increase in diameter nor trimming reduced the variance of the results.

Tandon et al. (2006) showed that measured  $|E^*|$  values on specimens 150 mm (6 in.) in diameter were more consistent than those measured on specimens 100 mm (4 in.) in diameter, especially when the length-to-diameter ratios is less than two. The study also showed that end-friction-reducing layers affect the accuracy and precision of measured dynamic modulus. Bowers et al. (2015), in a study of the use of smaller cylindrical specimens for complex modulus testing, showed that specimens having a diameter and height of  $38 \times 135$  mm (1.5 × 5.3 in.),  $50 \times 135$  mm (2 × 5.3 in.),  $38 \times 110$  mm (1.5 × 4.3 in.), or  $50 \times 110$  mm (2 × 4.3 in.) are suitable alternatives to the full-size specimen for 9.5-mm (3/8-in.) and 12.5-mm (0.5-in.) NMAS mixtures. Only the specimens 50 mm (2 in.) in diameter are suitable alternatives for 19-mm (0.75-in.) and 25-mm (1-in.) NMAS mixtures. Bonaquist (2008), in his ruggedness study for the dynamic modulus and flow number test, indicated that there was no significant difference in the dynamic modulus measurement between milled specimen ends and sawed specimen ends; however, the end conditions have significant effect on flow-number permanent strain.

Epps et al. (2000) found that the dry tensile strengths and TSRs were different between 100 mm (4 in.) and 150 mm (6 in.) SGC specimens. The study also reported differences between SGC and Hveem compaction methods. Saleh (2008) found that resilient modulus is affected by size and geometry; smaller-sized specimens tend to have higher moduli than larger-size specimens. Ahmed et al. (2014) also found that the resilient modulus and indirect tensile strength values of specimens prepared with 100 mm (4 in.) diameter and compacted with a

Marshall hammer were greater than those of specimens prepared with 150 mm (6 in.) diameter and compacted with a gyratory compactor.

Li (2013) studied the effect of specimen size on different types of asphalt-mixture fatigue tests [uniaxial tension and compression (UT/C), four-point bending (4PB), and IDT fatigue tests]. Results showed that the UT/C and IDT fatigue results are not significantly influenced by the specimen size. However, the 4PB test results depend on the dimension of the specimen, because the stress–strain field of the beam specimen varies along the length and cross section. Nsengiyumva et al. (2015) observed that a notch length from 5 mm (0.2 in.) to 25 mm (1 in.) and a specimen thickness of 40 mm (1.6 in.) to 60 mm (2.4 in.) showed good repeatability of SCB fracture energy with small coefficients of variation ( $\leq$  15%).

Porter (2016) studied the effects of three different types of notch geometry (a typical rectangular notch, a semicircular notch, and a fatigue-cracked notch) on the SCB fracture energy. The fracture energy measured with the semicircular notch was greater than that of the standard rectangular notch and is a measure of the crack propagation. The fracture energy measured with fatigue-cracked samples was less than that of the standard rectangular notch and is a more representative measure of both crack initiation and propagation. Barry (2016) observed that the SCB flexibility index increases with decreases in specimen thickness and increases in air voids. Based on the results of the study, correction factors were proposed. In a similar study by Rivera-Perez (2017), the SCB flexibility index was observed to be affected by notch length, and a correction factor was also proposed to account for these differences.

Lee et al. (2017) evaluated test specimen diameters of 75 mm (3 in.) and 100 mm (4 in.) and heights of 130 mm (5.1 in.) and 150 mm (6 in.) to determine an appropriate geometry for the DTCF test specimen; the study showed that specimen height and diameter do not affect the damage characteristic curve but affect the propensity of failure inside the gauge length during testing. Based on the results, a specimen of 100 mm (4 in.) in diameter and 130 mm (5.1 in.) in height with a 70 mm (2.75 in.) gauge length was recommended for testing.

#### Air Voids

Bonaquist (2011) reported that a wider tolerance level of 2% was not a significant factor affecting the reproducibility of either the  $E^*$  or flow number test. Dave et al. (2015) observed a weak positive and negative correlation of effect of air voids levels ranging from 1 to 6% on indirect tensile strength (ITS) and TSR, respectively. Marasteanu et al. (2010) found that there is minimal effect of specimen air void content on DCT, but it significantly affects SCB and IDT test results. Zhao (2011) showed that a decrease of 3% (7% to 4%) in air void content significantly increases rutting performance (using APA) and IDT (strength and fracture energy) but has no significant effect on moisture susceptibility (TSR). Azari (2014) compared the two standard methods of measuring of air voids [AASHTO T 166 (saturated surface dry, SSD) and AASHTO T 331 (CoreLok)], observing that the CoreLok tended to measure higher air void content and is less variable when evaluated inter-laboratory as compared to the SSD measurement. It was highlighted that this could be attributed to the subjectivity in SSD determination.

#### **Specimen Age or Shelf Life**

Minimal research has been conducted to evaluate the effect of specimen age or shelf life (including storage method) on performance test results; however, as a nonstandardized aspect of specimen fabrication, it may contribute to the variability of test results. Bonaquist (2011) showed that specimen age did not affect the dynamic modulus and flow number over the range of 5 to 200 days included in his study. The study included specimens with  $7.0\% \pm 1.0\%$  air void content, and no specific storage preparation was done between fabrication and testing.

#### **Anisotropy**

Over the years, the effect of anisotropy in fabrication of test specimens has been neglected. A few studies have been conducted to evaluate whether the anisotropic effect is significant. Mamlouk et al. (2002) showed that the effects can be ignored for asphalt mixtures fabricated using the SGC. Liang et al. (2006) evaluated specimens fabricated using the roller compactor and cored in the vertical, horizontal, and diagonal (at 45°) directions; the anisotropic behavior of HMA was found to be significant in this study. Kongkitkul et al. (2014), using special molds to compact the mix parallel and horizontal to loading direction, found that the anisotropic effect is significant in the compressive strength and the elastic stiffness of normal HMA and polymer-modified asphalt. Hofko (2013) found that the low-temperature (thermal stress-restrained specimen test), intermediate-temperature (cyclic fatigue), and high-temperature performance (triaxial compression) of HMA fabricated using roller compactors is sensitive to the anisotropy of the material as a result of the coring direction from compacted slabs. Castorena et al. (2017) conducted dynamic modulus and uniaxial cyclic fatigue on small geometry specimens that were cored both horizontally and vertically from SGC specimens. They found that the effect of anisotropy was minimal on measured dynamic modulus and fatigue properties.

## Summary of the Findings from the Literature: National and International Practices for Fabrication of Asphalt Specimens for Performance Tests in Laboratories

A summary of the findings from the literature regarding the impact of specimen fabrication practices on performance test results is presented in Table 1 through Table 9, organized by the various topics covered.

Table 1 summarizes findings on the potential effect of sampling location on performance test results. Based on volumetric evaluation, research has shown that there is little to no statistical difference resulting from choice of sampling location.

Table 2 summarizes the effect of mixture type on performance test results. The literature shows there is an expected difference in mechanical properties based on the mixture type, and the degree of difference is dependent on the plant or laboratory in which the mixture is produced.

The findings on the effect of aging conditioning protocols on performance test results are summarized in Table 3. Based on reported findings, different aging protocols can result in significantly different properties that can be captured by different performance tests. Age conditioning protocols that best simulate plant and field aging are recommended by various research studies.

Table 1. Effect of sampling location.

References	Major Findings	Performance Test Employed
Hassan (2002)	No statistical difference in asphalt content of samples obtained from the different locations (at the plant with a tube sampler, at the point of delivery, and behind the paver).	NA
Turner and West (2006)	Little statistical difference in the laboratory properties (volumetrics) as a result of sampling location (except for percent asphalt content).	NA
Elseifi (2007)	Sampling behind the paver provides a sample that is more representative of the final product and is being conducted by states without much difficulty.	NA

Note: NA = No performance tests were conducted in the study.

Table 2. Effect of mixture type.

References	Major Findings	Performance Test Employed
Johnson et al. (2010)	Laboratory-produced recycled mixtures are generally stiffer than the corresponding plant-produced mixture as a result of a better blending of the recycled and virgin binders occurring in the laboratory.	E*
Mogawer et al. (2012)	RPMLC materials were significantly stiffer than PMLC. With increase in RAP content, the PMLC had a higher increase in stiffness as compared to RPMLC.	E*
Jacques (2016)	Field cores have lower air void content compared to plant and laboratory-produced mixtures. Field cores and RPMLC had the highest stiffness followed by the LMLC and then the PMLC.	E*
Mohammad et al. (2016)	Recommended conversion factors for the difference in volumetric and mechanical properties of mixture type.	$HWT, E^*, IDT$
Daniel et al. (2018)	There is a difference in the viscoelastic and fatigue properties of LMLC, PMLC, and RPMLC, and the magnitude of the difference is dependent on RAP content and binder performance grade.	E*, DTCF
Rahbar-Rastegar and Daniel (2019)	Either PMLC or LMLC could produce higher stiffness depending on the plant where the PMLC is produced. No distinct trend in fatigue cracking behavior.	E*, DTCF

Table 3. Effect of aging conditioning protocols.

References	Major Findings	Performance Test Employed
Arega et al. (2013) and Partl et al. (2013)	Recommended the long-term aging of loose mixtures.	Not applicable
Lolly (2013)	Elevated short-term aging temperature (by 25°F) and time (2 and 4 hours) increase the stiffness of the asphalt mixtures measured in terms of dynamic modulus and IDT, with increased aging time having more effect.	$E^*$ , IDT
Elwardany et al. (2017)	Current standard long-term aging protocol of compacted specimen results in issues related to distortion in the specimen geometry and volumetrics as well as an aging gradient in the specimen. Use of a pressure aging vessel in place of oven aging to expedite aging deforms the compacted specimens. There is an advantage in terms of efficiency and specimen integrity on aging loose mixtures as opposed to compacted specimens.	E*, DTCF
Yin et al. (2015) and Newcomb et al. (2015)	Current standard short-term aging protocols are able to simulate the asphalt aging and absorption that occur during plant production and construction.	$M_R, E^*, HWT$
Kim et al. (2018)	Recommendation for loose mix aging in the oven at 95°C. Various times depending on climate location and pavement layer depth.	E*, DTCF
Rad et al. (2017)	Aging asphalt mixtures at a temperature over 100°C cause changes in the chemistry of the binder and therefore do not adequately reflect field aging.	E*, DTCF
Rahbar-Rastegar et al. (2018)	Aging loose mix for 5 days at 95°C simulated more aged properties than compacted specimen for 5 days at 85°C did. Longer aging protocols of 12 days at 95°C and 24 h at 135°C produced mixtures with similar rheological properties but different fracture properties.	E*, DCT, SCB
Zhang et al. (2019)	Aging protocols of 24 h at 135°C and 95°C for 12 days resulted in similar changes in both rheological and fatigue properties.	E*, DTCF, DCT, SCB

Table 4 summarizes the effect of moisture conditioning protocols on performance test results. The research indicates that discrepancies in results depend on the performance test and/or conditioning protocol employed.

The effect of compaction methods on performance test results is summarized in Table 5. The literature indicates that the different existing compaction methods result in varying mechanical properties. The literature also recommends to routinely calibrate the compaction devices for better precision and repeatability.

Table 6 summarizes the effect of specimen size and geometry on performance test results. The findings suggest that test result precision, typically related to stiffness characterization and flow and fracture properties, may be affected by specimen geometry and size. However, performance tests used to characterize fatigue behavior are not affected.

Table 7 summarizes the effect of specimen air voids on performance test results. Some tests results may be significantly affected by a minor change in air voids, whereas other tests can accommodate a wider air void tolerance level.

As listed in Table 8, the little research that has been published to evaluate the effect of storage or shelf life on performance test results indicates that it has no significant effect.

The literature related to effect of anisotropy on performance test results is summarized in Table 9. There are conflicting results from the literature as to whether anisotropy has a significant impact on measured mechanical properties.

Table 4. Effect of moisture conditioning protocols.

References	Major Findings	Performance Test Employed
Coplantz and Newcomb (1988)	There is no evidence of moisture damage to mixtures subjected to only vacuum saturation; however, damage becomes more severe with increase in the number of freeze–thaw cycles even with lower saturation levels.	$M_R$ , IDT
Alam et al. (1998)	There was no difference between the ECS saturation and static immersion saturation. Severity of the ECS conditioning process could be controlled by changing the confining pressure or the chamber temperature.	$M_R$
Epps et al. (2000) and Sebaaly et al. (2001)	There is no difference in TSR after conditioning with or without freeze-thaw. Saturation level has minor effect on the moisture-induced damage.	$TSR, M_R$
Solaimanian et al. (2007)	ECS conditioning procedure is the most promising when evaluated with dynamic modulus test to simulate field performance as compared to the TSR or HWT.	E*, TSR, HWT
Moaveni and Abuawad (2012)	AASHTO T 283 conditioning results in more severe moisture- induced damage as a result of the freeze–thaw cycle included in the procedure compared with the modified Illinois DOT, which does not include the freeze–thaw cycle.	TSR
Amelian et al. (2014)	There is a good correlation of the results of boiling water test to TSR and  E*  stiffness ratio but not retained Marshall stability after AASHTO T 283 moisture conditioning.	TSR, E*, Marshall Stability
Figueroa and Reyes (2016)	MIST conditioning results in more strength reduction as compared to AASHTO T 283 because of vacuum pressure included in the procedure to simulate realistic dynamic load effect.	TSR, Trapezoidal Fatigue
Vishal et al. (2018)	Moisture-induced damage using AASHTO T 283 conditioning process was similar to the MIST conditioning process at 60°C temperature, 40 psi pressure, and 3,500 conditioning cycles.	TSR, Marshall Stability

Table 5. Effect of compaction methods.

References	Major Findings	Performance Test Employed
Consuegra et al. (1989)	Five compaction devices were evaluated for mixtures from five projects; the Texas gyratory compactor was found to most closely correlate with field cores.	$M_R$ , ITS, and static creep
Sousa et al. (1991)	The compaction method was found to significantly affect measured properties; various methods were more or less sensitive to aggregate and asphalt characteristics.	FBF, IDT fatigue, creep in axial compression and shear
Button et al. (1994)	Four compaction methods were evaluated and compared to field cores; the Texas gyratory compactor was found to most closely simulate the field cores, but there were no statistically significant differences among the compaction types.	IDT, $M_R$ , Marshall stability, Hveem stability, repeated creep
Khan et al. (1998)	Five compaction methods were evaluated for four mixtures; the SGC with 1.25° angle of gyration was found to best represent field cores.	$M_R$ , static creep
Solaimanian et al. (1999)	Six different models of SGC (Rainhart, Troxler, Updated ITC, Test Quip, Pine, and ITC) produce similar results within the 1% air void tolerance level at the design gyration level.	NA
Harvey et al. (2000)	RPMLC specimens using the SGC have much greater resistance to permanent shear deformation than do field cores taken from the locations where the field mix was sampled.	RSST-CH
Khosla and Sadasivam (2002)	Mixtures from four field sites were evaluated using SGC and rolling wheel compactor (RWC); the RWC was found to most closely simulate field cores.	Frequency sweep test at constant height, repeated shear test at constant height, APA, North Carolina State University wheel tracking device
Epps et al. (2000)	There are differences between 100 mm SGC-, Marshall-, and Hveem-compacted specimens.	IDT, TSR
Prowell et al. (2003)	There is a strong trend between the internal angle of gyration measured by the DAVK and the resulting compacted sample density for a wide range of SGCs.	NA
DeVol et al. (2007)	Calibration of SGCs using internal-angle-of-gyration results in a more accurate and precise (closer to target and less variation) density as compared to use of external angle of gyration.	NA
Bonaquist (2011)	There is an insignificant difference in the result of dynamic modulus and flow number test conducted on specimens compacted using five different Superpave gyratory compactors (Interlaken, Pine AFGC125X, Pine AFG1, Servopac, Pine AFGB1A).	$E^*$ , Flow number
Mbarki et al. (2012)	There are significant differences between specimens cored horizontally from field cores and laboratory-compacted specimens.	DTCF
Azari (2014)	Comparison of SGC and kneading slab compactor showed differences depending on the measurements used for evaluation and the quality of the mixture.	HWT

Note: NA = No performance tests were conducted in the study.

Table 6. Effect of specimen size and geometry.

References	Major Findings	Performance Test Employed
Harvey et al. (2000)	An increase in diameter or trimming along the length of specimen does not appear to reduce the variance of the RSST-CH results.	RSST-CH
Epps et al. (2000)	Dry tensile strengths and tensile strength ratios were different between 100-mm and 150-mm SGC specimens.	IDT, TSR
Tandon et al. (2006)	Specimen geometry and the end-friction-reducing layers affect the accuracy and precision of dynamic modulus.	E*
Bonaquist (2008)	There is no significant difference in the dynamic modulus measurement between milled specimen ends and sawed specimen ends; however, the end conditions have significant effect on flow-number permanent strain.	$E^*$ , Flow number
Saleh (2008)	Resilient modulus is affected by size and geometry. Smaller- size specimens tend to have higher moduli than larger-size specimens.	$M_R$
Li (2013)	UT/C and IDT fatigue results are not significantly influenced by the specimen size. However, the 4PB test results depend on the dimension of the used specimen because the stress–strain field of the beam specimen varies along the length and cross section.	UT/C fatigue, IDT fatigue, 4PB fatigue
Ahmed et al. (2014)	The resilient modulus and indirect tensile strength values of specimens prepared with 100 mm diameter and compacted with Marshall hammer are greater than those of specimens prepared with 150 mm diameter and compacted with gyratory compactor.	$M_R$ , IDT
Nsengiyumva et al. (2015)	A notch length from 5 mm to 25 mm and a specimen thickness of 40 mm to 60 mm shows good repeatability of SCB fracture energy with small COVs ( $\leq$ 15%).	SCB
Bowers et al. (2015)	Small-scale cylindrical specimens having a diameter and height of $38 \times 135$ mm, $50 \times 135$ mm, $38 \times 110$ mm, and $50 \times 110$ mm are suitable alternatives to the full-size specimen for 9.5- and 12.5-mm NMAS mixtures. Only the 50-mm diameter specimens are suitable alternatives for 19- and 25-mm NMAS mixtures.	E*
Porter (2016)	Fracture energy measured with the semicircular notch was greater than that of the standard rectangular notch and is recommended to be a measure of solely the crack propagation while that measured with fatigue-cracked samples was less than that of the standard rectangular notch and is a more representative measure of both crack initiation and propagation.	SCB
Barry (2016)	SCB Flexibility Index increases with decrease in specimen thickness and increase in air voids. Correction factors are proposed.	SCB
Lee et al. (2017)	Specimen height and diameter do not affect the damage characteristic curve but affect the propensity of failure inside the gauge length during testing.	DTCF
Rivera-Perez (2017)	Proposed a new correction factor to account for difference in SCB test specimen notch length.	SCB

Table 7. Effect of specimen air voids.

References	Major Findings	Performance Test Employed
Marasteanu et al. (2010)	Minimal effect of specimen air void content on DCT, but significantly affects SCB and IDT test results.	DCT, IDT, SCB
Bonaquist (2011)	A wider tolerance air void level of 2% was not a significant factor affecting the reproducibility of either the dynamic modulus or flow number test.	E*, Flow number
Zhao (2011)	A difference of 3% (7% to 4%) in air void content significantly increases rutting performance and IDT (strength and fracture energy) but has no significant effect on moisture susceptibility (TSR).	APA, IDT, TSR
Azari (2014)	The AASHTO T 331 (CoreLok) method tends to measure higher air void contents and is less variable when evaluated inter-laboratory as compared to the AASHTO T 166 (SSD) method. This could be attributed to the subjectivity in SSD determination.	NA
Dave et al. (2015)	There is a weak positive and negative correlation of effect of air void level of range of 1 to 6% on ITS and TSR, respectively.	ITS, TSR

Note: NA = No performance tests were conducted in the study.

Table 8. Effect of shelf life.

References	Major Findings	Performance Test Employed
Bonaquist (2011)	Specimen age does not affect the dynamic modulus and flow number test (over the range of 5 to 200 days included in this study).	E*, Flow number

Table 9. Effect of anisotropy.

References	Major Findings	Performance Test Employed
Mamlouk et al. (2002)	Anisotropic effects can be ignored for specimens fabricated using the Superpave gyratory compactor.	Compression and tensile strength test
Liang et al. (2006)	The anisotropic behavior of HMA was found to be significant.	Confined static and dynamic triaxial compression test
Kongkitkul et al. (2014)	The anisotropic effect on the compressive strength and the elastic stiffness is significant for normal HMA and polymer-modified asphalt.	Triaxial compression test
Hofko (2013)	Low-, intermediate-, and high-temperature performance of HMA fabricated using roller compactors is sensitive to the anisotropy of the material as the result of compaction direction.	Thermal Stress Restrained Specimen Test (TSRST), cyclic IDT fatigue, triaxial cyclic compression test
Castorena et al. (2017)	The effects of anisotropy on dynamic modulus and uniaxial cyclic fatigue results obtained from vertically and horizontally cored small specimens are minimal.	SSG E*, SSG cyclic fatigue



## State of the Practice

A survey on practices related to fabrication of specimens for asphalt performance testing was distributed to state DOTs, Canadian provinces, and partner laboratories. A total of 80% of state DOTs, along with the District of Columbia, provided a response to the survey; no responses were received from Canadian provinces. Twenty-nine partner laboratories responded to the survey and are included in the analysis. The state DOT survey (referred to as "agency survey" throughout this chapter) is presented in Appendix A, along with the survey responses in Appendix B. The partner laboratory survey is also presented in Appendix A, and the partner laboratory survey responses are in Appendix C. The agency and partner laboratory survey responses are presented together for each question below.

## State of the Practice Related to the Use of Asphalt Laboratory Performance Tests

Many state DOTs (33/40) reported that they prepare asphalt concrete specimens for laboratory performance testing. This specimen preparation and testing is conducted either in house at agency laboratories or at consultant or university laboratories in the relative proportions shown in Figure 3. The survey data show that most (16/27) partner laboratories conduct performance tests for multiple agencies as shown in Figure 4.

Figure 5 and Figure 6 summarize the types of performance tests that agencies and partner laboratories report conducting, respectively. The Other category for agencies includes various forms of TSR (similar to AASHTO T 283), Thermal Stress Restrained Specimen Test (TSRST, AASHTO TP 10), Loaded Wheel Tester (different from APA or HWT), MIST (ASTM D 7890), Marshall Flow and Stability, Hveem Stability, Bending Beam Rheometer (BBR) Beam Sliver Test (AASHTO TP 125), Interlayer Bond Strength Test, Stress Sweep Rutting Test (AMPT), and Permeability Test. The other category for partner laboratories includes various forms of BBR Sliver Test (AASHTO TP 125),  $M_R$ ,  $C^*$  Fracture Test, Repeated Simple Shear Test (AASHTO T 320), flexural frequency sweep part of AASHTO T 321,  $N_{flex}$  IDT as proposed by the National Center for Asphalt Technology (NCAT), Oregon Field Torque Test, Interlayer Shear Strength (AASHTO TP 114), IDT  $E^*$  Test, Repeated Load Creep Recovery Test, Static Creep Test, and TSR (similar to AASHTO T 283). The HWT, SCB, and  $E^*$  tests are reported to be the most commonly run tests by both agencies and partner laboratories. The partner laboratories reported running a wider variety of performance tests, while agency responses were typically limited to one or two test types.

The number of agencies reporting that they use particular tests for mix design acceptance, in quality assurance processes, and routinely for research purposes is summarized in Figure 7, Figure 8, and Figure 9, respectively. Figure 10 summarizes the tests that agencies report are used

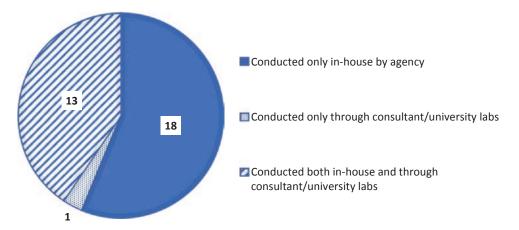


Figure 3. Performance testing location reported by agencies.

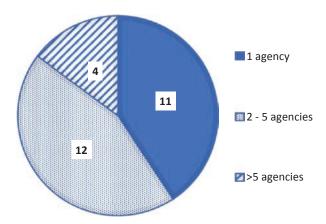


Figure 4. Number of agencies for which partner labs conduct performance tests.

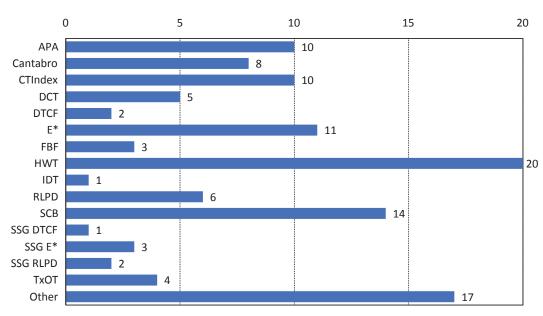


Figure 5. Performance tests that were conducted in house or by other entities that were used by agencies.

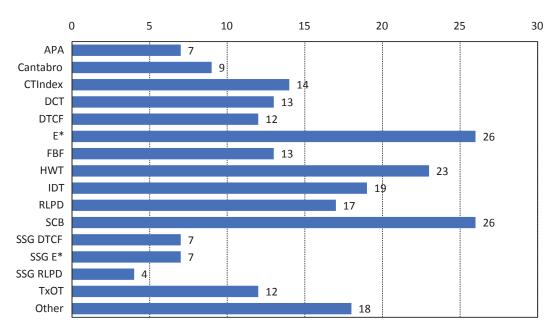


Figure 6. Number of partner labs conducting performance tests.

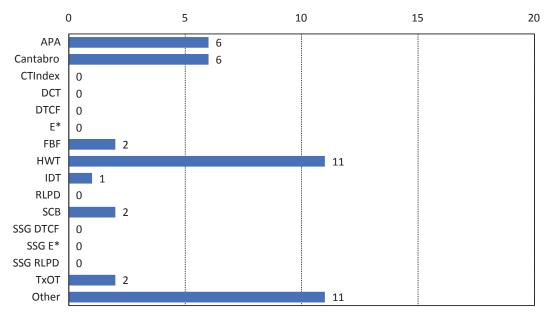


Figure 7. Number of agencies using performance tests for mix design acceptance.

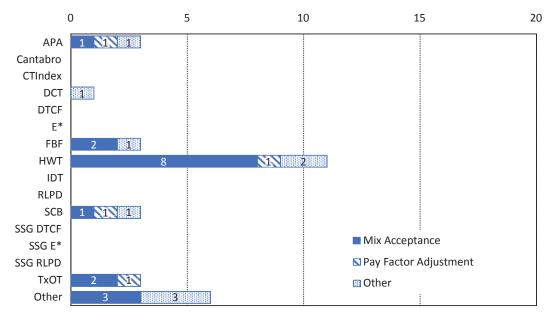


Figure 8. Number of agencies using performance tests for quality assurance processes.

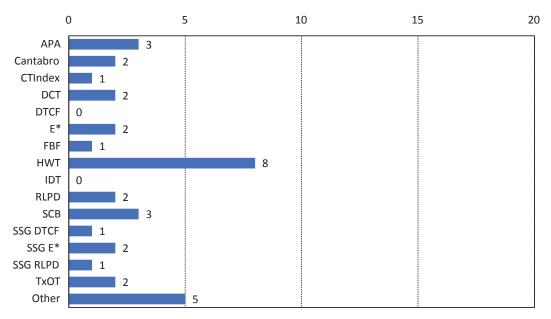


Figure 9. Number of agencies routinely using performance tests for research.

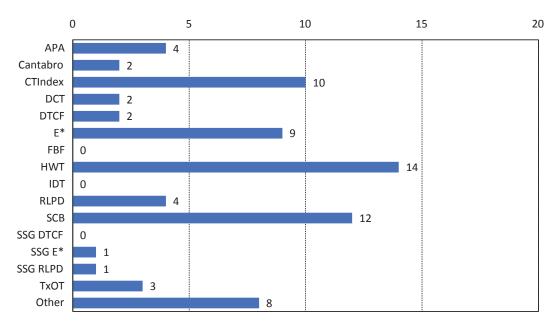


Figure 10. Number of agencies nonroutinely using performance tests for research or other purposes.

nonroutinely for research or other purposes. The uses of tests falling into the "other" category are summarized in Table 10. Agencies reported that most of the performance testing is conducted for mix design acceptance with lower proportions being conducted for QA and routine research; a broader range of tests are reported to be run on a nonroutine basis. Partner laboratories reported that over two-thirds (70%) of the performance testing is conducted for research purposes and the remaining conducted for mix design, mix acceptance, QA processes, or pay factor adjustments.

# Specimen Fabrication Practices for Laboratory Asphalt Performance Testing

Table 11 and Table 12 show the percentage of agencies and partner laboratories that use each piece of equipment in the fabrication of test specimens based on the number of agencies or partner laboratories using each test (e.g., 20% of agencies that fabricate APA specimens use a mix splitter in the fabrication process). The gyratory compactor is used almost exclusively for fabricating laboratory performance-test specimens in both agency and partner laboratories.

Table 10. Agency reported uses of "other" tests.

Performance Test Type	Mix Design Acceptance	Quality Assurance Processes	Routine Research	Nonroutine
BBR beam sliver				Х
Hveem stability	X	X		
Indirect tensile strength ratio	X	X	X	X
Interlayer bond strength		X	X	X
Loaded wheel	X			
Marshall flow and stability	X			
Moisture-induced sensitivity test				X
Permeability	X			
Stress sweep rutting			X	
Thermal stress restrained specimen				X

Table 11. Equipment used by agencies to fabricate performance test specimens.

	Equipment									
Test Type	Mix Splitter	Superpave Gyratory Compactor	Oven	Rotary Saw	Coring Drill	Core Drying Device	Gluing Templates	Gluing Jigs	Temperature Conditioning Chamber	Vacuum-Bag Sealing Device
APA	20% (2)	70% (7)	60% (6)	10% (1)	0% (0)	0% (0)	0% (0)	0% (0)	20% (2)	10% (1)
Cantabro	13% (1)	75% (6)	88% (7)	0% (0)	0% (0)	25% (2)	0% (0)	0% (0)	25% (2)	38% (3)
CTIndex	50% (5)	90% (9)	90% (9)	30% (3)	0% (0)	30% (3)	0% (0)	0% (0)	40% (4)	30% (3)
DCT	0% (0)	40% (2)	20% (1)	40% (2)	20% (1)	0% (0)	20% (1)	0% (0)	40% (2)	0% (0)
DTCF	50% (1)	100% (2)	100% (2)	100% (2)	100% (2)	0% (0)	50% (1)	100% (2)	100% (2)	0% (0)
E*	18% (2)	91% (10)	82% (9)	73% (8)	64% (7)	36% (4)	45% (5)	64% (7)	73% (8)	9% (1)
FBF	0% (0)	33% (1)	67% (2)	67% (2)	0% (0)	0% (0)	33% (1)	33% (1)	67% (2)	0% (0)
HWT	55% (11)	95% (19)	90% (18)	90% (18)	10% (2)	20% (4)	0% (0)	0% (0)	20% (4)	15% (3)
IDT	0% (0)	100% (1)	100% (1)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	100% (1)	0% (0)
RLPD	17% (1)	83% (5)	83% (5)	83% (5)	83% (5)	17% (1)	17% (1)	33% (2)	83% (5)	0% (0)
SCB	50% (7)	79% (11)	79% (11)	79% (11)	0% (0)	21% (3)	0% (0)	0% (0)	57% (8)	14% (2)
SSG DTCF	100% (1)	100% (1)	100% (1)	100% (1)	100% (1)	100% (1)	0% (0)	100% (1)	100% (1)	100% (1)
SSG E*	33% (1)	33% (1)	33% (1)	67% (2)	100% (3)	33% (1)	67% (2)	100% (3)	100% (3)	33% (1)
SSG RLPD	0% (0)	0% (0)	0% (0)	50% (1)	100% (2)	0% (0)	50% (1)	50% (1)	100% (2)	0% (0)
TxOT	0% (0)	100% (4)	100% (4)	100% (4)	25% (1)	25% (1)	25% (1)	100% (4)	75% (3)	0% (0)
Other	59% (10)	76% (13)	88% (15)	29% (5)	35% (6)	24% (4)	6% (1)	12% (2)	59% (10)	24% (4)

Note: Percentage of agencies that reported fabricating specimens for tests. Numbers within parentheses report actual responses.

Several agencies did report use of other compactor types (e.g., kneading compactor or Marshall hammer) but these were rare cases. The survey data show that ovens, saws, and temperature chambers are also frequently used pieces of equipment in the specimen fabrication process.

The percentage of agencies and partner laboratories using standard, modified standard, or nonstandardized/in-house procedures for fabricating specimens for each test are shown in Figure 11 and Figure 12, respectively Primarily, agencies reported that ASTM or AASHTO standards are followed as is or with some modifications. In-house procedures are reported for only a few test types. Most often, partner laboratories reported that standardized procedures are followed by either modified or in-house procedures and are used less than 30% of the time for most tests. Over 80% of agencies and 93% of partner laboratories reported that standard dimensions are used in the fabrication of specimens for performance testing.

The agency survey data showed that RPMLC and LMLC are the most common material types used for fabricating performance test specimens and that plant mixed, field compacted (PMFC or field cores) are used about half as frequently as the other types (Figure 13). Partner laboratories reported that laboratory mix is the most common material used to fabricate performance test specimens, followed by reheated plant mix and field cores (Figure 14). This is likely a result of the fact that partner laboratories conduct performance tests for research more often than for the QA process. The type of material used and broken down by test type is shown for agency and partner laboratories in Figure 15 and Figure 16, respectively. The three material types are used for all tests by partner laboratories.

Table 12. Equipment used by partner laboratories to fabricate performance test specimens.

	Equipment									
Test Type	Mix Splitter	Superpave Gyratory Compactor	Oven	Rotary Saw	Coring Drill	Core Drying Device	Gluing Templates	Gluing Jigs	Temperature Conditioning Chamber	Vacuum-Bag Sealing Device
APA	29% (2)	86% (6)	71% (5)	14% (1)	14% (1)	43% (3)	0% (0)	0% (0)	71% (5)	43% (3)
Cantabro	22% (2)	89% (8)	100% (9)	11% (1)	11% (1)	56% (5)	0% (0)	0% (0)	44% (4)	56% (5)
CTIndex	43% (6)	100% (14)	100% (14)	43% (6)	14% (2)	50% (7)	0% (0)	0% (0)	100% (14)	57% (8)
DCT	54% (7)	100% (13)	92% (12)	92% (12)	69% (9)	38% (5)	77% (10)	15% (2)	92% (12)	38% (5)
DTCF	50% (6)	100% (12)	92% (11)	92% (11)	92% (11)	75% (9)	92% (11)	92% (11)	92% (11)	67% (8)
E*	38% (10)	100% (26)	96% (25)	92% (24)	85% (22)	65% (17)	69% (18)	54% (14)	92% (24)	58% (15)
FBF	62% (8)	38% (5)	92% (12)	92% (12)	15% (2)	38% (5)	38% (5)	8% (1)	92% (12)	23% (3)
HWT	39% (9)	100% (23)	96% (22)	91% (21)	9% (2)	39% (9)	9% (2)	4% (1)	74% (17)	35% (8)
IDT	37% (7)	100% (19)	95% (18)	89% (17)	32% (6)	47% (9)	74% (14)	37% (7)	89% (17)	47% (9)
RLPD	47% (8)	100% (17)	94% (16)	88% (15)	88% (15)	65% (11)	47% (8)	35% (6)	88% (15)	47% (8)
SCB	35% (9)	100% (26)	96% (25)	96% (25)	15% (4)	58% (15)	23% (6)	12% (3)	96% (25)	42% (11)
SSG DTCF	57% (4)	86% (6)	71% (5)	86% (6)	86% (6)	86% (6)	86% (6)	86% (6)	86% (6)	43% (3)
SSG E*	57% (4)	86% (6)	71% (5)	86% (6)	86% (6)	86% (6)	86% (6)	29% (2)	86% (6)	43% (3)
SSG RLPD	50% (2)	100% (4)	75% (3)	75% (3)	75% (3)	75% (3)	75% (3)	25% (1)	75% (3)	25% (1)
ТхОТ	25% (3)	100% (12)	92% (11)	92% (11)	17% (2)	58% (7)	42% (5)	67% (8)	92% (11)	33% (4)
Other	22% (4)	67% (12)	78% (14)	72% (13)	50% (9)	61% (11)	28% (5)	22% (4)	72% (13)	61% (11)

Note: Percentage of partner laboratories that reported fabricating specimens for tests. Numbers within parentheses report actual responses.

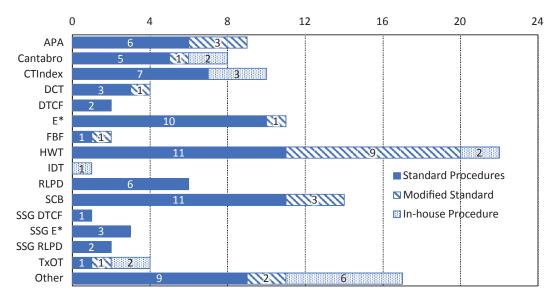


Figure 11. Number of agencies using different types of standards for specimen fabrication of performance test specimens.

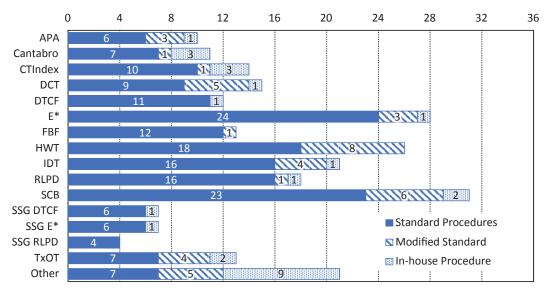


Figure 12. Number of partner labs using different types of standards for specimen fabrication of performance test specimens.

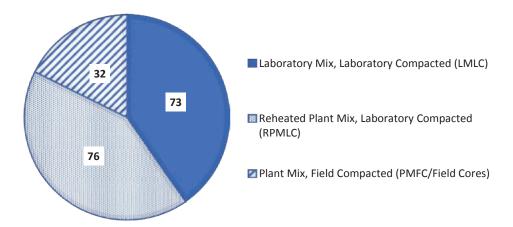


Figure 13. Types of mix that agencies use in fabrication of performance test specimens.

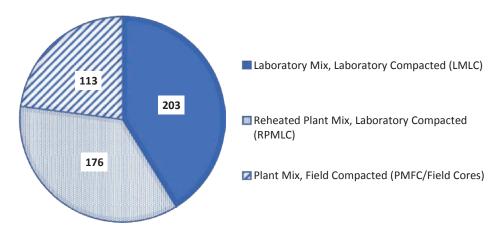


Figure 14. Types of mix that partner labs use in fabrication of performance test specimens.

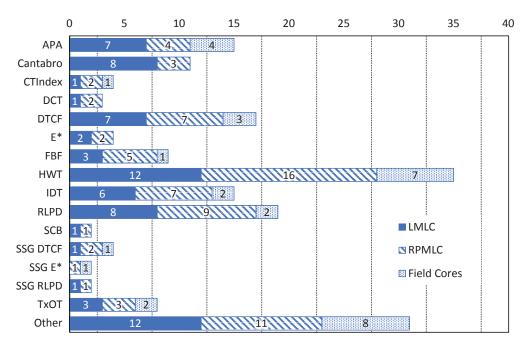


Figure 15. Types of mix that agencies use in fabrication of performance test specimens by test type.

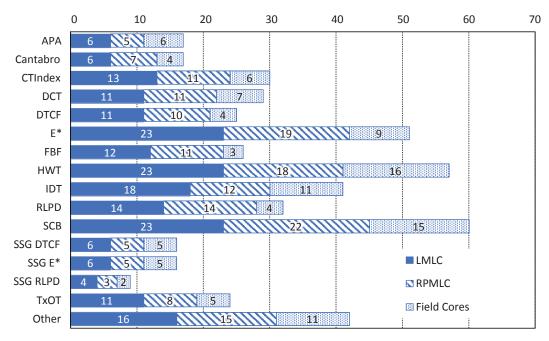


Figure 16. Types of mix that partner labs use in fabrication of performance test specimens by test type.

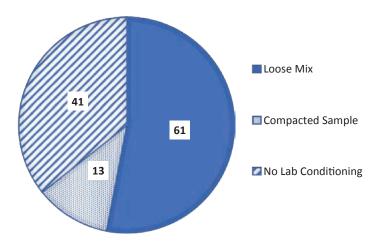


Figure 17. Distribution of agency lab practices with respect to laboratory conditioning during specimen fabrication for performance testing (no agencies reported both loose mix and compacted sample conditioning for a test type).

With respect to laboratory conditioning of asphalt mixtures during the specimen fabrication process, 37% of agency survey responses indicated no laboratory conditioning, whereas the remaining 63% of responses indicated a preference for the use of loose mix aging (Figure 17). The partner laboratories indicated that loose-mix conditioning is the most prevalent in the fabrication of performance test specimens and only 9% of entities utilized unconditioned test specimens (Figure 18). A more detailed presentation of the survey data from agencies and partner laboratories regarding laboratory conditioning is provided in Figure 19 and Figure 20, respectively. Apart from the SSG RLPD, at least one agency conducts some form of laboratory conditioning during the performance-test specimen-fabrication process for each test type. The data clearly show that the use of laboratory conditioning during the specimen fabrication process is extensively used by partner laboratories for various performance tests.

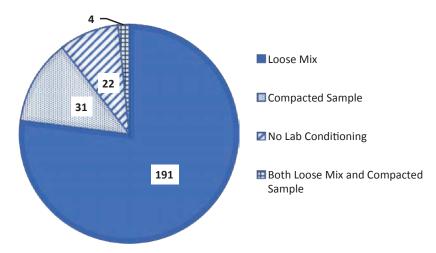


Figure 18. Distribution of partner laboratory practices with respect to laboratory conditioning during specimen fabrication for performance testing.

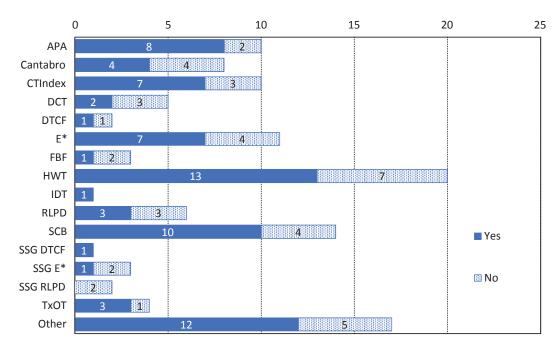


Figure 19. Number of agency labs conducting laboratory conditioning during specimen fabrication of performance test specimens.

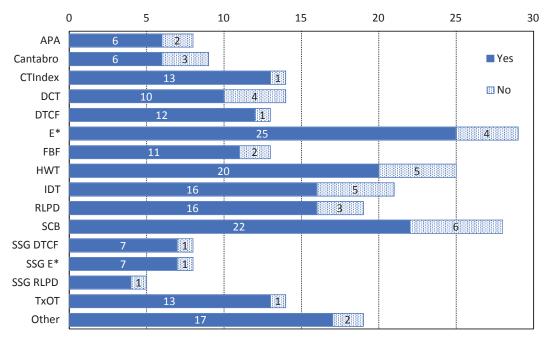


Figure 20. Number of partner labs conducting laboratory conditioning during specimen fabrication of performance test specimens.

A detailed breakdown of the distribution between loose mix and compacted sample laboratory conditioning procedures adopted by agencies and partner laboratories is plotted in Figure 21 and Figure 22, respectively. The survey data indicated that loose-mix conditioning is more often adopted by agencies in the performance-test specimen-fabrication process than conditioning of compacted samples. The only exception to this observation is for the FBF test; however, only three agencies responded for this test method. The SCB and IDT tests are the only ones with more than 25% of partner laboratories using compacted specimens for the laboratory conditioning process.

For the tests where agencies utilize a loose mix laboratory conditioning process, the AASHTO R 30 short-term aging protocol (4 hours of loose mix laboratory conditioning at 135°C (275°F)) is followed 59% of the time (Figure 23) while it is followed almost 90% of the time by partner laboratories (Figure 24). A more detailed distribution regarding use of the AASHTO R 30 short-term laboratory-conditioning protocol by test type is plotted in Figure 25 and Figure 26. Apart from IDT and TxOT, the AASHTO R 30 short-term, laboratory-aging protocol is favored by at least half of the agencies for all other tests. Evaluation of the survey data on loose-mix laboratory-conditioning processes other than AASHTO R 30 protocol revealed that the majority adopt 2 hours of laboratory conditioning (as opposed to 4 hours recommended by AASHTO R 30) and in many instances use the mix compaction temperature for laboratory conditioning [as opposed to temperature of 135°C (275°F) recommended by AASHTO R 30]. An alteration of laboratory conditioning time to 2 hours and/ or conditioning temperature to mix compaction temperatures accounts for nine of the 25 "other process" response in Figure 23. The most common processes other than AASHTO R 30 short-term laboratory aging used by partner laboratories are 8, 16, and 24-h conditioning at 135°C (275°F).

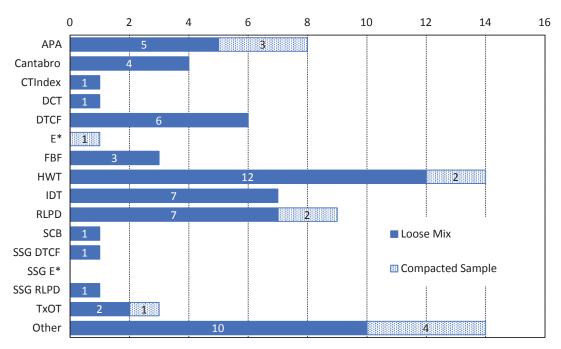


Figure 21. Use of loose mix versus compacted samples by agency labs for laboratory conditioning of performance test specimens (shown by test type).

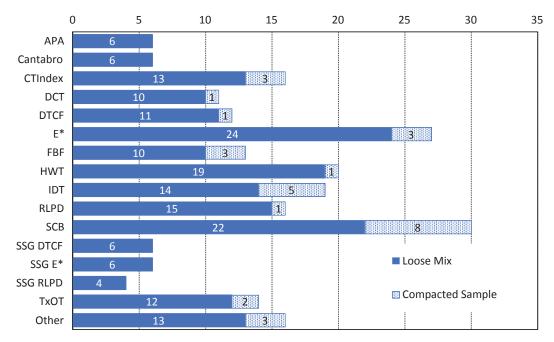


Figure 22. Use of loose mix versus compacted samples by partner labs for laboratory conditioning of performance test specimens (shown by test type).

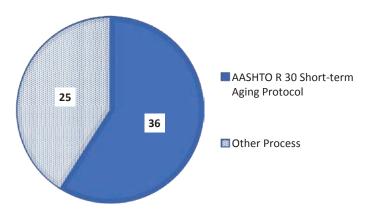


Figure 23. Loose-mix laboratory-conditioning procedure used by agency labs during performance-test specimen fabrication.

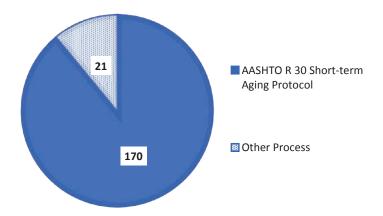


Figure 24. Loose-mix laboratory-conditioning procedure used by partner labs during performance-test specimen fabrication.

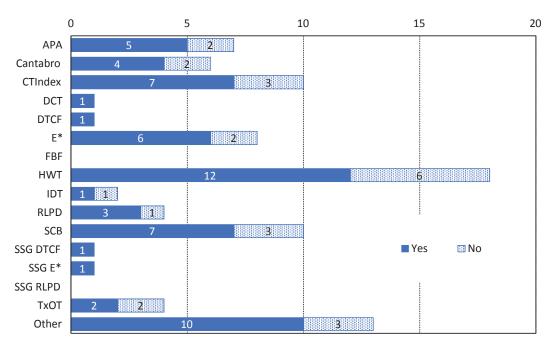


Figure 25. Number of agencies using AASHTO R 30 short-term aging protocol for loose-mix laboratory conditioning.

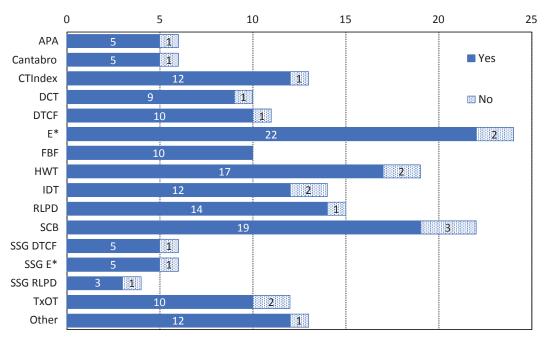


Figure 26. Number of partner labs using AASHTO R 30 short-term aging protocol for loose-mix laboratory conditioning (by test type).

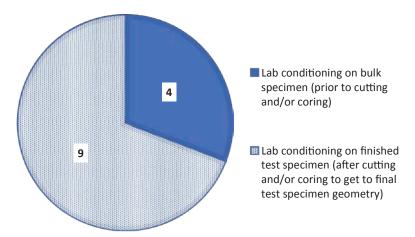


Figure 27. Distribution of agency laboratory practices regarding laboratory conditioning of compacted specimens.

For survey respondents indicating that they use laboratory conditioning on compacted-asphalt-mix specimens, the survey subsequently collected information on whether conditioning is conducted on bulk specimens (prior to cutting and/or coring) or on finished test specimens. The overall distribution of survey data shows that compacted-mix laboratory conditioning is most often conducted on finished test specimens (Figure 27 and Figure 28). Only 15% of agencies indicated that they use the AASHTO R 30 long-term laboratory aging procedure [5 days at 85°C (185°F)], while most partner laboratories use this procedure, as shown in Figure 29 and Figure 30. When agencies do not use the AASHTO R 30 long-term laboratory aging protocol, the laboratory conditioning on compacted specimens involves a shorter duration (typically 2 to 4 hours) of conditioning of the specimen at the test temperature. The type of specimen used for conditioning by partner laboratories is broken down by test type in Figure 31.

Survey results indicate that over 90% of agencies and partner lab practices for performance-test specimen fabrication require a target air void level (Figure 32 and Figure 33). The only exceptions to the target air void requirement were some instances of the Cantabro test and the SSG  $E^*$  and RLPD tests. One agency using small-scale geometry tests indicated that these

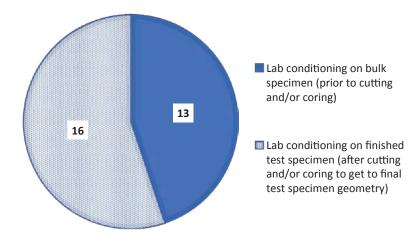


Figure 28. Distribution of partner laboratory practices regarding laboratory conditioning of compacted specimens.

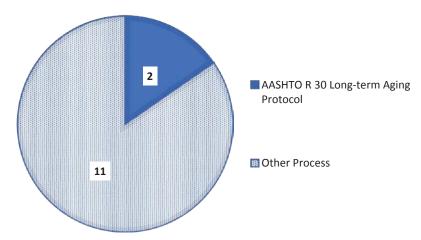


Figure 29. Preference of agency labs regarding protocol for long-term laboratory conditioning of compacted specimens for performance testing.

are often conducted on field cores, and thus air voids are not targeted during the specimen fabrication process.

Figure 34 and Figure 35 show the distribution of agency and partner laboratory air void requirements with respect to AASHTO/ASTM specifications and use of air void requirement on bulk sample versus finished test specimen, respectively. Most agencies and partner laboratories follow the recommendations provided in AASHTO and ASTM test methods for the corresponding performance test. For the remainder, agencies more frequently target air voids on bulk specimens, while partner laboratories target air voids on final test specimens.

With respect to the target air void level, the survey data showed that 7% is the most commonly adopted value by agencies and partner laboratories, as seen in Figure 36 and Figure 37. The other target air void levels used by agencies are 4, 5, and 6%; while partner laboratories use 5 and 8% target air voids. Agencies most commonly use a tolerance of  $\pm$  1% on target air voids (Figure 38) while the majority of partner laboratories allow  $\pm 0.5\%$  tolerance (Figure 39).

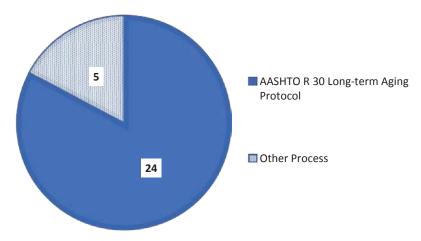


Figure 30. Preference of agency labs regarding protocol for long-term laboratory conditioning of compacted specimens for performance testing.

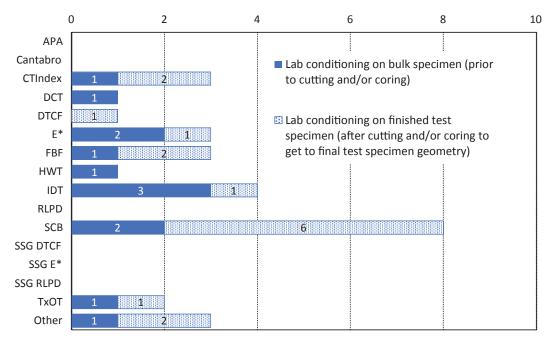


Figure 31. Distribution of partner laboratory practices regarding laboratory conditioning of compacted specimens (by test type).

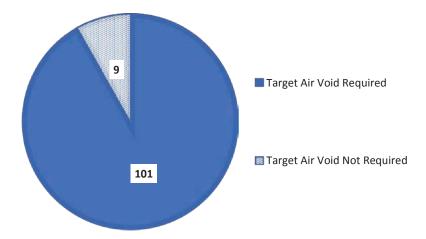


Figure 32. Distribution of agency laboratory practices regarding requirements of target air void level for performance test specimens.

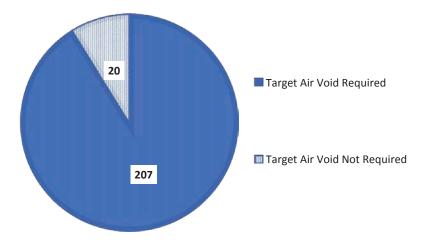


Figure 33. Distribution of partner laboratory practices regarding requirements of target air void level for performance test specimens.

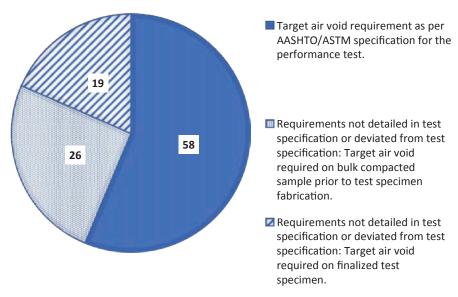


Figure 34. Agency laboratory practices regarding target air void requirements for performance test specimens.

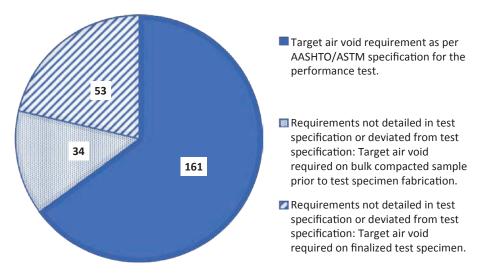


Figure 35. Partner laboratory practices regarding target air void requirements for performance test specimens.

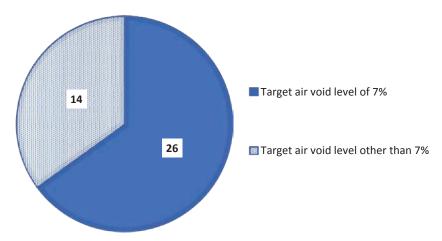


Figure 36. Target air void level requirements for performance test specimens as used by agency labs.

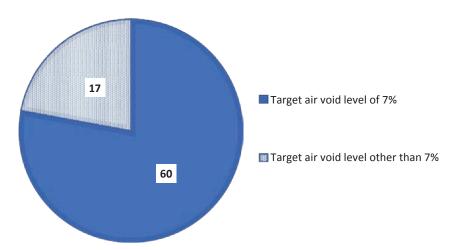


Figure 37. Target air void level requirements for performance test specimens as used by partner labs.

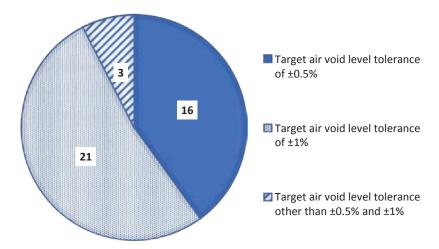


Figure 38. Allowable tolerances to target air void level for performance test specimens as used by agency labs.

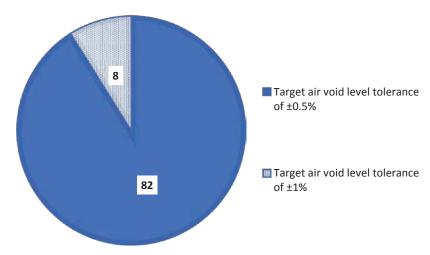


Figure 39. Allowable tolerances to target air void level for performance test specimens as used by partner labs.

Survey data for agency and partner-laboratory practices regarding maximum allowable storage times during the performance-test specimen-fabrication process are documented in Table 13 and Table 14, respectively. The majority of agencies do not have a fixed maximum allowable storage time, while a substantially larger number of partner laboratories reported that they have restrictions on the maximum storage times. For example, only one out of 11 agencies that use the  $E^*$  test reported that they limit the maximum storage time between finalized-test-specimen preparation and mechanical testing as opposed to nine partner laboratories having such restriction (out of 29 that conduct this test). Furthermore, the partner lab practices have more maximum allowable storage limitations during each phase of the specimen fabrication process. The most commonly used storage-time restriction by agencies is between the finalized-test-specimen fabrication and mechanical testing (most often a 1-day limit). Comments provided by agency survey takers indicated that a majority of agencies attempt to fabricate performance test specimens as soon as their laboratory operations allow. The results in Table 14 also illustrate that there is a very wide range of storage time limits in use by partner laboratories; even within the same category and for the same test laboratories have limits ranging from 3 days to 180 days.

The survey results regarding the preparation of mixture and test specimens for storage are shown in Figure 40 and Figure 41. The majority of agency respondents indicated that no specific preparations are undertaken for storage of samples and specimens. Most partner laboratories reported that they do not use any preparation method to store test specimens, but many store loose mixture in an airtight container prior to compaction. Partner lab responses for "other" preparation methods for storage included use of wax-lined boxes, storage in metal containers (unsealed) in climate-controlled spaces, and storage in coolers and freezers.

## **Challenges and Knowledge Gaps**

Both agencies and partner laboratories reported that the most frequent challenge encountered in fabrication of performance test specimens is meeting the air void requirements on the bulk or test specimens, as shown in Figure 42 and Figure 43. This is followed by challenges meeting dimensional requirements, equipment issues, and operator training. While these are the most common issues faced in the fabrication of test specimens, many agencies also commented

Table 13. Agency-reported allowable maximum storage times during performance-test specimen-fabrication process.

		Number of Agencies with Requirement for Maximum Storage Times Before, During, and After Specimen Fabrication for the Performance Tests (allowable maximum storage times in days)					
Test Type	Number of Agencies Using the Test	Between Loose-Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (Bulk) Specimen and Finalized Test Specimen	Between Finalized - Test- Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if Multiple Tests Are Conducted on Same Specimens)		
APA	10	NA	NA	1 (1)	1 (1)		
Cantabro	8	NA	NA	NA	NA		
CTIndex	10	1 (1)	NA	2 (1, 3)	NA		
DCT	5	NA	NA	NA	NA		
DTCF	2	NA	NA	NA	NA		
<i>E</i> *	11	NA	1 (3)	NA	NA		
FBF	3	NA	NA	NA	NA		
HWT	20	1 (1)	1 (1)	2(1,3)	1 (2)		
IDT	1	NA	NA	1 (3)	NA		
RLPD	6	NA	NA	NA	NA		
SCB	14	1 (1)	1 (1)	1 (1)	1 (2)		
SSG DTCF	1	NA	NA	1 (14)	NA		
SSG E*	3	NA	NA	1 (14)	NA		
SSG RLPD	2	NA	NA	NA	NA		
TxOT	4	NA	NA	NA	NA		
Other	17	3 (1/6, 1)	2 (1, 1)	2 (1, 14)	1 (2)		

Note: Maximum number of days allowed for storage is shown in parentheses. NA = No performance tests were conducted in the study.

that these issues were relatively infrequent. Less than 20% of partner laboratories reported that meeting dimensional requirements, operator training, and shelf storage times are frequent issues. Temperature tolerances and ambient laboratory conditions were not reported as frequent challenges.

Only half of the agencies reported that they track specimen rejection rates, while 80% of partner laboratories track them. Those agencies that track rejection rates reported that they range from 5 to 25%, with 10 to 15% being the most commonly reported range. Partner laboratories

Table 14. Partner laboratory reported allowable maximum storage times during performance-test-specimen fabrication process.

		Number of Partner Laboratories with Requirement for Maximum Storage Times Before, During, and After Specimen Fabrication for the Performance Tests (allowable maximum storage times in days)						
Test Type	Number of Partner Labs Using the Test	Between Loose - Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (Bulk) Specimen and Finalized Test Specimen	Between Finalized -Test- Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if Multiple Tests Are Conducted on Same Specimens)			
APA	8	2 (3, 30)	1 (5)	1 (5)	NA			
Cantabro	9	1 (5)	2 (5,7)	2 (5, 30)	NA			
CTIndex	14	4 (3, 30, 180)	6 (3, 5, 7)	7 (1, 3, 5, 7, 10, 30)	2 (7)			
DCT	14	1 (3)	2 (3, 5)	4 (2, 3, 10, 30)	1 (7)			
DTCF	13	3(5, 30, 180)	3 (3, 3, 14)	3 (2, 10, 14)	2 (2, 14)			
E*	29	6 (3, 30, 180)	8 (3, 5, 7, 14)	9 (2, 3, 5, 7, 10, 14, 30)	5 (2, 3, 7, 90)			
FBF	13	4 (3, 30, 180)	4 (3, 5, 7)	5 (2, 5, 10, 30)	1 (14)			
HWT	25	4 (3, 30, 180)	6 (3, 5, 7)	7 (2, 3, 5, 10, 30)	1 (7)			
IDT	21	3 (3, 5, 30)	5 (3, 5)	6 (2, 3, 5, 10)	2 (7, 14)			
RLPD	19	4 (3, 30, 180)	6 (3, 5, 7)	7 (2, 3, 5, 7, 10, 30)	2 (7)			
SCB	28	4 (3, 30, 180)	6 (3, 5, 7)	7 (2, 3, 5, 10, 30)	1 (7)			
SSG DTCF	8	2 (3, 180)	1 (14)	1 (14)	1 (2)			
SSG E*	8	2 (3, 180)	1 (14)	1 (14)	2 (2, 90)			
SSG RLPD	5	1 (3)	NA	NA	NA			
TxOT	14	3 (3, 5)	4 (3, 5, 7)	5 (2, 3, 5, 10)	NA			
Other	19	3 (3, 180)	5 (1, 3, 7)	3 (7, 30)	1 (7)			

Note: Maximum number of days allowed for storage is shown in parentheses. NA = No performance tests were conducted in the study.

reported that rejection rates typically range from 5% to 20%, with a few reporting higher numbers. A total of 83% of agencies reported that they are satisfied with the current rejection rate, and those that are not satisfied reported that rejection rates less than 5% to 10% are desired. Partner laboratories noted that the rejection rate depends on operator experience and the type of specimen being fabricated. A total of 90% of the partner laboratories are satisfied with the current rejection rate.

Almost 30% of agencies and 40% of the partner laboratories reported that they have observed gaps in knowledge that make it challenging to successfully fabricate performance

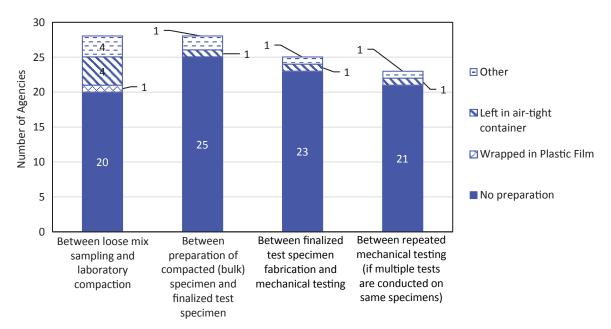


Figure 40. Distribution of agency practices with respect to preparation of performance test specimens for storage (data labels show number of responses for each option).

test specimens. The reported gaps include limited guidance on achieving air void ranges (including variation within gyratory specimens and measurement methodology), allowable time frames for testing, and laboratory aging protocols. Agencies also included the need for staff training and experience. Several agencies also reported that they are relatively new to specimen fabrication for performance testing and expect that continued experience will increase confidence and consistency. Several partner laboratories also questioned the necessity of some of the tolerances and the impact of this variability on the measured properties.

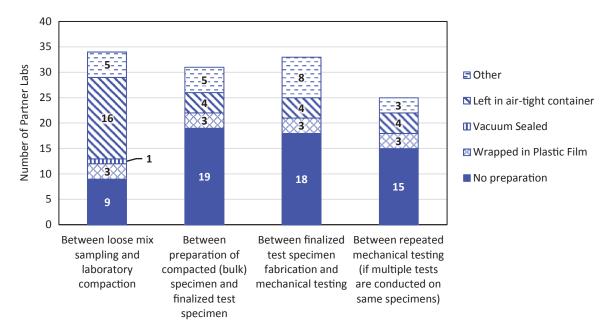


Figure 41. Distribution of partner lab practices with respect to preparation of performance test specimens for storage (data labels show number of responses for each option).



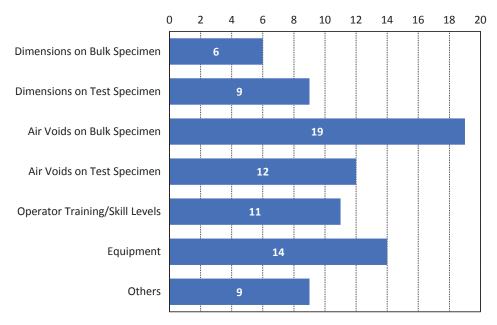


Figure 42. Most frequent issues agencies encountered in fabricating specimens.

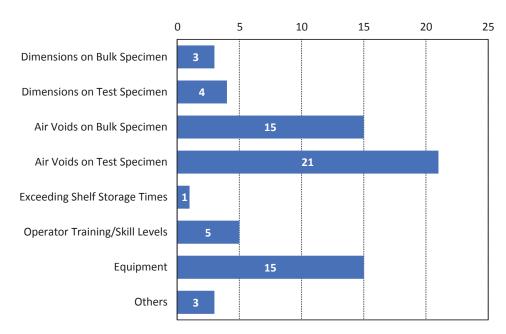


Figure 43. Most frequent issues partner labs encountered in fabricating test specimens.

Only eight agencies reported that they are currently sponsoring or planning to sponsor research related to the fabrication of laboratory specimens for performance testing. The descriptions of research provided in the survey responses indicate that these agencies are looking at performance-engineered mixture design approaches, various testing types, and long-term aging in the laboratory.

## **Chapter Summary**

The survey indicated that the majority of state agencies (33/40) fabricate specimens for asphalt-mixture performance tests; the fabrication and tests are conducted both in-house and at partner laboratories. With the exception of the APA, HWT, and Cantabro tests, most agencies indicated that performance tests are run most often for research purposes or on a nonroutine basis. Most of the partner laboratories (16/27) responding to the survey indicated that they fabricate specimens and conduct performance tests for more than one agency.

Both agency and partner laboratories reported that a gyratory compactor is used almost exclusively for fabricating laboratory performance-test specimens and that ovens, saws, and temperature chambers are also frequently used pieces of equipment. ASTM or AASHTO standards as written or with some modifications are primarily used for fabrication of test specimens by both agency and partner laboratories.

Agencies reported that RPMLC and LMLC material types are most commonly used (with equal frequency) to fabricate performance test specimens, while partner laboratories report that LMLC material is used most frequently. Loose-mix conditioning following the AASHTO R 30 short-term aging procedure is most commonly used by both agency and partner laboratories. For laboratories that condition compacted specimens, agency results indicate that this is most often performed on final test specimens using a process other than AASHTO R 30, while most partner laboratories report that they use AASHTO R 30.

Most laboratories have air void requirements for fabrication of performance test specimens, with the most common target air void level being 7%. However, agencies reported a typical tolerance of  $\pm 1\%$ , while most partner laboratories report a tolerance of  $\pm 0.5\%$ . The survey results indicated that most agencies do not have storage time restrictions and do not have specific preparation requirements for mixture samples or specimens. Many agencies indicated that specimens are fabricated and tested as quickly as operations allow. More partner laboratories reported storage time restrictions at various phases of performance-test specimen fabrication, but the limits are widely variable (1 to 180 days). Partner laboratories reported that loose mix is commonly stored in airtight containers prior to compaction.

The most frequent challenge in fabricating performance test specimens reported by both agencies and partner laboratories is meeting air void requirements. Approximately half of the agencies and 80% of the partner laboratories reported that they track rejection rates; typical rejection rates are reported to be 5 to 25%, with 10 to 15% being most common.

Almost 30% of agencies and 40% of partner laboratories reported they have observed gaps in knowledge that make it challenging to successfully fabricate performance test specimens. The reported gaps include staff training and experience, limited guidance on achieving air void ranges, allowable time frames for testing, and laboratory aging protocols.



CHAPTER 4

# **Case Examples**

The states of Arizona, Illinois, Maine, Montana, and Texas were the five states selected for more detailed investigation. There were a number of reasons why these states were selected to be focus states. All selected states indicated a willingness to participate in follow-up case example interviews, and they represent a geographic distribution that includes both cold and warm climates and also represent a range of agency sizes. The states of Illinois, Maine, and Texas have been very active in conducting various types of performance testing of asphalt specimens. Table 15 summarizes the types of tests used by each case example state and the purposes for which they are used.

During each case example interview, state agency representatives were asked to clarify and elaborate on their survey responses; there were standard additional questions asked of each agency and also questions unique to particular agencies depending upon the methods and tests used. The sections below provide the detailed case-example information for each selected state regarding mixture types, sampling and handling procedures, specimen fabrication equipment and procedures, and challenges.

#### Arizona

The Arizona Department of Transportation (Arizona DOT) reported that they prepare specimens and conduct laboratory performance testing. Arizona DOT conducts the HWT and the SCB test following the Illinois Flexibility Index Test (I-FIT) protocol (AASHTO TP 124) for research purposes on a nonroutine basis. They also fabricate specimens for university partners to run complex modulus, direct-tension cyclic-fatigue, and flow number tests for research projects.

## **Mixture Types, Sampling, and Handling Procedures**

Arizona DOT reported that reheated plant mix is used to fabricate specimens for all performance tests; the mixture is sampled following AASHTO T 168. They have a specific procedure for preparing and splitting field samples (ARIZ 416e, included in Appendix E). The procedure explains the use of a mechanical (clamshell) or quartermaster splitter to reduce material to the appropriate size for sampling. A closed-end sampler (Figure 44) is used to obtain the appropriate amount of material in the laboratory for specimen fabrication.

ARIZ 416e (see Appendix E) also describes the protocol for reheating material with limits on temperatures and time. Samples may be stored for indefinite periods of time at temperatures not exceeding  $140^{\circ}$ F. If necessary, the sample may be heated at  $290 \pm 10^{\circ}$ F for a maximum of 3 hours. The 3-hour time period begins when the oven reaches the specified temperature. Also,

Table 15. Test types and purpose for case example states.

Performance Test	Arizona	Illinois	Maine	Montana	Texas
Cantabro	-	-	-	-	Mix design acceptance
CTIndex	-	-	Nonroutine research	-	Routine research
E*	-	-	-	-	Nonroutine research
HWT	Nonroutine research	Mix acceptance and routine research	Routine research, mix design acceptance, and QA mix acceptance on select projects	Routine research, mix design acceptance, and QA mix acceptance	Routine research, mix design acceptance, and QA mix acceptance
IDT	-	-	-	-	Mix design acceptance
RLPD	-	-	Routine research	-	-
SCB	Nonroutine research	Mix acceptance and Routine research	-	-	-
SSG DTCF	-	-	Routine research	-	-
SSG E*	-	-	Routine research	-	-
ТхОТ	-	-	-	-	Routine research, mix design acceptance, and QA mix acceptance

Note: Hyphens indicate that the state does not use or conduct the test.

the material may be reheated for a maximum of 1 hour at a temperature not exceeding 300°F to restore pliability during sampling.

Arizona DOT reports that no laboratory conditioning is performed on mixtures or specimens beyond what is required for temperature conditioning with the HWT and SCB test procedures. They do not have procedures for preparing material for storage, and there are no requirements for maximum storage times beyond what the test specifications dictate. Typically testing is conducted immediately after specimens are fabricated, but loose mix can be stored for 4 to 8 weeks in rare cases.







Figure 44. Photographs of Arizona closed-end sampler (courtesy of Arizona DOT).

### **Specimen Fabrication Equipment and Procedures**

Arizona DOT reported that a Superpave gyratory compactor is used for all specimen fabrication although 90% of their mixtures are designed using the Marshall approach. Density requirements for the HWT and SCB test are as per the specification. They reported challenges meeting density in fabricating the 160-mm-tall specimens for SCB testing and they have observed inconsistencies in the air void distribution over the height of these specimens. Mix splitters, ovens, and rotary saws are used for all specimen fabrication.

#### **Challenges**

Arizona DOT reported that the most frequent issue they encounter in the specimen fabrication process is that air void requirements in the bulk specimens are not met for the SCB specimens; typically, the air void levels are too high, which they attribute to the taller specimens. However, they do not track rejection rates.

No gaps in knowledge that make it challenging to fabricate performance test specimens in-house have been observed, and Arizona DOT does not have plans to sponsor any research that addresses this issue. They do see a need for performance testing of friction courses, which they use extensively.

## Illinois

The Illinois Department of Transportation (Illinois DOT) responded that they prepare specimens and conduct laboratory performance testing; the acceptance activities are conducted in-house only by the agency. Illinois DOT routinely conducts the Illinois modified HWT (AASHTO T 324), Illinois modified I-FIT version of the SCB (AASHTO TP 124), and the Illinois modified Lottman test (AASHTO T 283) for mix acceptance and for research purposes.

## **Mixture Types, Sampling, and Handling Procedures**

For the three performance tests conducted by Illinois DOT, LMLC, PMLC, and RPMLC as well as field-cored materials are used to fabricate test specimens.

Illinois DOT reports that mixtures are sampled according to the agency's manual of test procedures (attached in Appendix E); the sampling location is dependent on the project tonnage per mixture. The sampling location for plant-mixed materials is either behind the paver or from a material transfer vehicle (MTV). An agency-specific material blending and splitting procedure is adopted by Illinois DOT. The procedure is comparable to the AASHTO R 47 and is described in detail in the Level 1 training manual for technicians (Appendix E). Illinois DOT reported the DOT prefers the riffle splitter of the various available splitting devices.

Illinois DOT did not report a specific procedure for reheating plant-produced loose mixtures for compaction in the laboratory. The short- and long-term specimen conditioning procedures depend on the test. For HWT, Illinois DOT does not conduct any laboratory conditioning besides that conducted on laboratory-produced mixture during the volumetric mix design process on HMA. For the I-FIT procedure, loose-mix conditioning of laboratory-produced mixes similar to the conditioning during the volumetric mix design is done. An additional 2 hours of laboratory conditioning is applied to WMA mixtures for both HWT and I-FIT procedures. Thereafter, fully prepared I-FIT specimens (compacted, cut, and notched) are subjected to long-term oven aging at 95°C (203°F) for 3 days. The conditioning is conducted by placing finalized test specimens face down (notched side facing toward the pan) in a metal pan lined with a barrier material. Illinois DOT has found that parchment paper is a relatively reusable, inexpensive barrier material. The conditioning temperature and time was selected on the basis of research sponsored by Illinois DOT that evaluated different aging times and temperatures. Illinois DOT also reported that the choice of conducting long-term oven aging on the finalized test specimen is partly driven by practicality (not having to redo volumetrics post-oven aging, and the like). The Illinois modified AASHTO T 283 procedure eliminates the freezing component of the moisture conditioning procedure, resulting in a conditioning process that involves 24-h soaking in 60°C (140°F) water bath for compacted, saturated specimens.

At present, Illinois DOT does not have a fixed storage duration time for plant-produced loose mix. The agency reported that test specimen fabrication happens as soon as possible from the time of mix sampling. If needed, Illinois DOT generally stores plant-produced loose mix in cloth bags or other storage containers. Previous Illinois DOT—sponsored and in-house research studies have shown that shelf aging of test specimens is not found to impact results of performance tests adopted by them if tested within approximately 3 weeks. The agency reported that once test specimens are fabricated, the testing is conducted very soon thereafter.

#### Specimen Fabrication Equipment and Procedures

Illinois DOT reported having agency-required modifications to the specimen fabrication requirements in the AASHTO specified procedures for HWT (AASHTO T 324), I-FIT (AASHTO TP 124), and moisture susceptibility using TSR (AASHTO T 283). All performance test specimens are compacted by Illinois DOT using the SGC with 150 mm diameter. Illinois DOT targets an air void level for both I-FIT and HWT test specimens to be  $7.0 \pm 1.0\%$ . The Illinois DOT manual of test procedures for materials (Appendix E) provides guidance regarding the bulk gyratory specimen air void level to achieve the target air void level in test specimens. For example, a 9.5-mm (3/8-in.) NMAS mix is recommended to be compacted to achieve gyratory-pill air void content in the range of 7.3 to 7.7% to meet the I-FIT—test-specimen air void target of  $7.0 \pm 1.0\%$ . For the Illinois modified Lottman procedure, the target air void level for test specimens of  $7.0 \pm 1.0\%$  is used. In addition to the current AASHTO TP 124

dimensional requirements for I-FIT test specimens, Illinois DOT reported requiring a maximum notch width of 2.25 mm (0.09 in.) and an allowable notch depth of  $15 \pm 1$  mm (0.6  $\pm$  0.04 in.).

Illinois DOT reported that ovens, rotary saws, and a core drying device are used for all specimen fabrication as necessary. A water bath is also used for equilibrating I-FIT specimen temperature.

## **Challenges**

Illinois DOT reported that the most frequent issues they encounter in the specimen fabrication process is failure of bulk and prepared specimens to meet dimensional or air void requirements. They also reported that there are infrequent occurrences of operational disruptions with respect to test specimen fabrication, and they have observed a low specimen rejection rate.

Illinois DOT reported that their previous research efforts on asphalt performance test specimen fabrication included both dense-graded and SMA mixtures to ensure that research is applicable to both types of mixtures. They are currently collecting air void information on SMA bulk specimens and finalized test specimens to develop guidance for their testing manual. Illinois DOT also noted that at present there is a lack of information on performance testing requirements for cold mixes.

#### Maine

The Maine Department of Transportation (Maine DOT) reported that they prepare specimens and conduct laboratory performance testing; these activities are conducted in house only. Maine DOT routinely conducts the HWT, SSG *E*\*, SSG DTCF, and RLPD for research purposes. The HWT is also conducted for mix design acceptance and QA mix acceptance on select projects. Maine DOT reported that the CTIndex test is conducted for research purposes on a nonroutine basis.

## **Mixture Types, Sampling, and Handling Procedures**

Maine DOT reported that reheated plant mix is used to fabricate specimens for all performance tests; laboratory-mixed and laboratory-compacted material is used to fabricate specimens for CTIndex, HWT, SSG  $E^*$ , SSG DTCF, and RLPD testing. Field cores are only used to fabricate specimens for the CTIndex testing.

Maine DOT reported that mixture is typically sampled from the MTV or paver hopper, though material for the AMPT testing can also be obtained from the truck at the plant. They use a quartermaster on-site for splitting the newly sampled material into cardboard sample boxes.

Maine DOT has a specific procedure (included in Appendix E) for the HWT. This procedure details temperatures and times for reheating plant material for fabrication of the HWT specimens. Maine DOT reported that they try to keep reheating to a minimum, and while they do not have specific procedures written for other test types, the procedure outlined for the HWT specimens is typically followed for the fabrication of all specimens. After mixture is reheated in the laboratory, Maine DOT uses a quartermaster twice and then a riffle splitter to achieve the appropriate mixture quantity for HWT and CTIndex specimen fabrication. For fabricating the SSG  $E^*$ , SSG DTCF, and RLPD specimens, a quartermaster is used twice.

Loose-mixture laboratory conditioning following the AASHTO R 30 short-term aging protocol is conducted by Maine DOT for all laboratory-produced mixtures used to fabricate specimens.

Maine DOT reported that the DOT wraps loose mix in plastic film for storage prior to laboratory compaction and that no other storage preparation is done between further specimen preparation steps. The plastic film is the most efficient method for the cardboard sampling boxes that are used. They reported that there are no requirements for maximum storage times for the HWT and CTIndex test specimens. Maine DOT requires that mechanical testing be conducted within 30 days of specimen fabrication for the SSG  $E^*$ , SSG DTCF, and RLPD tests. If specimens will be stored for more than 14 days prior to testing, they are wrapped and sealed either with plastic film (cut and cored specimens) or in a cylinder mold (bulk specimens). Maine DOT reported that these time limits were based on guidance from North Carolina State University to limit the amount of aging of the specimens and the potential impact on the results.

## **Specimen Fabrication Equipment and Procedures**

Maine DOT reported that a Superpave gyratory compactor is used for all specimen fabrication. Density requirements for the HWT and CTIndex test are as per the specification. The target air void levels for the SSG  $E^*$  and SSG DTCF tests are  $5\% \pm 0.7\%$ , and are  $5\% \pm 0.5\%$  for the RLPD test. These values are based on their specified target in-place density of  $5\% \pm 2.5\%$ . Maine DOT reported that 95% of the HWT specimens and 99% of the RLPD specimens meet density requirements.

Maine DOT reported that they have approximately a 25% failure rate with the small geometry specimens meeting density requirements, with more difficulty with the larger NMAS materials. They typically observe a 10% to 15% failure rate with 9.5-mm (3/8-in.) material and up to 40% with 19-mm (3/4-in.) material. Because of this, Maine DOT is considering using the larger specimen size for 19-mm (3/4-in.) mixtures in the future. Maine DOT technicians have developed a database of compaction information ( $G_{mm}$ , mass, gyration level, air void) for different materials that has helped improve the success rate of meeting density requirements over time. As a result of their experiences, Maine DOT no longer measures the density of the bulk specimen.

Maine DOT reported that ovens, rotary saws, and a core drying device are used for all specimen fabrication. Gluing templates and jigs, a temperature conditioning chamber, and a vacuum sealing device are used for SSG  $E^*$ , SSG DTCF, and RLPD testing.

#### **Challenges**

Maine DOT reported that the most frequent issue they encounter in the specimen fabrication process is that air void requirements of the final test specimen are not met; no bias has been observed on the high or low side. They also reported issues with specimen fabrication equipment. They have experienced challenges with asphalt-rich base materials and gap-graded rubber mixtures, particularly with gumming of core barrels.

Maine DOT reported that they have not observed any gaps in knowledge that make it challenging to fabricate performance test specimens in-house and do not have plans to sponsor any research that addresses this issue. They are considering testing on cold mixtures in the future.

#### **Montana**

The Montana Department of Transportation (Montana DOT) reported that they prepare specimens and conduct laboratory performance testing; these activities are conducted in house only. Montana DOT routinely conducts the HWT for mix design acceptance and QA mix acceptance, as well as routine research purposes.

## **Mixture Types, Sampling, and Handling Procedures**

Montana DOT reported that laboratory-mixed and laboratory-compacted material, field cores, and reheated plant mix are used to fabricate specimens for the HWT. The plant material is typically sampled behind the paver or from the windrow (Figure 45) using the procedures outlined in MT 303 (included in Appendix E) and the material is transported in containers constructed to minimize heat loss, contamination, or damage to the sample from mishandling during shipment. Montana DOT reported that they do not have specific protocols for reheating cooled mixture, but attempt to minimize reheating as much as possible. They follow AASHTO T 312 to maintain compaction temperature for gyratory specimens compacted at the plant; if the paving job is close enough to the central laboratory, material will be brought there for compaction prior to cooling. AASHTO R 47 is used to reduce samples to the appropriate size for fabrication.

Loose-mixture laboratory conditioning following the AASHTO R 30 short-term aging protocol is conducted by Montana DOT for all laboratory-produced mixtures used to fabricate specimens.

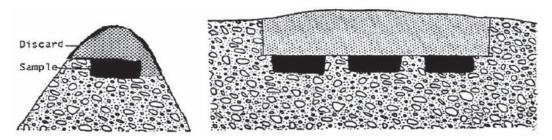
Montana DOT reported that they do not specify any kind of preparation for storage. They reported that there are no requirements for maximum storage times but that they are committed to providing paving acceptance results within 7 business days. Typically, mix-design verification testing is completed within a day of compaction, and plant-mix gyratory specimens are tested within 3 to 4 days of compaction.

#### **Specimen Fabrication Equipment and Procedures**

Montana DOT reported that specimens are fabricated using a kneading compactor (MT 335, included in Appendix E) in the main laboratory and a gyratory compactor at the plants.

Montana DOT has a specific procedure for the HWT (MT 334, included in Appendix E). This procedure details procedures for preparing HWT specimens using laboratory-produced mix, compacted slabs, gyratory specimens, and field cores. These procedures include guidance on specimen thickness and cutting and have equipment-specific procedures for one type of gyratory compactor. They also report that specimen thicknesses of 60 mm (2.4 in.) and 80 mm (3.1 in.) are used for testing at the central laboratory and satellite laboratories, respectively. There are no established tolerances associated with thickness; only the specification thickness range of 38 to 100 mm (1.5 to 4 in.) is used.

Density requirements for the HWT are as per the specification. Montana DOT has not quantitatively observed the rejection rate of test specimens but is satisfied with the current rate. Montana DOT reported that ovens, rotary saws, and a core drill are used for specimen fabrication.



Montana DOT windrow sampling procedure (Figure 2 from MT 303).

## Challenges

Montana DOT reported that the most frequent issue they encounter in the specimen fabrication process is that air void requirements of the bulk specimen are not met. This is a relatively rare occurrence, but they observe that typically the air voids are on the high side as a result of the general practice of erring on the side of using less versus too much material.

Montana DOT reported that they are currently gaining experience with gyratory compaction in the laboratory and are performing comparisons of cylindrical specimens and slabs. They are evaluating the difference between cutting specimens that have a thickness of 115 mm (4.5 in.) to a test specimen thickness of 60 mm (2.4 in.) versus compacting to a thickness of 60 mm (2.4 in.) directly. These evaluations are being done in-house, and they do not have plans to sponsor any research that addresses these issues.

Montana DOT is interested in testing of porous mixtures in the future, as well as methods to evaluate microsurfacing types of materials. They are also interested in a durability/low-temperature cracking test to go along with the HWT in a balanced design/specification approach, and the ease of specimen fabrication is a significant factor in their evaluation of different test methods.

#### Texas

The Texas Department of Transportation (Texas DOT) reported that they prepare specimens and conduct laboratory performance testing; these activities are conducted both in-house and by consultant and university laboratories on behalf of Texas DOT. Texas DOT reported that all verification testing is conducted in house, and the majority of tests are run at their central laboratory. Interagency contracts are used with university partners for conducting tests, typically when needed for forensic analysis or for research projects. Various tests and their usage by Texas DOT are summarized in Table 16. Texas DOT routinely conducts the Cantabro test, HWT, CTIndex, IDT, and TxOT. Texas DOT also conducts  $E^*$  testing on a nonroutine basis for research purposes (see Table 16).

## **Mixture Types, Sampling, and Handling Procedures**

Texas DOT reported that laboratory-mixed, laboratory-compacted specimens are used for all six performance tests used by their agency. Furthermore, field cores are used for  $E^*$ , HWT, and TxOT tests. Finally, reheated plant mix is used to fabricate specimens for all performance tests except the  $E^*$  test. Sampling of all plant-mixed materials for Texas DOT is done in

Table 16. Purpose of performance testing for Texas DOT.

Performance Test	Mix Design Acceptance	Mix Acceptance in QA Process	Routine Usage for Research	Nonroutine Usage for Research
Cantabro	<b>✓</b>			
CTIndex			✓	
E*				✓
HWT	✓	✓	<b>√</b>	
IDT	✓			
TxOT	✓	✓	✓	

with a straight edge.

accordance with the TEX-222-F test procedure. Texas DOT reported that approximately 90% or more of plant-mixed material for performance testing is sampled from trucks. Texas DOT also reported that in their construction contracts Texas DOT [TxDOT] explicitly states that "TxDOT reserves right to sample and test from any location." Splitting of sampled material is conducted by Texas DOT as per the TEX-200-F test method (Appendix E). This method allows for the use of a sample splitter (aka riffle splitter); quartering cloth; quartering machine; or mix-

ing on a smooth, clean surface with a large, flat scoop or shovel until blended; and quartering

Loose-mix conditioning of 120 minutes is used for all performance tests used by Texas DOT except for  $E^*$  when mix is being compacted directly from production without letting it cool down. If mix is allowed to cool down prior to compaction (typically when it has to be shipped to another location for specimen fabrication and testing), then the conditioning time is reduced to 90 minutes. Texas DOT reported that this reduction in conditioning time is based on the hypothesis that the mix continues to age in storage containers during the cooling process and thus requires less laboratory conditioning on reheating. Specific conditioning temperatures are dependent on the binder grade of the mixtures; these are described in the TEX-206-F test method (Appendix E).

Texas DOT reports that they do not have a storage time restriction on loose-mix sampling and time of compaction; however, once test specimens are fabricated, the storage time is limited to 3 days for all tests except the Texas overlay test. For that test, the storage time for final test specimen is limited to 5 days. The maximum time limits were determined by Texas DOT on the basis of internal studies that showed variations in measured performance properties (specifically for HWT and TxOT) for storage times in excess of 5 days.

## **Specimen Fabrication Equipment and Procedures**

Texas DOT reported that for all plant-produced hot- and warm-mix asphalt, a Superpave gyratory compactor is used for specimen fabrication. For a small number of lime-rock asphalt and cold recycled mixes, Texas DOT also uses the Hveem stabilometer. The air void requirement for all finalized performance test specimens is  $7 \pm 1.0\%$  with the exception of  $E^*$ . Since the  $E^*$  test is often employed by Texas DOT for forensic evaluations, the agency reported that these tests are run on specimens with the same air void level as in-place pavement. The allowable tolerance of 1.0% for specimen air voids is reported by Texas DOT to be on the basis of practicality of the fabrication process. Texas DOT reported that they have had less than a 5% specimen rejection rate for performance tests; the main causes for rejection were failure of finalized test specimens to meet air void requirements, challenges with operator training/skill levels, and equipment problems. Furthermore, most of the recent specimen rejections were reported to be the result of equipment breakdown issues.

Texas DOT reported that ovens are routinely used for all specimen fabrication. Rotary saws are used for  $E^*$ , HWT, and TxOT specimens, and a temperature conditioning chamber is also used for specimen conditioning of these three tests as well as the CTIndex test.

## **Challenges**

Texas DOT reported that the most frequent issue they encounter in the specimen fabrication process is for the TxOT, since this test has stricter dimensional tolerances and requires an epoxy-based gluing process. Specifically, operators are required to carefully glue the specimens to metal plates with uniform epoxy thickness and without filling up the gaps between the plates. At present, Texas DOT is evaluating the effects of long-term laboratory aging on

performance properties. Furthermore, the agency also reported that they have implemented performance testing of tack coats using shear tests (TEX 249-F) and are working on specifications to require this.

## **Chapter Summary**

The case examples illustrate the range of sampling and handling procedures for fabrication of performance test specimens that are used by the states. Some states have detailed guidance on some aspects (e.g., Maine and Texas have specific storage times for several types of test specimens) and little guidance in others (e.g., lack of specific reheating protocols). Interviewees from the five case example states consistently observed that failure to meet air void requirements was the common challenge in fabricating specimens and that operator skill and training are important.



## CHAPTER 5

## Conclusions

## **Chapter Summary and Key Findings**

As state highway agencies move toward performance-related specifications for asphalt-mixture design and construction and the evaluation of new materials, performance testing is becoming more common. Various research studies have shown that different specimen fabrication methods can significantly impact measured performance properties. However, general guidance on the best approaches to fabricating specimens has not been developed or documented in a manner that agencies can use to identify appropriate practices. The objective of this synthesis was to document procedures related to laboratory fabrication of asphalt performance-test specimens at state DOTs and partner laboratories that conduct performance testing on behalf of state DOTs.

The literature review and responses provided by 40 state DOTs and the District of Columbia and 29 partner laboratories provided valuable insight into current practices with respect to the fabrication of specimens for asphalt-mixture performance testing. Detailed interviews were conducted with state DOT agency personnel in five states. The information obtained in the interview sessions was used to acquire a more precise idea of the concerns and effective practices for the fabrication of asphalt-mixture specimens to be used in performance testing.

Based on the work carried out in this synthesis, the key findings are as follows:

- The use of performance tests in asphalt mix design, quality control, and research is becoming more widespread. Most performance tests are run for research purposes or on a nonroutine basis, but some tests have been incorporated into mix design and QA specifications in some states. Other states are looking to incorporate these tests in the near future.
- Most states are fabricating asphalt specimens for performance testing either in-house or at partner laboratories.
- There is a wide range of mixture sampling and splitting procedures used by state DOTs. The majority of these procedures are the same as those used by an agency for their QA process; however, these procedures are quite varied between agencies.
- Existing ASTM or AASHTO standards are typically followed as written or with some modification for the fabrication of performance test specimens; this is especially true for specimen dimensions and corresponding tolerances.
- There is a fairly high level of consistency in laboratories with respect to the required equipment to fabricate performance test specimens.
- The literature review indicated that factors such as mixture type and conditioning protocols
  can significantly impact the properties measured from performance tests, while the impact of
  other factors such as geometry and storage time are not well quantified or understood.
- Loose-mix laboratory conditioning is more commonly adopted by DOT and partner laboratories than aging on compacted specimens. The use of short-term laboratory conditioning in

- the specimen fabrication process is widespread both at DOT laboratories as well as partner laboratories. The use of loose-mix long-term conditioning is more commonly used than compacted mixture conditioning (AASHTO R 30) by state DOTs.
- Use of 7% air voids for performance specimens is most common, along with a  $\pm$  1% tolerance, for DOT laboratories. Partner laboratories also most commonly adopt 7% air void level; however,  $\pm 0.5\%$  air void tolerance is commonly used by these entities.
- Many existing standards and test methods do not have detailed guidance on various aspects of specimen fabrication, specifically for aspects such as target air void levels and laboratory conditioning protocols.
- There are minimal restrictions in place at DOT laboratories with respect to maximum allowable storage times during the performance-test specimen-fabrication process. Partner laboratories more commonly use maximum storage-time limits; however, there is lack of consensus on these limits and the reason for choice of specific maximum allowable storage times is not documented. The majority of laboratories do not have specific protocols to prepare specimens for storage. There have been limited to no previous studies conducted on systematic evaluation of impacts of storage times on performance properties of asphalt mixtures.
- Partner laboratories and agencies with more experience with performance testing have established protocols and specific guidance for fabricating specimens to maintain consistency. Some aspects (e.g., short-term aging and air void targets) are similar between laboratories while others (e.g., long-term aging and storage times/preparation) vary widely.
- The most commonly reported issue with fabrication of performance test specimens was achieving air void targets within allowable tolerances. Rejection rates are typically 10% to 15% across all specimen types. Specimens with which agencies have more experience fabricating (e.g., HWT) have rejection rates below 5%. Furthermore, the effect of air void tolerance level is not well studied and documented for newer performance tests.
- More specific guidance on fabrication of performance test specimens is needed, specifically the need for technician training.

## **Identified Gaps in Knowledge** and Future Research Needs

This section outlines knowledge gaps that were identified from literature review, surveys, and the case example interviews. Future activities are suggested for addressing these gaps based on the work carried out in this synthesis.

- There is a knowledge gap with respect to the impacts of mixture sampling location, and the sampling and splitting process, on the performance test results. The case example interviews for the five state DOTs (Arizona, Illinois, Maine, Montana, and Texas) indicated slightly different procedures for asphalt-mixture sampling location and procedure and splitting processes. Investigation into the effects of (1) differences in mixture sampling locations and procedures and (2) splitting procedures on asphalt laboratory-performance testing is suggested.
- A knowledge gap exists on the impact of how the compaction mold is charged on the resulting performance test specimens, and further research on this topic is suggested.
- While the impact of air voids has been studied for several established performance tests (such as  $E^*$ ), there is limited information available on the impacts of air void target tolerances (such as,  $\pm 0.5\%$  versus  $\pm 1\%$ ). This issue is also directly tied to the specimen rejection rate, as well as the challenges currently faced by agencies in the fabrication of performance test specimens, whereby the failure to meet the required air void target is the most prominent factor for specimen rejection. Future research is suggested on the impact of air void target values and tolerances on measured performance properties.

- The appropriate conditioning protocols to use for fabrication of performance test specimens were identified as a knowledge gap through the surveys and literature review. There are several ongoing national research projects addressing this question.
- Surveys and the literature review in this synthesis revealed that there is a knowledge gap with respect to maximum storage times and their impacts on asphalt performance-test results. At present, a large number of entities do not either have a standard practice with respect to maximum storage times during different phases of the specimen fabrication process or have time limits that are driven by practicality. This knowledge gap is associated with the processes for preparing specimens for storage, which is another area of opportunity for further evaluation. The effects of storage times of mixtures and specimens and preparation of the materials for storage on performance measurements, along with suitable limits for the maximum allowable storage times, are suggested for future research.
- Development of technician training tools, specifically for fabrication of asphalt specimens for
  performance testing in laboratories, is of interest to agencies and partner laboratories conducting performance testing. This is also of considerable interest to agencies that are adopting
  laboratory performance testing for routine usage.

## **Abbreviations**

4PB four-point bending

AASHTO American Association of State Highway and Transportation Officials

AMPT asphalt-mixture performance tester

APA Asphalt Pavement Analyzer test equipment ASTM American Society for Testing and Materials

BBR bending beam rheometer
CTIndex Cracking Tolerance Index
DAVK Dynamic Angle Validation Kit

DCT disc-shaped compact tension (fracture energy test)
DOT Department of Transportation (state highway agency)

DTCF direct tension cyclic fatigue

|E\*| dynamic modulus of asphalt mixtures
 E\* complex modulus of asphalt mixtures
 ECS Environmental Conditioning System

FBF flexural beam fatigue

FHWA Federal Highway Administration

G<sub>mb</sub> bulk specific gravity of asphalt mixtures

HMA hot-mix asphalt

HWT Hamburg Wheel Tracker

IDOT Illinois Department of Transportation

IDT Indirect Tensile Test

I-FIT Illinois Flexibility Index Test ITS indirect tensile strength

LMLC laboratory mixed laboratory compacted MIST Moisture-Induced Sensitivity Test

 $\begin{array}{ll} \text{M-E} & \text{mechanistic-empirical} \\ M_{R} & \text{Resilient Modulus Test} \\ \text{MTV} & \text{material transfer vehicle} \end{array}$ 

NCAT National Center for Asphalt Technology

NCHRP National Cooperative Highway Research Program

NMAS nominal maximum aggregate size

PG performance grade of a Superpave binder

PMFC plant mixed field compacted PMLC plant mixed laboratory compacted

QA quality assurance QC quality control

RAP reclaimed asphalt pavement reclaimed asphalt shingles

**RPMLC** reheated plant mixed laboratory compacted RSST-CH repeated simple shear test at constant height **RLPD** repeated load permanent deformation

**RWC** rolling wheel compactor SBS styrene-butadiene-styrene **SCB** semicircular bending test

S-VECD simplified viscoelastic continuum damage

**SMA** stone matrix asphalt

**SHRP** Strategic Highway Research Program

SSD saturated surface dry SSG small specimen geometry SGC Superpave gyratory compactor

TRID Transport Research International Documentation triaxial repeated load permanent deformation TRLPD

**TSR** tensile strength ratio

**TSRST** Thermal Stress Restrained Specimen Test

TxOTTexas Overlay Test

uniaxial tension and compression UT/C

**VTRC** Virginia Transportation Research Council

WMA warm-mix asphalt

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## Agency and Partner Laboratory Survey Questionnaires

# NCHRP Synthesis Topic 50-14 Agency Survey

Dear AASHTO Committee on Materials and Pavements member: The Transportation Research Board (TRB) is preparing a synthesis titled "Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories." This is being done for the National Cooperative Highway Research Program (NCHRP), under the sponsorship of the American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration (FHWA). This survey is the key component of the Synthesis 50-14 project and is intended to identify the current state of the practice in state and provincial transportation agencies with respect to fabrication of asphalt-mixture specimens that are used in laboratory performance tests. Your cooperation in completing the questionnaire will ensure the success of this effort. If you are not the appropriate person in your agency to complete this survey, please forward the survey link to the person in your agency who leads the efforts related to laboratory performance testing of asphalt mixtures. Please complete and submit this survey by March 2, 2019. We estimate that it should take approximately 15-20 minutes to complete. If you are unsure about a question, please provide information to the best of your knowledge. Please leave responses blank for questions where information may not be readily available. If you have any questions about this survey, please contact the project principal investigator, Dr. Jo E. Sias, at (603) 862-3277 or jo.sias@unh.edu.

The individual names of the respondents are anonymous, but not the agency's responses. Thank you for your time and expertise!

#### **SURVEY INSTRUCTIONS**

To view, download and print the entire survey, click on the following link: <a href="https://unh.box.com/shared/static/qi96q6tsl5zehrffg6qsj4cw4uioz5ok.pdf">https://unh.box.com/shared/static/qi96q6tsl5zehrffg6qsj4cw4uioz5ok.pdf</a>

To save your partial answers and complete the questionnaire later, just close the survey window. Survey responses are saved in real time and you will be able to open the survey again from your email.

Please note that when you reach the end of survey and click next, the survey will be submitted and you will no longer be able to access it or change your responses. To return to the questionnaire later, open the original email for the survey and click on the link that you used originally to initiate the survey. To pass a partially completed questionnaire to a colleague, simply close the survey and forward the original survey email to your colleague. They will be able to open the partially filled survey using the same link (If you prefer to review all responses before submission of survey, please make sure to let them know that they should not submit the survey. Once submitted, you will not be able to access it.)

format. Simply click on "Download PDF" link to download your survey responses.	F 
Identification of contact information	
O Name (first, last):	
O Agency:	
O Position/Title:	
O Telephone:	
O Email:	

#### **DEFINITIONS**

The following definitions are used to clarify the scope in this questionnaire:

Asphalt Mixtures: For the purposes of this survey, the term "asphalt mixtures" is intended to represent any dense-graded hot-mix asphalt (HMA) or warm-mix asphalt (WMA) or stone matrix asphalt (SMA) mixture that is made in the laboratory or produced at the plant. This term

includes mixtures which have been modified with the use of recycled materials (e.g., reclaimed asphalt pavement, reclaimed asphalt shingles, crumb rubber from recycled tires, etc.). This term does not include maintenance mixtures (e.g., cold mix asphalt, seal coats, etc.), in-place recycled mixtures (e.g., hot-in-place recycled asphalt, cold-in-place recycled asphalt, etc.) or specialized surface mixtures (e.g., open-grade friction course or gap-graded thin bonded overlays).

Laboratory Asphalt-Mixture Performance Tests: For purposes of this survey, laboratory asphalt-mixture performance tests are defined as any laboratory test procedure for mechanical characterization of asphalt mixtures to determine a fundamental engineering or empirical property (e.g., resilient modulus, creep properties, and fatigue properties) that can predict pavement performance and/or appear in primary performance prediction relationships (i.e., models that can be used to predict pavement stress, distress, or performance from combinations of predictors that represent traffic, environmental, roadbed, and structural conditions). Pavement performance in this definition is in context of asphalt-mixture durability and resistance to traffic- and climate-induced distresses.

<u>Specimen Fabrication for Performance Testing:</u> Specimen fabrication for this survey is defined as the comprehensive process by which loose asphalt mixture (made in laboratory or sampled from plant) is made into the finalized test specimen that is ready for mechanical characterization. The steps for fabrication include, but are not limited to, reheating, compaction, conditioning (e.g., laboratory aging or moisture), cutting, coring, air void determination, and gluing of loading platens or gage brackets.

$\bigcirc$	Please click	k here to inc	dicate that you	ı have revie	ewed the above	e shown defir	nitions.
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### Block-1: The questions in this section are used to determine the current status of laboratory asphalt performance testing at your agency.

1) Does your agency prepare and conduct asphalt laboratory performance testing (irrespective
of whether testing is conducted on a routine or supplemental basis, i.e., not part of routine
usage/specification/mix acceptance)?

) <b>'</b>	Yes (eith	er in-hous	se at agency	and/or t	hrough co	nsultant o	r university	labs)
1 (	No							

,	l/or by other entities on behalf of your agency)—select all that apply.
	Asphalt Pavement Analyzer Test (AASHTO T340)
	Cantabro Test
	Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)
	Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)
	Dynamic (Complex) Modulus Testing (AASHTO T342)
	Flexural Beam Fatigue Test (AASHTO T321)
	Flow Number (RLPD) Test (AASHTO T378)
	Hamburg Wheel Tracking Test (AASHTO T324)
	CTIndex Test
or TP124	Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or ASTM D8044)
	Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)
	Small-Scale Geometry Dynamic (Complex) Modulus Test
	Small-Scale Geometry Flow Number (RLPD) Test
	Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)
	Texas Overlay Test (TxDOT TEX-248-F)
	Other test 1: (briefly describe)
	Other test 2: (briefly describe)

3) How does your Agency use the results of the laboratory performance test (select all that apply)?

αρμιγ) :	Mix Design Acceptance	In Quality Assurance (QA) Process			Nonroutine Usage for Research or Other Purposes	Other	Routine Usage for Research Purposes (such as specification updates)
		For Mix Acceptance	For Pay Factor Adjustment	Other			
Asphalt Pavement Analyzer Test (AASHTO T340)							
Cantabro Test							
Direct Tension Cyclic Fatigue Test (S- VECD) (AASHTO TP107)							
Disk- Shaped Compact Tension (DCT) Test (ASTM D7313)							
Dynamic (Complex) Modulus Testing (AASHTO T342)							
Flexural Beam Fatigue Test (AASHTO T321)							
Flow Number (RLPD) Test (AASHTO T378)							

Hamburg Wheel Tracking Test (AASHTO T324)				
CTIndex Test				
Semi- Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)				
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S- VECD)				
Small-Scale Geometry Dynamic (Complex) Modulus Test				
Small-Scale Geometry Flow Number (RLPD) Test				
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)				
Texas Overlay Test (TxDOT TEX-248-F)				

CTIndex Test

Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories Other test 1 (briefly describe): Other test 2 (briefly describe): 4) At your agency, is the fabrication of test specimens for performance testing conducted using standardized AASHTO or ASTM specifications and/or agency-specific protocols? (Provide one response for each test.) Standardized Procedure with Some Agency-Standardized Procedures Recommended Other (nonstandardized (AASHTO or ASTM Modifications (AASHTO or procedure, such as specifications) ASTM specifications with entirely in-house protocol) some agency-specific modifications) Asphalt Pavement Analyzer Test (AASHTO T340) Cantabro Test Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107) Disk-Shaped Compact Tension (DCT) Test (ASTM D7313) Dynamic (Complex) Modulus Testing (AASHTO T342) Flexural Beam Fatique Test (AASHTO T321) Flow Number (RLPD) Test (AASHTO T378) Hamburg Wheel Tracking Test (AASHTO T324)

Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)						
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)						
<u>Small-Scale Geometry</u> Dynamic (Complex) Modulus Test						
Small-Scale Geometry Flow Number (RLPD) Test						
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)						
Texas Overlay Test (TxDOT TEX-248-F)						
Other test 1 (briefly describe):						
Other test 2 (briefly describe):						
laboratory performance to include agency name found.	nt describing agency-spectests, either (1) upload doc o or (2) please paste a link Analyzer Test (AASHTO T34	cuments: <u>FILE UPLOAD</u> to agency website wher	(please rename files			
O Cantabro Test						
O Direct Tension Cyc	clic Fatigue Test (S-VECD) (A	AASHTO TP107)				
O Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)						
O Dynamic (Complex	x) Modulus Testing (AASHTC	) T342)				
Flexural Beam Fatigue Test (AASHTO T321)						

○ Flow Number (RLPD) Test (AASHTO T378)
Hamburg Wheel Tracking Test (AASHTO T324)
CTIndex Test
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 of TP124 or ASTM D8044)
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)
Small-Scale Geometry Dynamic (Complex) Modulus Test
Small-Scale Geometry Flow Number (RLPD) Test
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)
Texas Overlay Test (TxDOT TEX-248-F)
Other test 1 (briefly describe):
Other test 2 (briefly describe):
6) Is asphalt laboratory performance testing conducted at your agency and/or by consultant/university labs on behalf of the agency?
Oconducted only in-house by agency
Oconducted only through consultant/university labs
Conducted both in-house and through consultant/university labs

7) Important component of this synthesis study is to document specimen fabrication practices of non-agency entities (such as consultant or university labs) that conduct performance testing on behalf of agencies. Please share the name of entities that conduct laboratory performance testing for your agency and provide an email address for sending the survey.

	Entity Name	Email Address for Sending Survey
1.		
2.		
3.		
4.		
5.		

Block-2: The questions in this section relate to the process involved in fabrication of asphalt performance test specimens. Details regarding compaction, cutting and coring, age conditioning, etc., will be gathered in this section. A list of required equipment to fabricate specimens will also be collected.

8) For laboratory performance tests used by your agency, are specimen dimensions as per	
standard specifications (such as AASHTO or ASTM)? (Select "No" if non-standard dimension	าร
are used for even a single performance test used by your agency.)	

O Yes

9) What are the dimensions of the final test specimen for the laboratory performance tests used by your agency? (Typical values are shown; please edit as necessary and fill all that apply.)

	Thickness	Diameter (if applicable)	Length (if applicable)	Width (if applicable)	If there are any additional features about the test specimen (e.g., flat faces or semi-circular shape), please describe them and share the dimensions used
Asphalt Pavement Analyzer Test (AASHTO T340)					
Cantabro Test					
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)					
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)					

Dynamic (Complex) Modulus Testing (AASHTO T342)			
Flexural Beam Fatigue Test (AASHTO T321)			
Flow Number (RLPD) Test (AASHTO T378)			
Hamburg Wheel Tracking Test (AASHTO T324)			
CTIndex Test			
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)			
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)			
Small-Scale Geometry Dynamic (Complex) Modulus Test			
Small-Scale			

<u>Geometry</u> Flow Number (RLPD) Test			
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)			
Texas Overlay Test (TxDOT TEX- 248-F)			
Other test 1 (briefly describe):			
Other test 2 (briefly describe):			

10) What type(s) of materials are evaluated using laboratory performance test(s) by your agency (check all that apply)?

	Lab Mixed, Lab Compacted	Plant Mixed and Field Compacted, or Field Cores	Reheated Plant Mixed Lab Compacted or Plant Mixed Lab Compacted at the Plant	Other
Asphalt Pavement Analyzer Test (AASHTO T340)				
Cantabro Test				
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)				

Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)		
Dynamic (Complex) Modulus Testing (AASHTO T342)		
Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)		
Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		
<u>Small-Scale</u> <u>Geometry</u> Flow Number (RLPD) Test		

82	Practices for	<sup>r</sup> Fabricating <i>i</i>	Asphalt Sp	ecimens for	Performance	Testina in	Laboratories
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Superpave Indirect Tens Strength ar Creep Tes (AASHTO T3	sile nd st						
Texas Overl Test (TxDC TEX-248-F	T						
Other test (briefly describe)							
Other test 2 (briefly describe):							
11) Please identify laboratory performance test(s) for which there is a laboratory conditioning requirement (for example, short- and/or long-term oven aging) as part of specimen fabrication process for your agency (select all that apply).							
	Asphalt Pavement Analyzer Test (AASHTO T340)						
	Cantabro Test						
	Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)						
	Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)						
	Dynamic (Complex) Modul	us Testing (AASHTO <sup>-</sup>	Г342)				
	Flexural Beam Fatigue Test (AASHTO T321)						
	Flow Number (RLPD) Test (AASHTO T378)						
	Hamburg Wheel Tracking Test (AASHTO T324)						
	CTIndex Test						
	Semi-Circular Bend (SCB)	Test (any version, I-FI	T, LTRC, Minnesota)	(AASHTO TP105			

	Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)							
	Small-Sca	ale Geometry Dynamic (Co	mplex) Modulus Test					
	Small-Scale Geometry Flow Number (RLPD) Test							
	Superpave	e Indirect Tensile Strength	and Creep Test (AASHTC	T322)				
	Texas Ove	erlay Test (TxDOT TEX-24	8-F)					
	Other test	1 (briefly describe):						
	Other test	2 (briefly describe):						
		during specimen fabricat	tion for laboratory perfor	or example, short- and/or mance testing (check all				
		Laboratory		Other (briefly describe)				
	_	Loose Mix	Compacted Sample					
Asphalt Pavo Analyzer 1 (AASHTO 1	Гest							
Cantabro <sup>-</sup>	Test							
Direct Tension Fatigue Test (S (AASHTO T	S-VECD)							
Disk-Shaped C Tension (DC (ASTM D7	T) Test							
Dynamic (Co Modulus Te (AASHTO T	esting							
Flexural Beam Test (AASHT)								
Flow Number Test (AASHT)								
Hamburg W Tracking T (AASHTO T	Гest							

Ω/I	Practices for	r Fahricating	Asphalt Specin	nens for Performa	ance Testing in	Lahoratoria
04	PIACHCES IC	)) Fabil(alino	ASDUAL SDECIL	neny ior Perioriiz	ance resilino in	raboratone

CTIndex Test							
Semi-Circular Ber (SCB) Test (any version, I-FIT, LTF Minnesota) (AASH TP105 or TP124 ASTM D8044)	y RC, ITO						
Small-Scale Geom Direct Tension Cy Fatigue Test (S-VE	clic						
Small-Scale Geom Dynamic (Comple Modulus Test							
Small-Scale Geome Flow Number (RLF Test							
Tensile Strength a	Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)						
	Texas Overlay Test (TxDOT TEX-248-F)						
Other test 1 (brief describe):	Other test 1 (briefly describe):						
Other test 2 (briefly describe):							
13) Please provide details (such as temperature and time) for the <u>loose mixture laboratory conditioning</u> during specimen fabrication process (fill all that is applicable).  Conditioned as per AASHTO R30 Short-Term Aging Short-Term Aging Distance Protects  Other Process Followed (briefly describe)  Non-AASHTO R30 Protocol Used: Aging Temperature and Aging Time							
		Protocol			Deg. Celsius		Minutes
Asphalt Pavement Analyzer Test (AASHTO T340)					Dog. Ocisius		Williates
Cantabro Test							

Direct Tension		
Cyclic Fatigue Test (S-VECD) (AASHTO TP107)		
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)		
Dynamic (Complex) Modulus Testing (AASHTO T342)		
Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)		
Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		
Small-Scale Geometry Flow Number (RLPD) Test		

0.0	D+!	for Following Almen	A    + C	: f Df	formance Testino	a ta Talamakanta
Xh	Practices	tor Fabricating	Asnnait Snec	imens for Perf	formance lesting	n in Lanoratories

Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)					
Texas Overlay Test (TxDOT TEX- 248-F)		)			
Other test 1 (briefly describe):					
Other test 2 (briefly describe):					
	-	d test spe Lab ( Speci	-	ing Test Special T	-
Asphalt Pavement Test (AASHTO					
Cantabro T	est				
Direct Tension Cyc Test (S-VECD) (A TP107)					
Disk-Shaped Comp (DCT) Test (AST)					
Dynamic (Complex Testing (AASHT					
Flexural Beam Fa (AASHTO T					
Flow Number (RL (AASHTO T					
Hamburg Wheel Tra (AASHTO T					
CTIndex Te	est				

O	_

Semi-Circular Bend ( (any version, I-FIT Minnesota) (AASHTC TP124 or ASTM [	, LTRC, ) TP105 or			
Small-Scale Geome Tension Cyclic Fatigu VECD)				
Small-Scale Geometr (Complex) Moduli				
Small-Scale Geome Number (RLPD)				
Superpave Indirect Strength and Cree (AASHTO T32	ep Test			
Texas Overlay Test TEX-248-F				
Other test 1 (briefly o	describe):			
Other test 2 (briefly of	describe):			
,	e details (such as te g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging Protocol	•	cable):	Other Process Followed (briefly describe)
,	g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging	s (fill all that is appli Non-AASHTO R3	cable):	Other Process Followed (briefly
,	g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging	s (fill all that is appli Non-AASHTO R3 Aging Temperatur	icable): 60 Protocol Used: e and Aging Time	Other Process Followed (briefly
conditioning during  Asphalt Pavement  Analyzer Test	g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging	s (fill all that is appli Non-AASHTO R3 Aging Temperatur	icable): 60 Protocol Used: e and Aging Time	Other Process Followed (briefly
Asphalt Pavement Analyzer Test (AASHTO T340)	g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging	s (fill all that is appli Non-AASHTO R3 Aging Temperatur	icable): 60 Protocol Used: e and Aging Time	Other Process Followed (briefly
Asphalt Pavement Analyzer Test (AASHTO T340) Cantabro Test  Direct Tension Cyclic Fatigue Test (S-VECD)	g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging	s (fill all that is appli Non-AASHTO R3 Aging Temperatur	icable): 60 Protocol Used: e and Aging Time	Other Process Followed (briefly

Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)		
Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		
<u>Small-Scale</u> <u>Geometry</u> Flow Number (RLPD) Test		
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)		
Texas Overlay Test (TxDOT TEX- 248-F)		
Other test 1 (briefly describe):		
Other test 2 (briefly describe):		

16) Is there a target air void level requirement for laboratory performance test specimens used by your agency? (Select one for each test.)

	162	INU
Asphalt Pavement Analyzer Test (AASHTO T340)	0	0
Cantabro Test	$\circ$	$\circ$
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)		$\circ$
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)	$\circ$	$\circ$
Dynamic (Complex) Modulus Testing (AASHTO T342)	$\circ$	$\circ$
Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)	0	$\circ$
Hamburg Wheel Tracking Test (AASHTO T324)	0	$\circ$
CTIndex Test	0	0
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044) <u>Small-Scale Geometry</u> Direct Tension Cyclic Fatigue Test (S-		
VECD)	0	$\circ$
Small-Scale Geometry Dynamic (Complex) Modulus Test	0	$\circ$
<u>Small-Scale Geometry</u> Flow Number (RLPD) Test	0	$\circ$
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)	0	$\circ$
Texas Overlay Test (TxDOT TEX-248-F)	0	$\circ$
Other test 1 (briefly describe):	0	
Other test 2 (briefly describe):	$\circ$	$\circ$

17) Please provide information regarding the target air void level requirement during fabrication of laboratory performance test specimens used by your agency or on behalf of your agency. (If requirements are in the AASHTO/ASTM specification, please select in first column and leave rest blank. Fill all that apply, leave blank if no requirements are in place.)

	Detailed Specific Deviated Specificat Air Void R Bulk Co Sample P Specimen (e.g., prior	nents Not d in Test cation or from Test ion: Target required on mpacted rior to Test Fabrication to cutting or ing)	Other (such as more than one target air void level; please briefly describe)	Requirements Not Detailed in Test Specification or Deviated from Test Specification: Target Air Void Required on Finalized Test Specimen (e.g., after all necessary cutting or coring)		Target Air Void Requirement as per AASHTO/ASTM Specification for the Performance Test
	Target Air Void Level (%)	Allowed Variation (+/- %)		Target Air Void Level (%)	Allowed Variation (+/- %)	Requirements as per Specification
Asphalt Pavement Analyzer Test (AASHTO T340)						
Cantabro Test						
Direct Tension Cyclic Fatigue Test (S- VECD) (AASHTO TP107)						
Disk- Shaped Compact Tension (DCT) Test (ASTM D7313)						

	ı	ı	1	ı	ı	ı
Dynamic (Complex) Modulus Testing (AASHTO T342)						
Flexural Beam Fatigue Test (AASHTO T321)						
Flow Number (RLPD) Test (AASHTO T378)						
Hamburg Wheel Tracking Test (AASHTO T324)						
CTIndex Test						
Semi- Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)						
Small- Scale Geometry Direct Tension Cyclic						

Fatigue Test (S- VECD)			
Small- Scale Geometry Dynamic (Complex) Modulus Test			
Small- Scale Geometry Flow Number (RLPD) Test			
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)			
Texas Overlay Test (TxDOT TEX-248- F)			
Other test 1 (briefly describe):			
Other test 2 (briefly describe):			

18) Identify equipment that is used in your laboratory to fabricate test specimens for laboratory performance tests (check all that apply):

SPP-177.	Lab Equipment (select all that apply)										
	Mix Splitter (e.g., quartermaster)	Superpave Gyratory Compactor	Oven(s)	Rotary Saw(s)	Coring Drill	Core Drying Device	Gluing Templates (e.g., template for marking location of gage points or to attach gage points)	Gluing Jigs (e.g., specimen holding devices to glue loading platens to test specimen)	Temperature Conditioning Chamber(s)	Vacuum Bag Sealing Devices (such as CoreLok)	Other(s) (briefly describe)
Asphalt Pavement Analyzer Test (AASHTO T340)											
Cantabro Test											
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)											
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)											

Dynamic (Complex) Modulus Testing (AASHTO T342)					
Flexural Beam Fatigue Test (AASHTO T321)					
Flow Number (RLPD) Test (AASHTO T378)					
Hamburg Wheel Tracking Test (AASHTO T324)					
CTIndex Test					
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)					
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)					
Small-Scale Geometry Dynamic (Complex) Modulus Test					
Small-Scale Geometry Flow Number (RLPD) Test					
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)					
Texas Overlay Test (TxDOT TEX-248-F)					
Other test 1 (briefly describe):					
Other test 2 (briefly describe):					

#### Block-3: The questions in this section relate to the operational constraints (such as storage times) and rejection rates of test specimens.

19) What are the allowable maximum storage times before, during, and after specimen fabrication for the performance tests that are instituted in your agency? Please use comments column to provide any additional relevant information (fill all that apply, leave blank if no requirements are in place).

	Between Loose Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (bulk) Specimen and Finalized Test Specimen	Between Finalized Test Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if multiple tests are conducted on same specimens)	Comments
	Maximum Allowable Time (days)	Maximum Allowable Time (days)	Maximum Allowable Time (days)	Maximum Allowable Time (days)	
Asphalt Pavement Analyzer Test (AASHTO T340)					
Cantabro Test					
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)					
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)					

	I	I			I
Dynamic (Complex) Modulus Testing (AASHTO T342)					
Flexural Beam Fatigue Test (AASHTO T321)					
Flow Number (RLPD) Test (AASHTO T378)					
Hamburg Wheel Tracking Test (AASHTO T324)					
CTIndex Test					
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)					
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)					
Small-Scale Geometry Dynamic (Complex) Modulus Test					
Small-Scale					

<u>Geometry</u> Flow Number (RLPD) Test			
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)			
Texas Overlay Test (TxDOT TEX- 248-F)			
Other test 1 (briefly describe):			
Other test 2 (briefly describe):			

20) How are performance test specimens prepared for storage at your agency (select all that apply)?

	Preparation Prior to Storage				Other (briefly describe)	
	No Preparation	Wrapped in Plastic Film	Vacuum Sealed	Coated in Wax	Left in Airtight Container	
Between loose mix sampling and laboratory compaction						
Between preparation of compacted (bulk) specimen and finalized test specimen						

Between finalized test specimen fabrication and mechanical testing						
Between repeated mechanical testing (if multiple tests are conducted on same specimens)						
24) Diagonia	1: t - t	<b>. . . . . . . . . .</b>				_
	indicate the most frequent causes of operational disruptions that you have d during the test specimen fabrication process (check all that apply).					
coring)	Not meeting dimensional requirements for bulk specimen (prior to cutting and/or )					
test sp	Not meeting dimensional requirements for prepared (after cutting and/or coring) t specimens					
coring)	Not meeting air void requirements for bulk specimen (prior to cutting and/or					
specim	Not meeting air void requirements for prepared (after cutting and/or coring) test mens					
	Exceeding shelf storage times					
	Not meeting temperature tolerance requirements for laboratory conditioning					ioning
	Laboratory ar	nbient conditio	ons (e.g., exce	ssive humidity	)	
	Challenges with operator training/skill levels					

Specimen fabrication equipment problems (e.g., problems with saws or jigs)
Others (please describe)
22) In your experience, what has been the rejection rate of test specimens (i.e., specimens that are not used for testing), due to the fabrication process (e.g., longer shelf storage than allowed, out-of-tolerance dimensions, wrong air void content, etc.) (select one and fill in the blank)?  O Typical specimen rejection rate: (%)
Rejection rate of specimens not observed
23) Is your agency satisfied with your performance test specimen rejection rate (select one and fill in the blank)?
○ Yes
O No: What rejection rate (%) would you consider as acceptable/satisfactory?
Block-4: Identification of Other Contacts and Suggestions for Future Research
24) Is your Agency currently sponsoring (or planning to sponsor) any research related to asphalt performance testing that specifically addresses the fabrication of laboratory specimens in-house in the future?
O Yes (please describe)
○ No
25) Have you observed any gaps in knowledge that have made it challenging for your Agency to start (or continue) successfully fabricating performance test specimens in-house?
O Yes (please describe)
○ No

26) The synthesis will also include case examples illustrating agency practices on asphalt performance test specimen fabrication. The development of the case example(s) may require an additional follow-up interview. Agencies will be provided the opportunity to review the case example write-up for accuracy. Would your agency be interested in participating in a case example?
○ Yes
○ No
27) If you have any additional information or thoughts you would like to share regarding this topic, please share them here:

END OF SURVEY Please click on "Submit Survey!" button to submit your survey.

NOTE: By clicking "Submit Survey!" button here you will end the survey and you will be unable to go back and review or revise your responses. Thank you for your willingness to participate in this NCHRP Synthesis 50-14!

While names of survey respondents will be kept anonymous, agency responses will be identified in the reports. If you need any additional information about this survey or about the project, please contact Dr. Jo E. Sias (jo.sias@unh.edu).

## NCHRP Synthesis Topic 50-14 Partner **Laboratory Survey**

Dear Colleague: The Transportation Research Board (TRB) is preparing a synthesis titled "Practices for Fabricating Asphalt Specimens for Performance Testing in Laboratories." This is being done for the National Cooperative Highway Research Program (NCHRP), under the sponsorship of the American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration (FHWA). A State Transportation Agency identified you as a contact person that conducts asphalt laboratory performance tests on behalf of the agency. This survey is the key component of the Synthesis 50-14 project and is intended to identify the current state of the practice with respect to fabrication of asphalt-mixture specimens that are used in laboratory performance tests. Your cooperation in completing the questionnaire will ensure the success of this effort. If you are not the appropriate person in your organization to complete this survey, please forward the survey link to the person in your agency who leads the efforts related to laboratory performance testing of asphalt mixtures. Please complete and submit this survey by March 2, 2019. We estimate that it should take approximately 15-20 minutes to complete. If you are unsure about a question, please provide information to the best of your knowledge. Please leave responses blank for questions where information may not be readily available. If you have any questions about this survey, please contact the project principal investigator, Dr. Jo E. Sias, at (603) 862-3277 or jo.sias@unh.edu

The individual names of the respondents will be kept anonymous.

Thank you for your time and expertise!

#### SURVEY INSTRUCTIONS

To view, download and print the entire survey, Click on the following link: https://unh.box.com/shared/static/rafgoun51t7mkbggm24ggu6e9z06lpjx.pdf

To save your partial answers and complete the questionnaire later, just close the survey window. Survey responses are saved in real time and you will be able to open the survey again from your email.

Please note that when you reach the end of survey and click next, the survey will be submitted and you will no longer be able to access it or change your responses. To return to the questionnaire later, open the original email for the survey and click on the link that you used originally to initiate the survey. To pass a partially completed

questionnaire to a colleague, simply close the survey and forward the original survey email to your colleague. They will be able to open the partially filled survey using the same link. (If you prefer to review all responses before submission of survey, please make sure to let them know that they should not submit the survey. Once submitted, you will not be able to access it.)

format. Simply click on "Download PDF" link to download your survey responses.	
Identification of contact information	
Name (first, last):	
Organization:	
O Position/Title:	
O Telephone:	
O Email:	

#### **DEFINITIONS**

The following definitions are used to clarify the scope in this questionnaire:

Asphalt Mixtures: For the purposes of this survey, the term "asphalt mixtures" is intended to represent any dense-graded hot-mix asphalt (HMA), warm-mix asphalt (WMA), or stone matrix asphalt (SMA) mixture that is made in the laboratory or produced at the plant. This term includes mixtures which have been modified with the use of recycled materials (e.g., reclaimed asphalt pavement, reclaimed asphalt shingles, crumb rubber from recycled tires, etc.). This term does not include maintenance mixtures (e.g., cold mix asphalt, seal coats, etc.), in-place recycled mixtures (e.g., hot-in-place recycled asphalt, cold-in-place recycled asphalt, etc.) or specialized surface mixtures (e.g., open-grade friction course or gap-graded thin bonded overlays).

Laboratory Asphalt-Mixture Performance Tests: For purposes of this survey, laboratory asphaltmixture performance tests are defined as any laboratory test procedure for mechanical characterization of asphalt mixtures to determine a fundamental, engineering or empirical property (e.g., resilient modulus, creep properties, and fatigue properties) that can predict pavement performance and/or appear in primary performance prediction relationships (i.e., models that can be used to predict pavement stress, distress, or performance from combinations of predictors that represent traffic, environmental, roadbed, and structural conditions). Pavement performance in this definition is in context of asphalt-mixture durability

and resistance to traffic- and climate-induced distresses.
Specimen Fabrication for Performance Testing: Specimen fabrication for this survey is defined as the comprehensive process by which loose asphalt mixture (made in laboratory or sampled from plant) is made into the finalized test specimen that is ready for mechanical characterization. The steps for fabrication include, but are not limited to, reheating, compaction, conditioning (e.g., laboratory aging or moisture), cutting, coring, air void determination, and gluing of loading platens or gage brackets.
O Please click here to indicate that you have reviewed the above-shown definitions.
Block-1: The questions in this section are used to determine the current status of laboratory asphalt performance testing at your organization.
Does your organization prepare specimens and conduct asphalt laboratory performance tests?
○ Yes
○ No
2) Please provide a list of transportation agencies that contract asphalt laboratory performance testing to your organization (if more than 15, please provide list of most recent 15 agencies that have contracted with your organization for asphalt laboratory performance testing).
Agency 1

O Agency 3

O Agency 4		
O Agency 5		
O Agency 6		
O Agency 7		
O Agency 8		
O Agency 9		
O Agency 10		
O Agency 11		
O Agency 12		
O Agency 13		
O Agency 14		
O Agency 15		
3) For agencies identified in the purpose of performance testing	previous question, please provides — select all that apply.	e information regarding the
	Test Required as Part of Mix	
	Design, Mix Acceptance, QA Process or Pay Factor Adjustment (select if any of these conditions apply)	Performance Testing as Part of a Research Study (or research studies)
Agency 1		
Agency 2		
Agency 3		
Agency 4		

Agency 5						
Agency 6						
Agency 7						
Agency 8						
Agency 9						
Agency 10						
Agency 11						
Agency 12						
Agency 13	ency 13					
Agency 14	gency 14					
Agency 15						
	4) Please select the types of laboratory asphalt performance testing conducted by your organization—select all that apply.					
Asphalt Pavement Analyzer Test (AASHTO T340)						
Cantabro Test	Cantabro Test					
Direct Tension C	Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)					
Disk-Shaped Cor	Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)					
Dynamic (Compl	Dynamic (Complex) Modulus Testing (AASHTO T342)					
Flexural Beam F	Flexural Beam Fatigue Test (AASHTO T321)					

	Flow Number (RLPD) Test (AASHTO T378)				
	Hamburg Wheel Tracking Test (AASHTO T324)				
	CTIndex Test				
	Semi-Circular Bend (SCB) Test ( (AASHTO TP105 or TP124 or AS	•	, Minnesota)		
	Small-Scale Geometry Direct Ter	nsion Cyclic Fatigue Test	t (S-VECD)		
	Small-Scale Geometry Dynamic	(Complex) Modulus Test			
	Small-Scale Geometry Flow Num	nber (RLPD) Test			
	Superpave Indirect Tensile Stren	gth and Creep Test (AAS	SHTO T322)		
	Texas Overlay Test (TxDOT TEX	(-248-F)			
	Other test 1 (briefly describe):				
	Other test 2 (briefly describe):				
using standa	ganization, is the fabrication of tes ardized AASHTO or ASTM specific e for each test)?	eations and/or agency speciations and/or agency speciations.	_		
	Standardized Procedures (AASHTO or ASTM specifications)	with Some Agency- Recommended Modifications (AASHTO or ASTM specifications with some agency-specific modifications)	Other (nonstandardized procedure, such as entirely in-house protocol)		
Asphalt Pa Analyzer Test T340	(AASHTO				
Cantabro	Test				

-	-	-
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files to include organization name) or (2) please paste a link to a website where documents can be found. Asphalt Pavement Analyzer Test (AASHTO T340) Cantabro Test Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107) Disk-Shaped Compact Tension (DCT) Test (ASTM D7313) Opnamic (Complex) Modulus Testing (AASHTO T342) Flexural Beam Fatigue Test (AASHTO T321) Flow Number (RLPD) Test (AASHTO T378) Hamburg Wheel Tracking Test (AASHTO T324) CTIndex Test Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044) Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD) Small-Scale Geometry Dynamic (Complex) Modulus Test Small-Scale Geometry Flow Number (RLPD) Test Superpave Indirect Tensile Strength and Creep Test (AASHTO T322) Texas Overlay Test (TxDOT TEX-248-F) Other test 1 (briefly describe): Other test 2 (briefly describe):

6) If you have a document describing organization-specific procedures for fabricating specimens for laboratory performance tests, either (1) upload documents: FILE UPLOAD (please rename

Block-2: The questions in this section relate to the process involved in fabrication of asphalt performance test specimens. Details regarding compaction, cutting and coring, age conditioning, etc., will be gathered in this section. A list of required equipment to fabricate specimens will also be collected.

as per standard	performance tests co specifications (such as used for any performa	s AASHTO or AST	M)? (Select "No" if	non-standard
O Yes				
○ No				

8) What are the dimensions of the final test specimen for the laboratory performance tests conducted by your organization on behalf of state transportation agencies? (Typical values are shown; please edit as necessary and fill all that apply.)

	Thickness	Diameter (if applicable)	Length (if applicable)	Width (if applicable)	If There Are Any Additional Features About the Test Specimen (e.g., flat faces or semi-circular shape; please describe them and share the dimensions used)
Asphalt Pavement Analyzer Test (AASHTO T340)					
Cantabro Test					

Direct	1		
Tension			
Cyclic			
Fatigue Test (S-VECD)			
(AASHTO			
TP107)			
Disk-Shaped			
Compact Tension			
(DCT) Test			
(ASTM			
D7313)			
Dynamic (Complex)			
Modulus			
Testing			
(AASHTO T342)			
Flexural			
Beam			
Fatigue Test			
(AASHTO T321)			
Flow Number			
(RLPD) Test			
(AASHTO			
T378)			
Hamburg Wheel			
Tracking Test			
(AASHTO			
T324)			
CTIndex Test			
Semi-Circular Bend (SCB)			
Test (any			
version, I-			
FIT, LTRC, Minnesota)			
(AASHTO			
TP105 or TP124 or			
ASTM			
D8044)			

Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)			
Small-Scale Geometry Dynamic (Complex) Modulus Test			
Small-Scale Geometry Flow Number (RLPD) Test			
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)			
Texas Overlay Test (TxDOT TEX-248-F)			
Other test 1 (briefly describe):			
Other test 2 (briefly describe):			

9) What type(s) of materials are evaluated using laboratory performance test(s) by your organization on behalf of state transportation agencies (check all that apply)?

	Lab Mixed, Lab Compacted	Plant Mixed and Field Compacted, or Field Cores	Reheated Plant Mixed Lab Compacted or Plant Mixed Lab Compacted at the Plant	Other
Asphalt Pavement Analyzer Test (AASHTO T340)				

Cantabro Test		
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)		
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)		
Dynamic (Complex) Modulus Testing (AASHTO T342)		
Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)		
Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		

<u>Small-Scal</u> <u>Geometry</u> Flo Number (RLF Test	ow			
Superpave Indirect Tens Strength an Creep Tes (AASHTO T3	sile od t			
Texas Overl Test (TxDO TEX-248-F	Ť			
Other test (briefly describe):				
Other test 2 (briefly describe):				
10) Please identify laboratory performance test(s) for which there is a laboratory conditioning requirement (for example, short- and/or long-term oven aging) as part of specimen fabrication process (select all that apply).				
-		or long-term oven ag	ging) as part of spec	•
process (selec				•
process (select	t all that apply).			•
process (selection	t all that apply). Asphalt Pavement Analyz	er Test (AASHTO T34	40)	•
process (selection)	t all that apply).  Asphalt Pavement Analyz  Cantabro Test	er Test (AASHTO T34	40) AASHTO TP107)	•
process (selection)	t all that apply).  Asphalt Pavement Analyz  Cantabro Test  Direct Tension Cyclic Fati	er Test (AASHTO T34 gue Test (S-VECD) (A	40) AASHTO TP107) TM D7313)	•
process (selection)	t all that apply).  Asphalt Pavement Analyz  Cantabro Test  Direct Tension Cyclic Fati  Disk-Shaped Compact Te	er Test (AASHTO T34 gue Test (S-VECD) (A ension (DCT) Test (AS	40) AASHTO TP107) TM D7313)	•
process (selection)	t all that apply).  Asphalt Pavement Analyz  Cantabro Test  Direct Tension Cyclic Fati  Disk-Shaped Compact Te	gue Test (AASHTO T34 gue Test (S-VECD) (A ension (DCT) Test (AS ulus Testing (AASHTO est (AASHTO T321)	40) AASHTO TP107) TM D7313)	•

	CTIndex T	est			
or TP124	Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 4 or ASTM D8044)				
	Small-Scal	<i>l<u>e Geometry</u> Direct Tensi</i> o	n Cyclic Fatigue Test (S-\	/ECD)	
	Small-Scal	<i>le Geometry</i> Dynamic (Co	mplex) Modulus Test		
	Small-Scal	<i>le Geometry</i> Flow Number	(RLPD) Test		
	Superpave	Indirect Tensile Strength	and Creep Test (AASHT)	O T322)	
	Texas Ove	rlay Test (TxDOT TEX-24	-8-F)		
	Other test	1 (briefly describe):			
	Other test 2 (briefly describe):				
	Otner test	2 (briefly describe):			
,	rovide info	rmation regarding the la	• • • • • • • • • • • • • • • • • • • •	or example, short- and/or rmance testing (check all	
long-term over	rovide info	rmation regarding the la during specimen fabrica	• • • • • • • • • • • • • • • • • • • •	•	
long-term over	rovide info	rmation regarding the la during specimen fabrica	tion for laboratory perfo	rmance testing (check all	
long-term over	rovide info en aging) d vement Test	rmation regarding the la during specimen fabrica Laboratory	tion for laboratory perfo	rmance testing (check all	
long-term over that apply).  Asphalt Pav Analyzer	rovide info en aging) o vement Test T340)	rmation regarding the la during specimen fabrica Laboratory	tion for laboratory perfo	rmance testing (check all	
long-term over that apply).  Asphalt Pav Analyzer (AASHTO	rovide information aging) of the content of the con	rmation regarding the la during specimen fabrica Laboratory	tion for laboratory perfo	rmance testing (check all	
Iong-term over that apply).  Asphalt Pave Analyzer (AASHTO)  Cantabro  Direct Tension Fatigue Test (	rovide information aging) of the rest (T340)  Test (T940)	rmation regarding the la during specimen fabrica Laboratory	tion for laboratory perfo	rmance testing (check all	

Dynamic (Complex) Modulus Testing (AASHTO T342)		
Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)		
Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry  Dynamic (Complex)  Modulus Test		
Small-Scale Geometry Flow Number (RLPD) Test		
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)		
Texas Overlay Test (TxDOT TEX-248-F)		
Other test 1 (briefly describe):		
Other test 2 (briefly describe):		

12) Please provide details (such as temperature and time) for the <u>loose mixture laboratory conditioning</u> during specimen fabrication process (fill all that is applicable).

	Conditioned as per AASHTO R30 Short-Term Aging Protocol	Other Process Followed (briefly describe)		30 Protocol Used: re and Aging Time
			Deg. Celsius	Minutes
Asphalt Pavement Analyzer Test (AASHTO T340)				
Cantabro Test				
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)				
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)				
Dynamic (Complex) Modulus Testing (AASHTO T342)				
Flexural Beam Fatigue Test (AASHTO T321)				
Flow Number (RLPD) Test (AASHTO T378)				
Hamburg Wheel Tracking Test (AASHTO T324)				
CTIndex Test				
Semi-Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)				

Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		
<u>Small-Scale</u> <u>Geometry</u> Flow Number (RLPD) Test		
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)		
Texas Overlay Test (TxDOT TEX- 248-F)		
Other test 1 (briefly describe):		
Other test 2 (briefly describe):		

13) Is laboratory conditioning of compacted specimens conducted on bulk (prior to cutting and coring) specimens or on finished test specimens (after cutting and coring) (select one)?

	Lab Conditioning on Bulk Specimen (prior to cutting and/or coring)	Lab Conditioning on Finished Test Specimen (after cutting and/or coring to get to final test specimen geometry)
Asphalt Pavement Analyzer Test (AASHTO T340)		
Cantabro Test		
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)		
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)		
Dynamic (Complex) Modulus Testing (AASHTO T342)		
Flexural Beam Fatigue Test (AASHTO T321)		
Flow Number (RLPD) Test (AASHTO T378)		
Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S- VECD)		
<u>Small-Scale Geometry</u> Dynamic (Complex) Modulus Test		
Small-Scale Geometry Flow Number (RLPD) Test		

Superpave Indirect Strength and Cre (AASHTO T3	ep Test			
Texas Overlay Tes TEX-248-F				
Other test 1 (briefly	describe):			
Other test 2 (briefly	describe):			
, ,	e details (such as te g fabrication proces Conditioned as per AASHTO R30 Long-Term Aging Protocol	•	cable).  0 Protocol Used:	Other Process Followed (briefly describe)
		Degree Celsius	Time	
Asphalt Pavement Analyzer Test (AASHTO T340)				
Cantabro Test				
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)				
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)				
Dynamic (Complex) Modulus Testing (AASHTO T342)				
Flexural Beam Fatigue Test (AASHTO T321)				
Flow Number (RLPD) Test (AASHTO T378)				

Hamburg Wheel Tracking Test (AASHTO T324)		
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		
<u>Small-Scale</u> <u>Geometry</u> Flow Number (RLPD) Test		
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)		
Texas Overlay Test (TxDOT TEX- 248-F)		
Other test 1 (briefly describe):		
Other test 2 (briefly describe):		

15) Is there a target air void level requirement for laboratory performance test specimens used by your organization (select one for each test)?

	162	INO
Asphalt Pavement Analyzer Test (AASHTO T340)	0	0
Cantabro Test	$\circ$	0
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)	$\circ$	0
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)	$\circ$	0
Dynamic (Complex) Modulus Testing (AASHTO T342)	0	0
Flexural Beam Fatigue Test (AASHTO T321)	0	0
Flow Number (RLPD) Test (AASHTO T378)	$\circ$	0
Hamburg Wheel Tracking Test (AASHTO T324)		0
CTIndex Test	$\circ$	0
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)	0	0
<u>Small-Scale Geometry</u> Direct Tension Cyclic Fatigue Test (S- VECD)	$\circ$	0
<u>Small-Scale Geometry</u> Dynamic (Complex) Modulus Test	$\circ$	$\circ$
Small-Scale Geometry Flow Number (RLPD) Test	0	$\circ$
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)	$\circ$	$\circ$
Texas Overlay Test (TxDOT TEX-248-F)	$\circ$	0
Other test 1 (briefly describe):	$\circ$	0
Other test 2 (briefly describe):	0	0

16) Please provide information regarding the target air void level requirement during fabrication of laboratory performance test specimens. (If requirements are in the AASHTO/ASTM specification for the laboratory performance test, please select in first column and leave the rest blank. Fill all that apply; leave blank if no requirements are in place.)

	Requirements Not  Detailed in Test Specification or Deviated from Test Specification: Target Air Void Required on Bulk Compacted Sample Prior to Test Specimen Fabrication (e.g., prior to cutting or coring)		Other (such as more than one target air void level; please briefly describe)	Requirements Not  Detailed in Test Specification or Deviated from Test Specification: Target Air Void Required on Finalized Test Specimen (e.g., after all necessary cutting or coring)		Target Air Void Requirement as per AASHTO/ASTM Specification for the Performance Test
	Target Air Void Level (%)	Allowed Variation (+/- %)		Target Air Void Level (%)	Allowed Variation (+/- %)	Requirements as per Specification
Asphalt Pavement Analyzer Test (AASHTO T340)						
Cantabro Test						
Direct Tension Cyclic Fatigue Test (S- VECD) (AASHTO TP107)						
Disk- Shaped Compact Tension (DCT) Test (ASTM D7313)						

	ı	1	ı	ı	ı
Dynamic (Complex) Modulus Testing (AASHTO T342)					
Flexural Beam Fatigue Test (AASHTO T321)					
Flow Number (RLPD) Test (AASHTO T378)					
Hamburg Wheel Tracking Test (AASHTO T324)					
CTIndex Test					
Semi- Circular Bend (SCB) Test (any version, I- FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)					
Small- Scale Geometry Direct Tension Cyclic					

Fatigue Test (S- VECD)			
Small- Scale Geometry Dynamic (Complex) Modulus Test			
Small- Scale Geometry Flow Number (RLPD) Test			
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)			
Texas Overlay Test (TxDOT TEX-248- F)			
Other test 1 (briefly describe):			
Other test 2 (briefly describe):			

17) Identify equipment that is used in your laboratory to fabricate test specimens for laboratory performance tests (check all that apply).

apply).		Lab	Equ	ipme	nt (s	elect	all th	at ap	ply)		
	Mix Splitter (e.g., quartermaster)	Superpave Gyratory Compactor	Oven(s)	Rotary Saw(s)	Coring Drill	Core Drying Device	Gluing Templates (e.g., template for marking location of gage points or to attach gage points)	Gluing Jigs (e.g., specimen holding devices to glue loading platens to test specimen)	Temperature Conditioning Chamber(s)	Vacuum Bag Sealing Devices (such as CoreLok)	Other(s) (briefly describe)
Asphalt Pavement Analyzer Test (AASHTO T340)											
Cantabro Test											
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)											
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)											

Dynamic (Complex) Modulus Testing (AASHTO T342)					
Flexural Beam Fatigue Test (AASHTO T321)					
Flow Number (RLPD) Test (AASHTO T378)					
Hamburg Wheel Tracking Test (AASHTO T324)					
CTIndex Test					
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)					
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)					
Small-Scale Geometry Dynamic (Complex) Modulus Test					
Small-Scale Geometry Flow Number (RLPD) Test					
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)					
Texas Overlay Test (TxDOT TEX-248-F)					
Other test 1 (briefly describe):					
Other test 2 (briefly describe):					

## Block-3: The questions in this section relate to the operational constraints (such as storage times) and rejection rates of test specimens.

18) What are the allowable maximum storage times before, during, and after specimen fabrication for the performance tests that are instituted in your organization? Please use comments column to provide any additional relevant information (fill all that apply, leave blank if no requirements are in place).

	Between Loose Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (bulk) Specimen and Finalized Test Specimen	Between Finalized Test Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if multiple tests are conducted on same specimens)	Comments
	Maximum Allowable Time (days)	Maximum Allowable Time (days)	Maximum Allowable Time (days)	Maximum Allowable Time (days)	
Asphalt Pavement Analyzer Test (AASHTO T340)					
Cantabro Test					
Direct Tension Cyclic Fatigue Test (S-VECD) (AASHTO TP107)					
Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)					

Dynamic (Complex) Modulus Testing (AASHTO T342)			
Flexural Beam Fatigue Test (AASHTO T321)			
Flow Number (RLPD) Test (AASHTO T378)			
Hamburg Wheel Tracking Test (AASHTO T324)			
CTIndex Test			
Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota) (AASHTO TP105 or TP124 or ASTM D8044)			
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)			
Small-Scale Geometry Dynamic (Complex) Modulus Test			

Small-Scale Geometry Flow Number (RLPD) Test			
Superpave Indirect Tensile Strength and Creep Test (AASHTO T322)			
Texas Overlay Test (TxDOT TEX- 248-F)			
Other test 1 (briefly describe):			
Other test 2 (briefly describe):			

19) How are performance test specimens prepared for storage at your organization? (select all that apply)

			Other (briefly describe)			
	No preparation	Wrapped in Plastic Film	Vacuum Sealed	Coated in Wax	Left in Airtight Container	
Between loose mix sampling and laboratory compaction						
Between preparation of compacted (bulk) specimen and finalized test specimen						

Between finalized test specimen fabrication and mechanical testing								
Between repeated mechanical testing (if multiple tests are conducted on same specimens)								
>								
=	20) Please indicate the most frequent causes of operational disruptions that you have encountered during the test specimen fabrication process (check all that apply)?							
coring)	Not meeting dimensional requirements for bulk specimen (prior to cutting and/or							
test spec	Not meeting dimensional requirements for prepared (after cutting and/or coring) test specimens							
coring)	Not meeting air void requirements for bulk specimen (prior to cutting and/or							
specime	Not meeting air void requirements for prepared (after cutting and/or coring) test specimens							
	Exceeding shelf storage times							
	Not meeting t	emperature to	lerance requir	ements for lab	oratory conditi	ioning		
	Laboratory ambient conditions (e.g., excessive humidity)							
	Challenges with operator training/skill levels							

	Specimen fabrication equipment problems (e.g., problems with saws or jigs)
	Others (please describe)
are not used	sperience, what has been the rejection rate of test specimens (i.e., specimens that for testing) due to the fabrication process (e.g., longer shelf storage than allowed, ce dimensions, wrong air void content, etc.)? (Select one and fill in the blank.)
O Typica	al specimen rejection rate: (%)
O Rejec	tion rate of specimens not observed
22) Is your or one and fill in	ganization satisfied with your performance test specimen rejection rate? (Select the blank.)
O Yes	
O No: W	hat rejection rate (%) would you consider as acceptable/satisfactory?
Block-4: Suç	ggestions for Future Research
,	observed any gaps in knowledge that have made it challenging for your to start (or continue) successfully fabricating performance test specimens in-
O Yes (	please describe)
○ No	
test specime follow-up inte	nesis will also include case examples illustrating practices on asphalt performance in fabrication. The development of the case example(s) may require an additional erview. Organizations will be provided the opportunity to review the case example occuracy. Would your organization be interested in participating in a case example?
O Yes	
○ No	

25) If you have any additional information or thoughts you would like to share regarding this topic, please share them here:

END OF SURVEY Please click on "Submit Survey!" button to submit your survey.

NOTE: By clicking "Submit Survey!" button here you will <u>end the survey</u> and you will be <u>unable</u> to go back and review or revise your responses. Thank you for your willingness to participate in this NCHRP Synthesis 50-14!

Names of survey respondents will be kept anonymous.

If you need any additional information about this survey or about the project, please contact Dr. Jo E. Sias (jo.sias@unh.edu).



# State Transportation Agency Survey Responses

The responses to the state highway agency survey questionnaire are presented in this appendix.

**Current Status of Laboratory Asphalt Performance Testing** 

Question 1: Does your agency prepare and conduct asphalt laboratory performance testing (irrespective of whether testing is conducted on a routine or supplemental basis; i.e., not part of routine usage/specification/mix acceptance)?

Does your agency prepare and conduct asphalt laboratory performance testing (irrespective of whether testing is				
conducted on a routine or supplemental basis; i.e., no	t part of routine usage/specification/mix acceptance)?			
Yes (either in-house at agency and/or through	No			
consultant or university labs)	INO			
AK, AL, AR, AZ, CA, CO, DC, FL, GA, IA, IL, IN,				
KS, MA, ME, MN, MO, MS, MT, ND, NH, NJ, NM,	CT, DE, MD, MI, NC, NY, RI, WA			
NV, OH, OK, SC, SD, TN, TX, UT, VA, VT				

Question 2: "Please select the types of laboratory asphalt performance testing conducted by your agency (inhouse and/or by other entities on behalf of your agency)."

Test	Agencies
APA	AK, AL, FL, GA, IA, ND, NJ, SC, SD
Cantabro	FL, MA, MS, NJ, OK, SC, TN, TX
CTIndex	GA, ME, MO, OH, OK, TN, TX, UT
DCT	CO, IA, MN, ND, SD
DTCF	MO
E*	CO, FL, MO, MS, NH, OK, SC, SD, TX
FBF	IA, MA, NJ
HWT	AZ, CA, CO, FL, GA, IA, IL, IN, MA, ME, MO, MT, NM, OH, OK, TN, TX, UT, VT
IDT	TX
RLPD	CO, FL, MO, MS, SD
SCB	AZ, GA, IL, IN, MA, MN, MO, ND, OH, OK, SD, UT, VT
SSG DTCF	ME
SSG E*	CO, ME
SSG RLPD	CO
TxOT	FL, NJ, TX
Other 1	AR, CA, DC, FL, GA, IL, KS, ME, NV, OH, TN, UT, VA
Other 2	FL, GA, VA

	Other Test - 1	Other Test - 2								
Agency	Brief Description	Agency	Brief Description							
AR	In-House (ARDOT 480-07)	FL	T-283							
DC	Superpave Gyratory Compactor (AASHTO T312)	GA	GDT-66 Tensile Splitting Ratio (TSR)							
FL	Interlayer Bond Strength	KS	Moisture Induced Sensitivity Test (ASTM D7890)							
GA	GDT-1 Permeability Testing	VA	TSR							
IL	IL mod AASHTO T283									
KS	Thermal Stress Restrained Specimen Test (TSRST TP-10)									
ME	Stress Sweep Rutting (AMPT)									
NJ	AASHTO T 283									
NV	Hveem Stability									
ОН	TSR (similar to AASHTO T 283)									
TN	Marshall Flow and Stability									
UT	BBR Beam Sliver Test, AASHTO TP 125									
VA	Bond Shear Testing									

### Question 3: "How does your Agency use the results of the laboratory performance test (select all that apply)?"

### (a) For Mix Design Acceptance

Test	AK	AL	AR	AZ	CA	СО	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	MT	ND	NH	NJ	NM	NV	ОН	OK	SC	SD	TN	TX	UT	VA	VT
APA	X	X						X														X					X	X					
Cantabro								X						X								X					X		X	X			
CTIndex																																	
DCT																																	
DTCF																																	
E*																																	
FBF														X								X											
HWT					X				X	X	X			X	X		X		X							X				X	X		
IDT																														X			
RLPD																																	
SCB											X						X																
SSG DTCF																																	
SSG E*																																	
SSG RLPD																																	
TxOT																						X								X			
Other-1			X		X		X		X		X													X	X				X				
Other-2								X	X																							X	

# (b) In Quality Assurance (QA) Process

Test	AK	AL	AR	AZ	CA	СО	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	МТ	ND	NH	NJ	NM	NV	ОН	ОК	SC	SD	TN	TX	UT	VA	VT
APA										О												М,Р											
Cantabro																																	
CTIndex																																	
DCT										О																							
DTCF																																	
E*																																	
FBF										О				M								M											
HWT					M				M	M	M				M		M,P,O		M											M	О		
IDT																																	
RLPD																																	
SCB																	M,P,O																
SSG DTCF																																	
SSG E*																																	
SSG RLPD																																	
TxOT																						М,Р								M			
Other-1					M		М,О	О																M									
Other-2																																О	

M: For Mix Acceptance; P: For Pay Factor Adjustment; O: Other.

(c) Routine usage for research purposes (such as specification update)

Test	AK	AL	AR	AZ	CA	СО	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	MT	ND	NH	NJ	NM	NV	ОН	OK	SC	SD	TN	TX	UT	VA	VT
APA								X														X						X					
Cantabro								X										X															
CTIndex																														X			
DCT						X																						X					
DTCF																																	
E*						X																						X					
FBF																						X											
HWT						X		X			X			X	X				X											X			X
IDT																																	
RLPD						X																						X					
SCB											X																	X					X
SSG DTCF															X																		
SSG E*						X									X																		
SSG RLPD						X																											
TxOT																						X								X			
Other-1							X	X			X				X																		
Other-2								X																									

# (d) Nonroutine usage for research or other purposes

Test	AK	AL	AR	ΑZ	CA	СО	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	МТ	ND	NH	NJ	NM	NV	ОН	OK	SC	SD	TN	TX	UT	VA	VT
APA								X	X							X				X													
Cantabro								X																		X							
CTIndex									X				X		X	X	X								X	X			X	X	X		
DCT																X				X													
DTCF													X				X																
E*								X					X			X	X	X			X					X	X			X			
FBF																																	
HWT				X	X			X	X	X	X	X		X		X	X						X		X				X	X			
IDT																																	
RLPD								X					X				X	X															
SCB				X					X		X	X	X	X		X	X			X					X	X					X		
SSG DTCF																																	
SSG E*													X																				
SSG RLPD													X																				
TxOT								X					X																	X			
Other-1								X			X		X																		X	X	
Other-2								X					X																			X	

Question 4: "At your agency, is the fabrication of test specimens for performance testing conducted using standardized AASHTO or ASTM specifications and/or agency-specific protocols (provide one response for each test)?

Test	Standardized Procedures (AASHTO or ASTM specifications)	Standardized Procedure with some agency recommended modifications	Other (non-standardized procedure, such as entirely in-house protocol)
APA	6	3	0
Cantabro	5	1	2
CTIndex	7	0	3
DCT	4	2	0
DTCF	4	0	0
E*	11	1	0
FBF	1	1	1
HWT	11	9	2
IDT	1	0	1
RLPD	6	0	0
SCB	12	3	0
SSG DTCF	2	0	0
SSG E*	4	0	0
SSG RLPD	2	0	0
TxOT	1	1	2
Other-1	7	1	5
Other-2	2	1	1

Question 5: "If you have a document describing agency-specific procedures for fabricating specimens for laboratory performance tests, either: (1) upload documents: FILE UPLOAD (please rename files to include agency name) or (2) please paste a link to agency website where documents can be found."

Asphalt Pavement Analyzer Test (AASHTO T340)

Refer to ATM 419 at http://dot.alaska.gov/stwddes/desmaterials/mat\_waqtc/assets/pdf/testman/atm\_2018.pdf

## Cantabro Test

http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit245.pdf

# Hamburg Wheel Tracking Test

- http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit242.pdf
- https://www.codot.gov/business/designsupport/matgeo/manuals/2015-cdot-lab-manual-testprocedures-rev-2019/cpls/cp-ls-5100/%2808%29%20CPL%205112-15/view

# Superpave Indirect Tensile Strength and Creep Test

• http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit226.pdf

### Texas Overlay Test

http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit248.pdf

#### Other Test 1

- <a href="https://www.nevadadot.com/doing-business/about-ndot/ndot-divisions/operations/materials-section/materials-test-manual">https://www.nevadadot.com/doing-business/about-ndot/ndot-divisions/operations/materials-section/materials-test-manual</a>
- <a href="https://extranet.ddot.dc.gov/QAQC.Web/LoginNew.aspxReturnUrl=%2fQAQC.Web%2fMaterialTests%2fManageLogs.aspx%3fCat%3d10&Cat=10">https://extranet.ddot.dc.gov/QAQC.Web/LoginNew.aspxReturnUrl=%2fQAQC.Web%2fMaterialTests%2fManageLogs.aspx%3fCat%3d10&Cat=10</a>
- http://www.virginiadot.org/business/resources/Materials/bu-mat-VTMs.pdf, VTM-128
- <a href="http://infonet.dot.state.fl.us/materials/administration/resources/library/publications/fstm/Methods/fm5-599.pdf">http://infonet.dot.state.fl.us/materials/administration/resources/library/publications/fstm/Methods/fm5-599.pdf</a>
- http://www.arkansashighways.com/materials\_division/A--FIELDMAN.pdf

## Other Test 2

• <a href="http://infonet.dot.state.fl.us/materials/administration/resources/library/publications/fstm/Methods/fm1-t283.pdf">http://infonet.dot.state.fl.us/materials/administration/resources/library/publications/fstm/Methods/fm1-t283.pdf</a>

# Question 6: "Is asphalt laboratory performance testing conducted at your agency and/or by consultant/university labs on behalf of the agency?"

Response	Number of Agencies
Conducted only in-house by agency	18
Conducted only through consultant/university labs	1
Conducted both in-house and through consultant/university labs	14

Question 7: "An important component of this synthesis study is to document specimen fabrication practices of non-agency entities (such as consultant or university labs) that conduct performance testing on behalf of agencies. Please share the name of entities that conduct laboratory performance testing for your agency and provide an email address for sending the survey."

American Engineering Testing, Braun Intertec, Center for Transportation Research (CTR) at UT Austin, Clemson University, Interstate Testing, Kansas State University, Knife River Corporation, National Center for Asphalt Technology, Rutgers University, South Dakota School of Mines and Technology, Texas A&M Transportation Institute (TTI), Tri-County Technical College, University of Massachusetts Dartmouth, University of Minnesota, University of Nevada Reno, University of New Hampshire, University of New Mexico, University of North Dakota, University of Texas-El Paso

#### **Fabrication of Asphalt Performance Test Specimens**

Question 8: "For laboratory performance tests used by your agency, are specimen dimensions as per standard specifications (such as AASHTO or ASTM)? (Select "No" if non-standard dimensions are used for even a single performance test used by your agency.)"

	Specimen Dimensions as per Standard Specifications
Answer	Agency
Yes	AL, AR, AZ, CO, DC, FL, IA, IL, IN, ME, MN, MO, MS, MT, NH, NJ, NM, NV, OH, OK, SC, SD, TN, UT, VT
No	AK, CA, GA, MA, TX, VA

Question 9: "What are the dimensions of the final test specimen for the laboratory performance tests used by your agency? (Typical values are shown; please edit as necessary and fill all that apply.)"

NOTE: Respondents were requested to provide dimensions only when dimensions other than those recommended in test standards were used.

Thickness	Diameter (if applicable)	Length (if applicable)	Width (if applicable)	If there are any additional features about the test specimen (e.g., flat faces or semi-circular shape), please describe them and share the dimensions used							
		Asphalt Paveme	nt Analyzer Test								
89 mm	150 mm	N.A.	N.A.	Thickness = $75 + /-3 \text{ mm}$							
75 mm	150 mm	N.A.	N.A.								
			pro Test								
115 mm	150 mm	N.A.	N.A.								
115 mm	150 mm	N.A.	N.A.								
		<u>-</u>	Fatigue Test (S-VEC								
	Ε	Disk-Shaped Compac	et Tension (DCT) Te	st							
		Dynamic (Complex	x) Modulus Testing								
N.A.	100 mm	150 mm	N.A.								
	Flexural Bean	n Fatigue Test									
2 inch	N.A.	15 inch	2.5 inch								
		Flow Number	r (RLPD) Test								
	Hamburg Wheel Tracking Test  0-62 mm										
60-62 mm	150 mm	N.A.	N.A.								
60 +/- 1.0 mm	150 mm	N.A.	N.A.								
60 mm	150 mm	N.A.	N.A.								
62 mm	150 mm	N.A.	N.A.								
		CTInd	ex Test								
60-62 mm	150 mm	N.A.	N.A.								
62 mm	150 mm	N.A.	N.A.								
	Se	mi-Circular Bend (S	SCB) Test (any version	on)							
50 mm	150 mm	N.A.	N.A.	Faces are not saw-cut							
60 mm	150 mm	N.A.	N.A.								
	Small-Scale G	eometry Direct Tens	sion Cyclic Fatigue T	Cest (S-VECD)							
	Small-Sc	cale Geometry Dyna	mic (Complex) Mod	ulus Test							
	Smal	l-Scale Geometry Fl	low Number (RLPD)	Test							
	Super	rpave Indirect Tensil	le Strength and Creep	Test							
2.4 inch	5.9 inch	N.A.	N.A.								
		Texas Ov	erlay Test								
1.5 inch	6 inch	N.A.	3.0 inch								
		Other	Test 1								
75 mm	150 mm	N.A.	N.A.								
95 +/-5 mm	150 mm	N.A.	N.A.								
	100 or 150 mm	N.A.	N.A.								
		Other	Test 2								
95 mm	150 mm	N.A.	N.A.	T283							
63.5mm	100 or 150 mm	N.A.	N.A.								

Question 10: "What type(s) of materials are evaluated using laboratory performance test(s) by your agency (check all that apply)?"

# (a) Laboratory mixed, laboratory compacted

Test	AK	AL	AR	ΑZ	CA	СО	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	МТ	ND	NH	NJ	NM	NV	ОН	OK	SC	SD	TN	TX	UT	VA	VT
APA	X	X						X	X													X					X	X					
Cantabro								X						X				X				X				X	X		X	X			
CTIndex									X								X								X	X				X	X		
DCT																												X					
DTCF																	X																
E*								X									X	X			X					X	X			X			
FBF														X								X											
HWT								X	X		X			X	X		X		X				X		X	X				X	X		
IDT																														X			
RLPD								X									X	X															
SCB									X		X			X			X								X	X		X			X		
SSG DTCF															X																		
SSG E*															X																		
SSG RLPD																																	
TxOT								X														X								X			
Other-1			X				X		X		X				X									X	X				X		X		
Other-2								X	X																							X	

# (b) Plant mixed and field compacted, or field cores

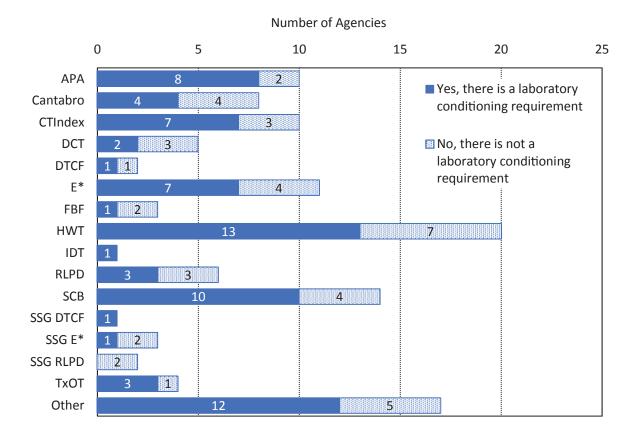
Test	AK	AL	AR	AZ	CA	СО	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	MT	ND	NH	NJ	NM	NV	ОН	ОК	SC	SD	TN	TX	UT	VA	VT
APA								X	X													X						X					
Cantabro																																	
CTIndex															X		X																
DCT																																	
DTCF																	X				X									X			
E*																	X																
FBF																																	
HWT					X				X		X						X		X											X	X		
IDT																																	
RLPD																	X																
SCB											X						X																
SSG DTCF																																	
SSG E*													X																				
SSG RLPD													X																				
TxOT																						X								X			
Other-1					X		X	X	X		X																				X	X	
Other-2									X																								

(c) Reheated plant mixed laboratory compacted or plant mixed laboratory compacted at the plant

Test	AK	AL	AR	AZ	CA	CO	DC	FL	GA	IA	IL	IN	KS	MA	ME	MN	МО	MS	MT	ND	NH	NJ	NM	NV	ОН	OK	SC	SD	TN	TX	UT	VA	VT
APA								X	X													X						X					
Cantabro								X										X												X			
CTIndex													X				X																
DCT						X										X																	
DTCF						X		X					X				X				X					X		X					
E*														X								X											
FBF						X		X					X				X											X					
HWT				X	X	X		X	X		X	X		X	X		X		X				X		X				X	X			X
IDT													X		X		X								X	X			X	X			
RLPD				X							X	X	X				X								X	X					X		X
SCB															X																		
SSG DTCF						X									X																		
SSG E*						X																											
SSG RLPD																														X			
TxOT													X									X								X			
Other-1					X		X		X		X		X		X									X							X		ł
Other-2									X				X																			X	l

(d) Other: No respondents selected "other."

Question 11: "Please identify laboratory performance test(s) for which there is a laboratory conditioning requirement (for example, short and/or long-term oven aging) as part of specimen fabrication process for your agency (select all that apply)."



Question 12: "Please provide information regarding the laboratory conditioning (for example, short and/or long-term oven aging) during specimen fabrication for laboratory performance testing (check all that apply)."

Test	AK	AL	AR	AZ	СО	DC	FL	GA	IL	KS	MA	ME	MN	МО	MS	MT	NH	NJ	NM	NV	ОН	ОК	SC	SD	TX	UT	VA
APA	LM	CS					LM	LM, CS										CS					LM	LM			
Cantabro							LM								LM								LM		LM		
DTCF														LM													
DCT																								LM			
E*							LM							LM	LM		LM					LM	LM				
FBF																		CS									
RLPD							LM							LM	LM												
HWT				CS	LM		LM	LM	LM		LM	LM		LM		LM			LM, CS		LM				LM	LM	
CTIndex								LM				LM		LM							LM	LM			LM	LM	
SCB				CS				LM	CS		LM			LM							LM	LM		LM		LM	
SSG DTCF												LM															
SSG E*												LM															
SSG RLPD																											
IDT																									LM		
ТхОТ							LM											CS							LM		
Other-1			LM			LM		LM, CS	CS	CS		LM								LM	LM					LM	
Other-2							LM	LM, CS																			LM

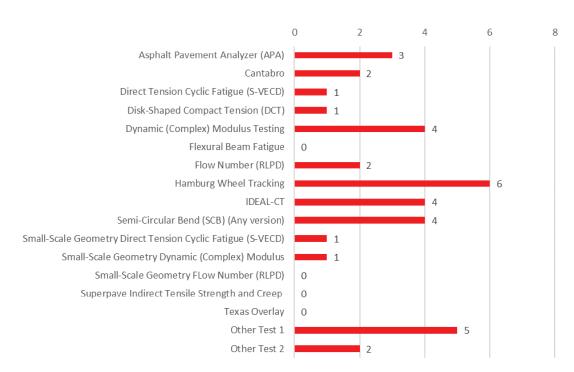
CS: Compacted Sample; LM: Loose Mix

## "Other" responses and brief description

Asphalt Pavement Analyzer (APA)	Short-term aging only (2 hours at compaction temperature)
Cantabro	Short-term aging only (2 hours at compaction temperature)
Direct Tension Cyclic Fatigue (S-VECD)	
Disk-Shaped Compact Tension (DCT)	Conditioning compacted specimen at a temperature before testing
Dynamic (Complex) Modulus Testing	Short-term aging only (2 hours at compaction temperature)
Flexural Beam Fatigue	
Flow Number (RLPD)	Short-term aging only (2 hours at compaction temperature)
Hamburg Wheel Tracking	Short-term aging as defined in R30; 4 hours; for volumetric mix design; short-term aging only (2 hours at compaction temperature); 45 min @ 50°C
CTIndex	
Semi-Circular Bend (SCB) (any version)	4 hours; loose mix for Volumetric Mix Design AND Long-Term Aging 3 days @ 95°C on Compacted Specimens; 2 hours @ 25°C
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)	
Small-Scale Geometry Dynamic (Complex) Modulus	
Small-Scale Geometry FLow Number (RLPD)	
Superpave Indirect Tensile Strength and Creep	
Texas Overlay	Short-term aging only (2 hours at compaction temperature)
Other Test 1	AASHTO R 30 Long-Term Aging; short-term (2 hours); loose mix for Volumetric Mix Design AND 1 day in 60°C water bath per AASHTO T283 for three specimens; after compaction, must sit at room temperature for 4 to 24 hours (a little different than T 283)
Other Test 2	Short-term aging only (2 hours at compaction temperature)

Question 13: "Please provide details (such as temperature and time) for the loose mixture laboratory conditioning during specimen fabrication process (fill in all information that is applicable)."

Number of agencies indicating that loose mix conditioning is done as per AASHTO R 30 short-term aging protocol:



#### Loose mix aging temperature and aging time reported for non-AASHTO R30 protocol:

Test	Temperature (degrees Celsius)	Time (minutes)
Asphalt Pavement Analyzer (APA)		
Cantabro	120	
Direct Tension Cyclic Fatigue (S-VECD)		
Disk-Shaped Compact Tension (DCT)		
Dynamic (Complex) Modulus Testing		
Flexural Beam Fatigue		
Flow Number (RLPD)		
Hamburg Wheel Tracking	135	240, 120, 120
CTIndex		120
Semi-Circular Bend (SCB) (any version)	135	240
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus		
Small-Scale Geometry Flow Number (RLPD)		
Superpave Indirect Tensile Strength and Creep	120	
Texas Overlay	120	
Other Test 1		
Other Test 2		

# Descriptions of "other process followed" for loose mix conditioning:

Aspnait Pavement Analyzer (APA) ag Sh dif it i Cantabro the	emp = midpoint of mix compaction temperature range; for 120 +/-5 mins; short-term ging only (2 hours at compaction temperature) hort-term aging only (2 hours at compaction temperature); time is a total of 2 hours. It iffers if molding directly from plant/lab (2-h cure if mix was just mixed and still hot). If is being shipped from a location to another location to be molded at a later date (the
Cantabro Sh dif it i the the	hort-term aging only (2 hours at compaction temperature); time is a total of 2 hours. It iffers if molding directly from plant/lab (2-h cure if mix was just mixed and still hot). If
	bought is that the mix continued to age in the box/bucket until it cooled completely), aus it will only require 1.5 hours of additional cure time upon reheating the material. emperature based on binding grade. See Table 1 in Tex206-F attp://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit206.pdf),
Direct Tension Cyclic Fatigue (S-VECD)	
Disk-Shaped Compact Tension (DCT)	
Testing ter	hort-term aging only (2 hours at compaction temperature); heat mix to compaction mp. Gyrate to height to achieve 7% air voids.
Flexural Beam Fatigue	
	hort-term aging only (2 hours at compaction temperature)
Hamburg Wheel Tracking 2 h	hort-term aging only (2 hours at compaction temperature); for Volumetric Mix Design, hours aging at compaction temperature for binder grade; the mixed material shall be nort-term age for 2 hours; temperature is based on binder grade
CTIndex graming local lo	esearch being conducted for aging; 2 hours aging at compaction temperature for binder rade; time is a total of 2 hours. It differs if molding directly from plant/lab (2-h cure if ax was just mixed and still hot). If it is being shipped from a location to another exaction to be molded at a later date (the thought is that the mix continued to age in the ex/bucket until it cooled completely), thus it will only require 1.5 hours of additional are time upon reheating the material. Temperature based on binder grade. See Table 1 in ex206-F. <a href="http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F">http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F</a> series/pdfs/bit206.pdf
	esearch being conducted for aging; 2 hours aging at compaction temperature for binder
	rade
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)	
Small-Scale Geometry Dynamic (Complex) Modulus	
Small-Scale Geometry Flow Number (RLPD)	
Superpave Indirect Tensile be Strength and Creep un rel	ime is a total of 2 hours. It differs if molding directly from plant/lab (2-h cure if mix as just mixed and still hot). If it is being shipped from a location to another location to be molded at a later date (the thought is that the mix continued to age in the box/bucket ntil it cooled completely), it will only require 1.5-hours of additional cure time upon cheating the material. Temperature based on binder grade. See Table 1 in Tex206-F. http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit206.pdf
Texas Overlay the	hort-term aging only (2 hours at compaction temperature); time is a total of 2 hours. It iffers if molding directly from plant/lab (2-h cure if mix was just mixed and still hot). If is being shipped from a location to another location to be molded at a later date (the lought is that the mix continued to age in the box/bucket until it cooled completely), thus it will only require 1.5 hours of additional cure time upon reheating the material. The emperature based on binder grade. See Table 1 in Tex206-F.  http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F series/pdfs/bit206.pdf
	5 hours at 140°F; 2 hours aging at compaction temperature for binder grade
1 1 2 2	ompaction temp; short-term aging only (2 hours at compaction temperature)

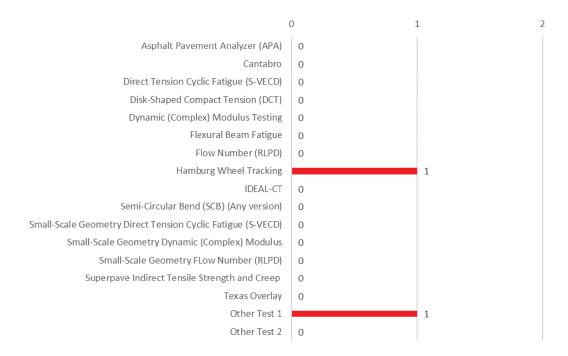
Question 14: "Is laboratory conditioning of compacted specimens conducted on bulk (prior to cutting and coring) specimens or on finished test specimens (after cutting and coring) (select one)?"

Test	AK	AL	AR	AZ	СО	DC	FL	GA	IL	KS	MA	ME	MN	MO	MS	MT	NH	NJ	NM	NV	ОН	OK	SC	SD	TX	UT	VA
APA		F						F										F									
Cantabro																											
CTIndex																											
DCT																											
DTCF																											
E*																											
FBF																		F									
HWT				В															В								
IDT																											
RLPD																											
SCB				В					F																		
SSG DTCF																											
SSG E*																											
SSG RLPD																											
TxOT																		F									
Other-1								F	F	В																	
Other-2								F																			

B: Lab conditioning on bulk specimen (prior to cutting and/or coring); F: Lab conditioning on finished test specimen (after cutting and/or coring to get to final test specimen geometry)

#### Question 15: "Please provide details (such as temperature and time) for the compacted specimen conditioning during fabrication process (fill in all information that is applicable)."

Number of agencies indicating that compacted specimen conditioning is done as per AASHTO R 30 long-term aging protocol:



# Compacted specimen aging temperature and aging time reported for non-AASHTO R30 protocol:

Test	Temperature (degrees Celsius)	Time (hours)					
Asphalt Pavement Analyzer (APA)	48.89-63.89	3					
Asphalt Pavement Analyzer (APA)	64	6					
Cantabro							
Direct Tension Cyclic Fatigue (S-VECD)							
Disk-Shaped Compact Tension (DCT)							
Dynamic (Complex) Modulus Testing							
Flexural Beam Fatigue	15	2					
Flow Number (RLPD)							
Hamburg Wheel Tracking							
CTIndex							
Semi-Circular Bend (SCB) (any version)	95	72					
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)							
Small-Scale Geometry Dynamic (Complex) Modulus							
Small-Scale Geometry Flow Number (RLPD)							
Superpave Indirect Tensile Strength and Creep							
Texas Overlay	25	2					
Other Test 1	77 degrees F water saturation wi	th vacuum					
Other Test 1	Freeze/thaw warm water bath 0, 140, 55 degrees F						
Other Test 2	24 hours in 60°C water bath for	3 specimens per AASHTO T283					

No descriptions of "other process followed" for compacted specimen conditioning were reported.

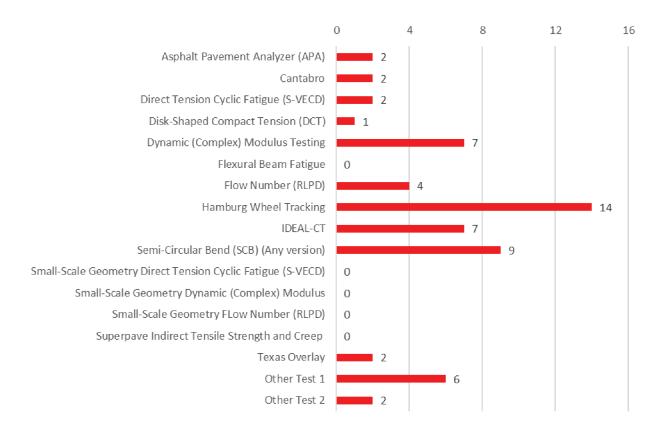
Question 16: "Is there a target air void level requirement for laboratory performance test specimens used by your agency? (Select one for each test.)"

TEST	AK	AL	AR	AZ	CA	CO	DC	FL	GA	IL	IN	KS	MA	ME	MN	МО	MS	MT	NH	NJ	NM	NV	ОН	OK	SC	SD	TN	TX	UT	VA	VT
APA	Y	Y						Y	Y											Y					Y	Y					
Cantabro								N					Y				N			N				Y	Y		Y	Y			
CTIndex									Y			Y		Y	Y	Y							Y	Y			Y	Y	Y		
DCT						Y									Y											Y					
DTCF												Y				Y															
E*						Y		Y				Y			Y	Y	Y		Y					Y	Y	Y		Y			
FBF													Y							Y											
HWT				Y	Y	Y		Y	Y	Y	Y		Y	Y	Y	Y		Y			Y		Y	Y			Y	Y	Y		Y
IDT																												Y			
RLPD						Y		Y				Y				Y	Y									Y					
SCB				Y					Y	Y	Y	Y	Y		Y	Y							Y	Y		Y			Y		Y
SSG DTCF														Y																	
SSG E*						N						N		Y																	
SSG RLPD						N						N																			
TxOT								Y				Y								Y								Y			
Other-1			Y		Y		Y	N	Y	Y		Y		Y								Y	Y				Y		Y	N	
Other-2								Y	Y			Y																		Y	

Y: Yes; N: No

Question 17: "Please provide information regarding the target air void level requirement during fabrication of laboratory performance test specimens used by your agency or on behalf of your agency. (If requirements are in the AASHTO/ASTM specification, please select in first column and leave rest blank. Fill in all information that applies and leave blank if no requirements are in place.)"

Number of agencies responding that target air void requirements are as per AASHTO/ASTM specifications.



■ Target air void requirement as per AASHTO/ASTM specification for the performance test.

# Target air void level requirements not detailed in test specification or deviated from test specification:

%) Target Air Void Level (%) sphalt Pavement Analyzer Test 5-7% SMA 6-8% all other	Allowed Variation (+/- %)
5-7% SMA	
Varies based on mix	
4% air void at Nodes	
4% all void at Nodes	
Cantabro Test	<b>L</b>
7	1
Only done on OGEC, target 20%	-
7	0.5
haped Compact Tension (DCT) Test	
amic (Complex) Modulus Testing	•
7	0.5
Flexural Beam Fatigue Test	
1.5 for waterproof bridge mix	
Flow Number (RLPD) Test	
7	0.5
Hamburg Wheel Tracking Test	
7	0.5
1.5 for waterproof bridge mix	
CTIndex Test	
7	0.5
	itu from cores after compaction.
ircular Bend (SCB) Test (any version)	0.5
1	0.5
7 m voids are not that critical with this test.	·
Other Test 2	
	Flexural Beam Fatigue Test

Question 18: "Identify equipment that is used in your laboratory to fabricate test specimens for laboratory performance tests (check all that apply)."

Test	Mix Splitter (e.g., quartermaster)	Superpave Gyratory Compactor	Oven(s)	Rotary Saw(s)	Coring Drill	Core Drying Device	Gluing Templates (e.g., template for marking location of gage points or to attach gage points)	Gluing Jigs (e.g., specimen holding devices to glue loading platens to test specimen)	Temperature Conditioning Chamber(s)	Vacuum Bag Sealing Devices (such as CoreLok)
Asphalt Pavement Analyzer Test	2	7	6	1	0	0	0	0	2	1
Cantabro Test	1	6	7	0	0	2	0	0	2	3
Direct Tension Cyclic Fatigue Test (S- VECD)	1	2	2	2	2	0	1	2	2	0
Disk-Shaped Compact Tension (DCT) Test	0	2	1	2	1	0	1	0	2	0
Dynamic (Complex) Modulus Testing	2	10	9	8	7	4	5	7	8	1
Flexural Beam Fatigue Test	0	1	2	2	0	0	1	1	2	0
Flow Number (RLPD) Test	1	5	5	5	5	1	1	2	5	0
Hamburg Wheel Tracking Test	11	19	18	18	2	4	0	0	4	3
CTIndex Test	5	9	9	3	0	3	0	0	4	3
Semi-Circular Bend (SCB) Test (any version)	7	11	11	11	0	3	0	0	8	2
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)	1	1	1	1	1	1	0	1	1	1
Small-Scale Geometry Dynamic (Complex) Modulus Test	1	1	1	2	3	1	2	3	3	1
Small-Scale Geometry Flow Number (RLPD) Test	0	0	0	1	2	0	1	1	2	0
Superpave Indirect Tensile Strength and Creep Test	0	1	1	0	0	0	0	0	1	0
Texas Overlay Test	0	4	4	4	1	1	1	4	3	0
Other Test 1	8	9	11	5	6	4	1	2	7	3
Other Test 2	2	4	4	0	0	0	0	0	3	1

# "Other" responses and brief descriptions:

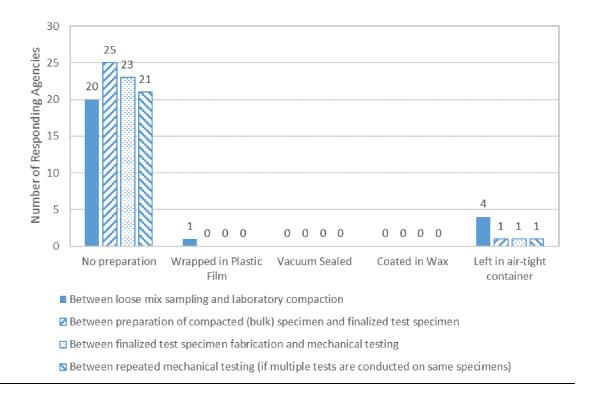
Test	Other(s) (briefly de	escribe)
Asphalt Pavement Analyzer Test		
Cantabro Test	Vacuum bag required for OGFC	Marshall hammer
Direct Tension Cyclic Fatigue Test (S-VECD)		
Disk-Shaped Compact Tension (DCT) Test		
Dynamic (Complex) Modulus Testing		
Flexural Beam Fatigue Test	Beam compactor	
Flow Number (RLPD) Test		
Hamburg Wheel Tracking Test	Riffle splitter NOT quartermaster	
CTIndex Test		
Semi-Circular Bend (SCB) Test (any version)	Riffle splitter NOT quartermaster	
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus Test		
Small-Scale Geometry Flow Number (RLPD) Test		
Superpave Indirect Tensile Strength and Creep Test		
Texas Overlay Test		
Other Test 1	Hveem compactor	Marshall hammer
Other Test 2		

#### **Operational Constraints and Rejection Rates of Test Specimens**

Question 19: "What is the allowable maximum storage time before, during, and after specimen fabrication for the performance tests that are instituted in your agency? Please use comments column to provide any additional relevant information (fill all that apply, leave blank if no requirements are in place)."

	Allowable Maxi	mum Storage Times Before, Perform	During, and After Specin nance Tests	
Test	Between Loose Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (bulk) Specimen and Finalized Test Specimen	Between Finalized Test Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if multiple tests are conducted on same specimens)
Asphalt Pavement			1	1
Analyzer Test			1	1
Cantabro Test				
Direct Tension Cyclic Fatigue Test (S-VECD)				
Disk-Shaped				
Compact Tension				
(DCT) Test				
Dynamic				
(Complex)		3		
Modulus Testing				
Flexural Beam				
Fatigue Test				
Flow Number				
(RLPD) Test				
Hamburg Wheel	ASAP, 1	ASAP, within 24 hours	> 1, ASAP, 1, 3	ASAP, same day or 2 OR
Tracking Test	710711,1	if possible		less
CTIndex Test	1		1,3	
Semi-Circular		ASAP, within 24 hours		ASAP, same day or 2 OR
Bend (SCB) Test	ASAP, 1	if possible	1, ASAP	less
(any version)		ii possible		1033
Small-Scale				
Geometry Direct			14	
Tension Cyclic				
Fatigue Test				
Small-Scale				
Geometry			1.4	
Dynamic			14	
(Complex)				
Modulus Test Small-Scale				
Geometry Flow				
Number (RLPD)				
Test				
Superpave Indirect				
Tensile Strength			3	
and Creep Test			5	
Texas Overlay Test				
		1, ASAP, within 24		ASAP, same day or 2 OR
Other Test 1	1, ASAP, 1, 0.167	hours if possible	1, ASAP, 14	less
Other Test 2				

Question 20: "How are performance test specimens prepared for storage at your agency? (Select all that apply.)"

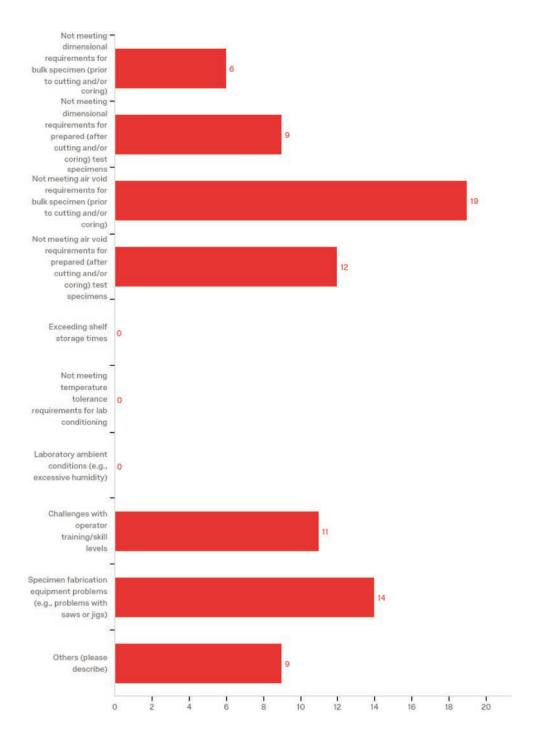


#### "Other" responses and brief description

Between Loose Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (bulk) Specimen and Finalized Test Specimen	Between Finalized Test Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if multiple tests are conducted on same specimens)
N/A	NA	Overnight at room temperature	N/A
Stored in original job- site sample box	Stored moisture-free at room temperature	Tested right away	N.A.
In a cloth bag when necessary	Generally do not store specimens	N/A	Generally do not store specimens
N/A.		N.A.	
STOA		Generally do not store specimens	
Typically shipped to us in paper sacks or cardboard boxes		Specimens are stored indoors in an air-conditioned room and are stabilized to prevent any creep or specimen distortion.	

STOA = Short Term Oven Aging

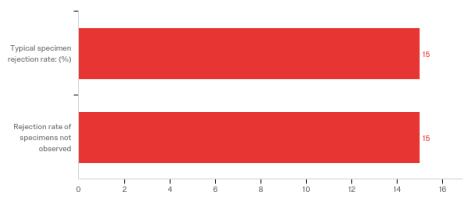
Question 21: "Please indicate the most frequent causes of operational disruptions that you have encountered during the test specimen fabrication process (check all that apply)."



#### "Other" responses:

Issues with the testing equipment
Machine issues
NA
The machine itself has been the major issue for any delays we see.
These situations only occur very infrequently.
We're relatively new to compacting specimens to 7.0% with our newer technicians.
Equipment breakdown has been the largest issue over the last few years.
None of the above
Still run testing with not meeting AV for TSR.

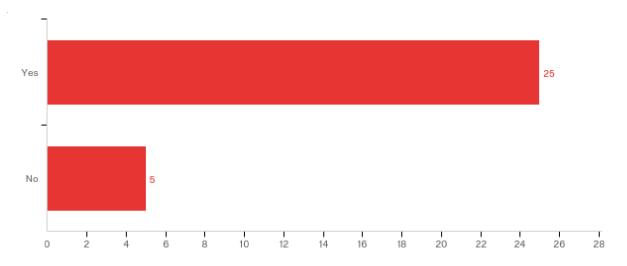
Question 22: "In your experience, what has been the rejection rate of test specimens (i.e., specimens that are not used for testing) due to the fabrication process (e.g., longer shelf storage than allowed, out-of-tolerance dimensions, wrong air void content, etc.) (Select one and fill in the blank)."



#### Typical specimen rejection rates reported:

Typical specimen rejection rate: (%)
15
15
< 10%
25
Less than 10%
< 0.01%
5
< 5%
< 5%
Depends on the technician's experience. 10-percent rejection rate for a good technician.
0
10
less than 5%
5 to 10%
20

Question 23: "Is your agency satisfied with your performance test specimen rejection rate? (Select one and fill in the blank.) If no, what rejection rate (%) would you consider as acceptable/satisfactory?"

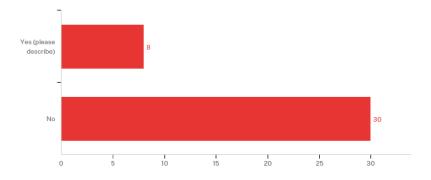


Responses to "If no, what rejection rate (%) would you consider as acceptable/satisfactory?":

Less than 5%
5%
The majority of testing is on HWTD which the rejection rate is good. For the SCB, we have more rejections due to dimensions but this might be due to the small number of samples that we have been testing so far.
Lower than 10%
NA

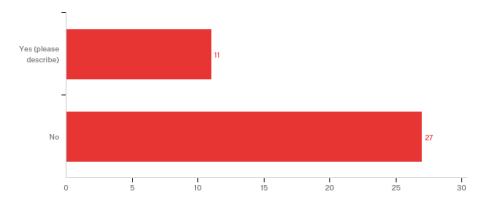
#### Identification of Other Contacts and Suggestions for Future Research

Question 24: "Is your Agency currently sponsoring (or planning to sponsor) any research related to asphalt performance testing that specifically addresses the fabrication of laboratory specimens in-house in the future?"



Yes (please describe)
Balanced mix design research project
Cracking performance testing
SCB Test, IDT, IDEAL-CT
Pilot projects evaluating current production mixes in New York State using Texas Overlay, APA, Flow Number, and Dynamic Modulus.
Some work is being done through research contract.
Some work is being done by research branch of agency.
Only research that mildly fits into this category would be looking at long- term aging in the laboratory on the final HMA mixture for cracking performance tests.
Currently looking at halance Mix Design research project

Question 25: "Have you observed any gaps in knowledge that have made it challenging for your Agency to start (or continue) successfully fabricating performance test specimens in-house?"



#### Yes (please describe)

#### Minor test preparation instructions

Our lab staff are most experienced with fabricating slabs for testing in the Hamburg. We are currently trying to gain experience in fabricating SGC specimens, specifically to height and void content.

General inexperience is making specimens and targeting air voids. Just took lots of practice on extra samples.

There is not a lot of direction about allowable time frames (see the "N.A." answers from previous questions). Also when to age samples long-term or not and at what temperature(s) to age.

Meeting AV target at different labs

SCB tolerances were difficult to meet. Agency not performing SCB testing at this time.

Saw cutting of SCB samples within tolerances is challenging.

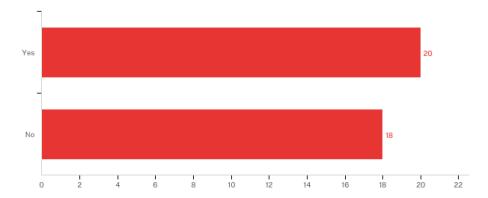
We are attempting to close the gap through Balanced Mix Design training. Our Mix Design Engineer recently completed a training course on the topic and will lead our Performance Testing Program.

Our staff needs training in test procedures and need expert's help in setting up baseline criteria for rutting and cracking tests.

Our state currently lacks experience in gyratory compact since we are a Marshall state.

We have a lot of newer technicians. We also are starting to get more involved with performance testing that's relatively new to our lab.

Question 26: "The synthesis will also include case examples illustrating agency practices on asphalt performance test specimen fabrication. The development of the case example(s) may require an additional follow-up interview. Agencies will be provided the opportunity to review the case example write-up for accuracy. Would your agency be interested in participating in a case example?"



Question 27: "If you have any additional information or thoughts you would like to share regarding this topic, please share them here."

Performance testing is critical in assuring a quality asphalt pavement and maximizing its useful life.

Performance testing for production (QC/QA) needs to be simple and quick.

Agency is just relatively new to fabrication of specimens. Hopefully get better soon when we get a performance mix test in our specifications (at least a few years out).

None

None

Just so you are aware, the majority (greater than 90%) of our performance testing is with the HWTD.

Agency has owned an APA in the past for a number of years but did not implement. We have an AMPT and can conduct Dynamic Modulus, Flow Number, and Texas Overlay testing. But we very infrequently run these tests. We have experimented with the Cantabro Test in the past but are not interested in continuing to use it. Our research contractor has run beam fatigue tests for us in the past but we have not had the need for that for several years. I know the specimens seem the same to you but the I-FIT (TP124), TP105, and the Louisiana Method are all different tests and should not be grouped together. This survey took considerably longer than 15 minutes to complete. Also, on about half of the questions, the screen "timed-out" and I had to go back and re-log into the survey. I hope these responses are helpful. Thank you

I wrote up a white paper on the I-FIT/SCB and its shortcomings. Can provide if interested.

Difficulty fabricating specimens for in-house SCB testing.

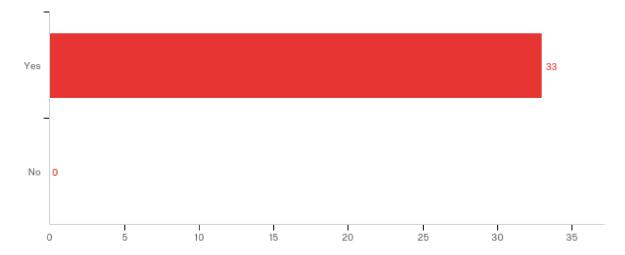


# Partner Laboratory Survey Responses

The responses to the partner laboratory survey questionnaire are presented in this appendix.

**Current Status of Laboratory Asphalt Performance Testing** 

Question 1: Does your organization prepare specimens and conduct asphalt laboratory performance tests?



Question 2: Please provide list of transportation agencies that contract asphalt laboratory performance testing to your organization. (If more than 15, please provide list of most recent 15 agencies that have contracted with your organization for asphalt laboratory performance testing.)

AASHTO Materials Reference Library (AASHTO RE:SOURCE), Alabama Department of Transportation, Arizona Department of Transportation (2), Arkansas Department of Transportation, Asphalt contractors doing work for Caltrans on projects with PRS, Beltrami County (MN), Benton County (MN), Brown County (MN), California Department of Resources Recycling and Recovery Research, California Department of Transportation, Carver County (MN), Chisago County (MN), City of Phoenix, Colorado Department of Transportation, Connecticut Department of Transportation, Federal Aviation Administration (3), Federal Highway Administration (3), Florida Department of Transportation (5), Hennepin County (MN), Illinois Department of Transportation (2), Illinois Tollway Authority, Indiana Department of Transportation, Ingham County Road Council, Iowa Department of Transportation, Louisiana Department of Transportation and Development, Michigan Department of Environmental Quality (3), Minnesota Department of Transportation (6), Missouri Department of Transportation (2), National Cooperative Highway Research Program (2), Nevada Department of Transportation (2), New Hampshire Department of Transportation, New York Department of Transportation, North Carolina Department of Transportation (2), Oklahoma Department of Transportation (2), Olmsted County (MN), Oregon Department of Transportation, Otter Tail County (MN), Pennsylvania Department of Transportation, Pennsylvania Turnpike, Private industry (2), Regional Transportation Commission, Sibley County (MN), South Dakota Department of Transportation, St. Louis County (MN), Stutsman County (ND), Tennessee Department of Transportation, Texas Department of Transportation (3), Transportation Research Board (2), U.S. Air Force Civil Engineering Center, U.S. Army Corps of Engineers (2), Utah Department of Transportation, Virginia Department of Transportation, Washington County (MN), Washington Department of Transportation, Wisconsin Department of Transportation (5), Wright County (MN)

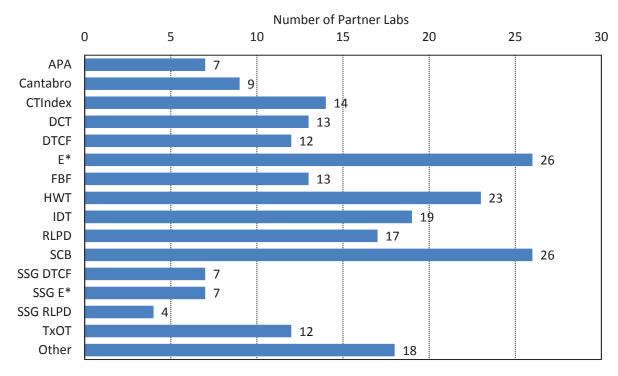
Numbers in parentheses represent the number of times an entity was identified by the partner laboratory.

Question 3: "For the agencies identified in previous question, please provide information regarding the purpose of the performance testing (select all that apply)."

Partner Lab		Agency 2	Agency 3	Agency 4	Agency 5	Agency 6	Agency 7	Agency 8	Agency 9	Agency 10	Agency 11	Agency 12	Agency 13	Agency 14	Agency 15
1	P														
2	P, Q	P, Q	Q												
3	P														
4	Q	Q P	Q	Q	Q	Q	Q	Q	Q	Q	Q	P, Q	P, Q	Q	Q
5	P	P	P												
6	P, Q														
7	P														
8	P														
9	P, Q	P, Q	P, Q												
10	P	P	Q	P											
11	P														
12	P, Q	P, Q	P, Q												
13	P	P	P												
14	P	P	P												
15	P	P	P	P	P	P	P	P	P						
16															
17	P	P	P	P	P	P	P	P	P	P	P				
18	P	P	P												
19	P, Q	Q	P, Q												
20	P	P													
21															
22	P														
23	P														
24	P, Q														
25	P, Q	P	P	P	P	P	P	P	P						
26	P														
27															
28	P	P													
29	P														
30	P, Q														
31	P														
32	P														
33															

P: Performance testing as part of a research study (or research studies); Q: Test required as part of mix design, mix acceptance, QA process or pay factor adjustment (select if any of these conditions apply).

Question 4: "Please select the types of laboratory asphalt performance testing conducted by your organization-select all that apply:"



"Other" responses and brief descriptions

Other Test-1 (briefly describe):	Other Test-2 (briefly describe):				
IDT (creep-recovery, strength, etc.)	Thermal Stress Restrained Specimen test				
BBR on small HMA beams	Static Load Creep				
Stress Sweep Rutting Test	IDT E* (NC state proposed test method)				
Repeated Load Creep Recovery  AASHTO TP114	Oregon Field Tack Coat Test and several other tack tests at the emulsion and mix level Indirect Tensile Ratio Test (AASHTO T283 modified)				
Oregon Field Torque test	Flexural Frequency Sweep—part of AASHTO T 321				
N <sub>flex</sub> IDT test—as proposed by NCAT					
Repeated Simple Shear Test AASHTO T 320					
Uniaxial Fatigue ( Tension-Compression)					
Resilient Modulus (ASTM 7369)					
C* Fracture Test					
Resilient Modulus					
Bending Beam Test (AASHTO TP125)					

Question 5: "At your organization, is the fabrication of test specimens for performance testing conducted using standardized AASHTO or ASTM specifications and/or agency-specific protocols? (Provide one response for each test.)"

Test	Standardized Procedures (AASHTO or ASTM specifications)	Standardized Procedure with Some Agency Recommended Modifications	Other (nonstandardized procedure, such as entirely in-house protocol)		
APA	6	3	1		
Cantabro	7	1	3		
CTIndex	10	1	3		
DCT	9	5	1		
DTCF	11	0	1		
E*	24	3	1		
FBF	12	1	0		
HWT	18	8	0		
IDT	16	4	1		
RLPD	16	1	1		
SCB	23	6	2		
SSG DTCF	6	0	1		
SSG E*	6	0	1		
SSG RLPD	4	0	0		
TxOT	7	4	2		
Other-1	6	2	6		
Other-2	6	3	1		

Question 6: "If you have a document describing organization-specific procedures for fabricating specimens for laboratory performance tests, either: (1) upload documents: FILE UPLOAD (please rename files to include organization name) or (2) please paste a link to a website where documents can be found."

Asphalt Pavement Analyzer Test (AASHTO T340)

• AASHTO T340, and also modified loading parameters of 250-lb load, 250-psi hose pressure (according to FAA AC 150-5370-10H) and 325-lb load, 325-psi hose pressure

#### Cantabro Test

• AASHTO TP108 and also <a href="https://apps.dtic.mil/dtic/tr/fulltext/u2/a590558.pdf">https://apps.dtic.mil/dtic/tr/fulltext/u2/a590558.pdf</a>

Disk-Shaped Compact Tension (DCT) Test (ASTM D7313)

• SEE ASTM D7313-13/MNdot Modified

Dynamic (Complex) Modulus Testing (AASHTO T342)

- AASHTO T342
- <a href="http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf">http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf</a>
- AASHTO T 342

Flexural Beam Fatigue Test (AASHTO T321)

 http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf

#### Flow Number (RLPD) Test (AASHTO T378)

http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3 Sample Preparation for LL HMA-Pavement I-5%20Sacramento 2018-07-20.pdf

#### Hamburg Wheel Tracking Test

- http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/testproceduresmanual2015.pdf
- AASHTO T324
- **AASHTO T324**
- https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302

#### CTIndex Test

https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302

### Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota)

- AASHTO TP124
- Received from Illinois DOT, can't find on their website
- AASHTO TP105
- https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302

## Superpave Indirect Tensile Strength and Creep Test

AASHTO T322

#### Other Test-1

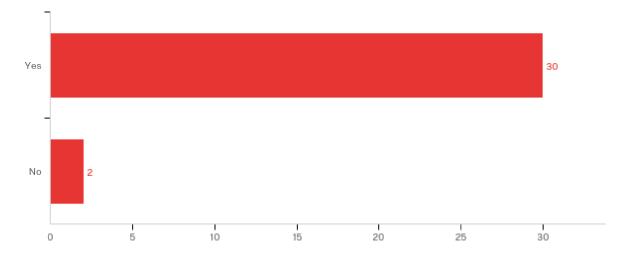
- https://apps.dtic.mil/dtic/tr/fulltext/u2/a590740.pdf
- http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3 Sample Preparation for LL HMA-Pavement I-5%20Sacramento 2018-07-20.pdf
- Uploaded (C Fracture Test—ASU)
- https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302

#### Other Test-2

https://apps.dtic.mil/dtic/tr/fulltext/u2/a590740.pdf

#### **Fabrication of Asphalt Performance Test Specimens**

Question 7: "For laboratory performance tests used by your organization, are specimen dimensions as per standard specifications (such as AASHTO or ASTM)? (Select "No" if nonstandard dimensions are used for any performance tests that are conducted on behalf of an agency.)"



Question 8: "What are the dimensions of the final test specimen for the laboratory performance tests conducted by your organization on behalf of transportation agencies? (Typical values are shown; please edit as necessary and fill all that apply.)"

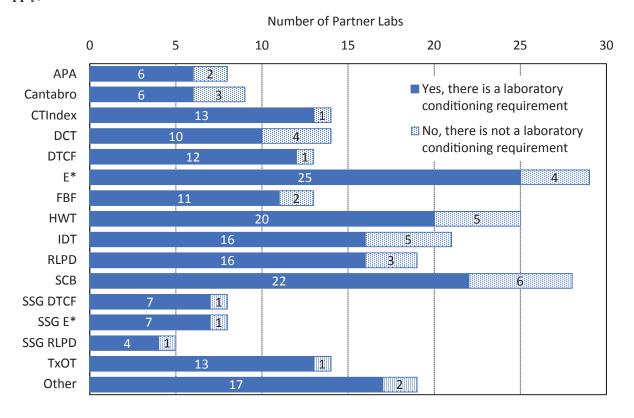
NOTE: Respondents were requested to provide dimensions only when dimensions other than those recommended in test standards were used.

				T
Thickness	Diameter (if applicable)	Length (if applicable)	Width (if applicable)	If there are any additional features about the test specimen (e.g., flat faces or semi-circular shape), please describe them and share the dimensions used
		Asphalt Paver	nent Analyzer Test	
89 mm	150 mm	Ñ.A.	N.A.	Thickness=75+/-3 mm
		Cant	abro Test	
100 mm	150 mm	N.A.	N.A.	
	Ι	Direct Tension Cycli	c Fatigue Test (S-VEC	CD)
N.A.	100 mm	130 mm	N.A.	
N.A.	100 mm	130 mm	N.A.	
		Disk-Shaped Comp	act Tension (DCT) Te	st
50 mm	150 mm	N.A.	N.A.	
		Dynamic (Comp	lex) Modulus Testing	
N.A.	100 mm	150 mm	N.A.	
N.A.	100 mm	150 mm	N.A.	
		Flexural Be	am Fatigue Test	
2 inch	N.A.	15 inch	2.5 inch	
		Flow Numb	per (RLPD) Test	
N.A.	100 mm	150 mm	N.A.	
N.A.	100 mm	150 mm	N.A.	
		Hamburg Wh	neel Tracking Test	
2.4 inch	5.9 inch	N.A.	N.A.	
2.4 inch	5.9 inch	N.A.	N.A.	
		CTIı	ndex Test	
62 mm	150 mm	N.A.	N.A.	
		Semi-Circular Bend	(SCB) Test (any version	on)
50 mm	150 mm	N.A.	N.A.	
57 mm	150 mm	N.A.	N.A.	
	Small-Scale	Geometry Direct Te	ension Cyclic Fatigue	Test (S-VECD)
N.A.	38 mm	100 mm	N.A.	
	Small-	Scale Geometry Dyn	namic (Complex) Mod	ulus Test
N.A.	38 mm	100 mm	N.A.	
	Sm	all-Scale Geometry	Flow Number (RLPD)	) Test
			sile Strength and Cree	
50 mm	150 mm	N.A.	N.A.	100 mm diameter.
38 mm	150 mm	N.A.	N.A.	
			Overlay Test	·
37.5 mm	150 mm	N.A.	75 mm	
37.5 mm	150 mm	N.A.	75 mm	
			er Test 1	·
100 mm	150 mm	N.A.	N.A.	
100 mm	150 mm	N.A.	N.A.	
			er Test 2	
62 mm	130 mm	N.A.	N.A.	Cylindrical specimen
50 mm	150 mm	N.A.	N.A.	•
-				

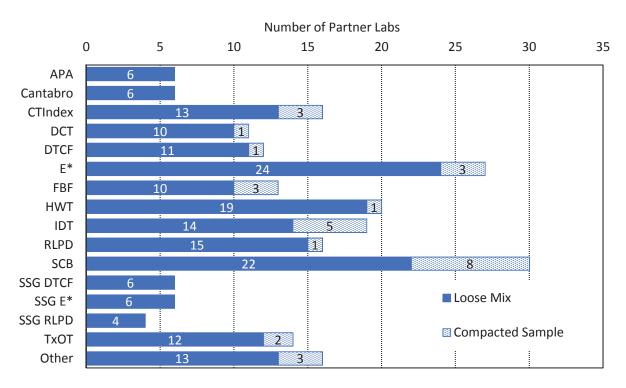
Question 9: "What type(s) of materials are evaluated using laboratory performance test(s) by your organization on behalf of state transportation agencies (check all that apply)?"

Test	Lab mixed, lab compacted	Reheated plant mixed lab compacted or plant mixed lab compacted at the plant	Plant mixed and field compacted, or field cores	Other (briefly describe)
APA	6	5	6	
Cantabro	6	7	4	
CTIndex	13	11	6	Research only
DCT	11	11	7	
DTCF	11	10	4	
E*	23	19	9	
FBF	12	11	3	
HWT	23	18	16	
IDT	18	12	11	
RLPD	14	14	4	
SCB	23	22	15	
SSG DTCF	6	5	5	
SSG E*	6	5	5	
SSG RLPD	4	3	2	
TxOT	11	8	5	Research only
Other-1	10	10	7	
Other-2	6	5	4	

Question 10: "Please identify laboratory performance test(s) for which there is a laboratory conditioning requirement (e.g., short- and/or long-term oven aging) as part of specimen fabrication process (select all that apply)."



Question 11: "Please provide information regarding the laboratory conditioning (e.g., short- and/or long-term oven aging) during specimen fabrication for laboratory performance testing (check all that apply)."

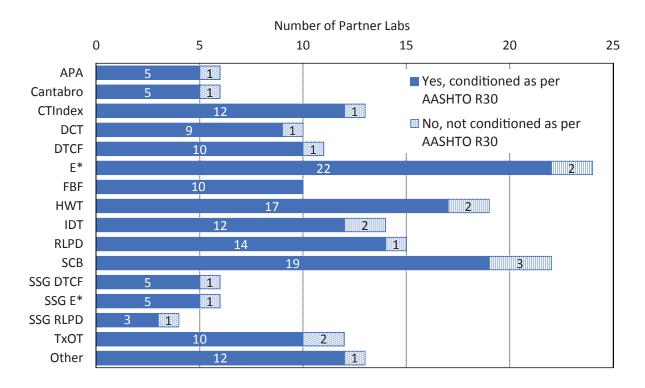


#### "Other" responses and brief description:

Asphalt Pavement Analyzer (APA)	Only on lab-produced mix
Cantabro	Only on lab-produced mix
Direct Tension Cyclic Fatigue (S-VECD)	Only on lab-produced mix
Disk-Shaped Compact Tension (DCT)	2-h STOA; Short- & long-term
Dynamic (Complex) Modulus Testing	2-h STOA; short-term; Only on lab-produced mix; STOA
Flexural Beam Fatigue	2-h STOA; Only on lab-produced mix; STOA
Flow Number (RLPD)	2-h STOA; Short-term; Only on lab-produced mix
Hamburg Wheel Tracking	2-h STOA; Short-term; Only on lab-produced mix
CTIndex	2-h STOA; Short-term; Only on lab-produced mix
Semi-Circular Bend (SCB) (any version)	2-h STOA; Short and long-term; PAV; Only on lab-produced mix; STOA on mix, LTOA on sample
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)	Only on lab-produced mix
Small-Scale Geometry Dynamic (Complex) Modulus	Only on lab-produced mix
Small-Scale Geometry Flow Number (RLPD)	Only on lab-produced mix
Superpave Indirect Tensile Strength and Creep	2-h STOA; Only on lab-produced mix
Texas Overlay	Short and long-term; Only on lab-produced mix
Other Test-1	NA; Only on lab-produced mix
Other Test-2	NA; Only on lab-produced mix

STOA = Short Term Oven Aging

Question 12: "Please provide details (such as temperature and time) for the loose mixture laboratory conditioning during specimen fabrication process (fill in all information that is applicable)."



#### Loose mix aging temperature and aging time reported for non-AASHTO R30 protocol:

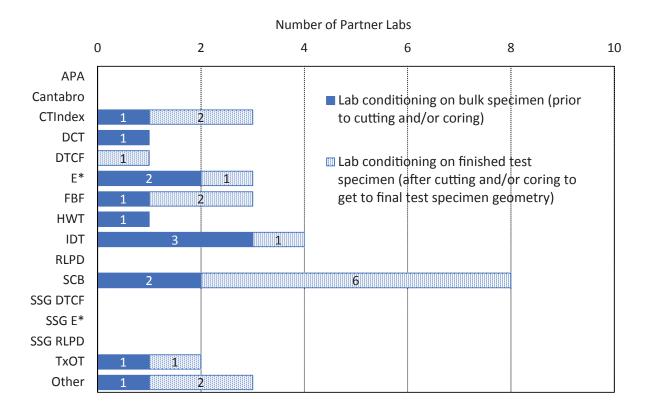
Test	Temperature (degrees Celsius)	Time (minutes)
Asphalt Pavement Analyzer (APA)		
Cantabro	85; 25	7,200
Direct Tension Cyclic Fatigue (S-VECD)	85; 95	7,200; 7,200/17,280
Disk-Shaped Compact Tension (DCT)	85; 135; 95	7,200; 960; 7,200/17,280
Dynamic (Complex) Modulus Testing	85; 95	7,200; 7,200/19,280
Flexural Beam Fatigue		
Flow Number (RLPD)	85	7,200
Hamburg Wheel Tracking	135; 85	120; 7,200
CTIndex	85; 135; 135; 20	7,200; 960; 480
Semi-Circular Bend (SCB) (any version)	95; 85; 135; 135; 20	4,320; 7,200; 960; 480; 7,200/17,280
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)	85	7,200
Small-Scale Geometry Dynamic (Complex) Modulus	85	7,200
Small-Scale Geometry Flow Number (RLPD)		
Superpave Indirect Tensile Strength and Creep	85	7,200
Texas Overlay	135; 85; 135; 135	120; 7,200; 960; 480
Other Test-1	85	7,200
Other Test-2	85	7,200

# Descriptions of "other process followed" for loose mix conditioning:

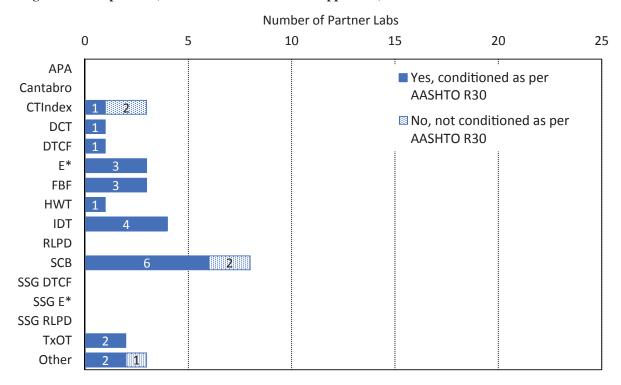
Asphalt Pavement Analyzer (APA)	
Cantabro	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Direct Tension Cyclic Fatigue (S-VECD)	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Disk-Shaped Compact Tension (DCT)	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h; long-term varies 12 to 16 h
Dynamic (Complex) Modulus Testing	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Flexural Beam Fatigue	Experimenting now
Flow Number (RLPD)	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Hamburg Wheel Tracking	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
CTIndex	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h; long-term varies 12 to 16 h; 8 h at 135°C is for long-term (critical) oven aging in addition to short-term oven aging; experimenting now
Semi-Circular Bend (SCB) (any version)	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h; long-term varies 12 to 16 h; 8 h at 135°C is for long-term (critical) oven aging in addition to short-term oven aging; experimenting now
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Small-Scale Geometry Dynamic (Complex) Modulus	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Small-Scale Geometry Flow Number (RLPD)	
Superpave Indirect Tensile Strength and Creep	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Texas Overlay	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h; long-term varies 12 to 16 h; 8 h at 135°C is for long-term (critical) oven aging in addition to short-term oven aging.
Other Test-1	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.
Other Test-2	We do all loose mix conditioning (both STOA and LTOA). LTOA is 85°C for 5 d or 135°C for 24 h.; experimenting now.

STOA = Short Term Oven Aging

Question 13: "Is laboratory conditioning of compacted specimens conducted on bulk (prior to cutting and coring) specimens or on finished test specimens (after cutting and coring) (select one)?"



Question 14: "Please provide details (such as temperature and time) for the compacted specimen conditioning during fabrication process (fill in all information that is applicable)."



# Compacted specimen aging temperature and aging time reported for non-AASHTO R30 protocol:

Test	Temperature (degrees Celsius)	Time (hours)
Asphalt Pavement Analyzer (APA)		
Asphalt Pavement Analyzer (APA)		
Cantabro		
Direct Tension Cyclic Fatigue (S-VECD)		
Disk-Shaped Compact Tension (DCT)		
Dynamic (Complex) Modulus Testing		
Flexural Beam Fatigue		
Flow Number (RLPD)		
Hamburg Wheel Tracking		
CTIndex	85	5d
Semi-Circular Bend (SCB) (any version)	95; 85	4320; 5d
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)		
Small-Scale Geometry Dynamic (Complex) Modulus		
Small-Scale Geometry Flow Number (RLPD)		
Superpave Indirect Tensile Strength and Creep		
Texas Overlay		
Other Test-1		
Other Test-2		

# Descriptions of "other process followed" for compacted specimen conditioning:

Asphalt Pavement Analyzer (APA)	
Cantabro	
Direct Tension Cyclic Fatigue (S-VECD)	
Disk-Shaped Compact Tension (DCT)	
Dynamic (Complex) Modulus Testing	
Flexural Beam Fatigue	We have research on this now
Flow Number (RLPD)	
Hamburg Wheel Tracking	
CTIndex	Loose mix conditioned; we have research on this now
Semi-Circular Bend (SCB) (any version)	Loose mix conditioned; we have research on this now
Small-Scale Geometry Direct Tension Cyclic Fatigue (S-VECD)	
Small-Scale Geometry Dynamic (Complex) Modulus	
Small-Scale Geometry Flow Number (RLPD)	
Superpave Indirect Tensile Strength and Creep	
Texas Overlay	
Other Test-1	
Other Test-2	We have research on this now

Question 15: "Is there a target air void level requirement for laboratory performance test specimens used by your organization? (Select one for each test.)"

Test	Target Air Void Required	Target Air Void Not Required
APA	6	1
Cantabro	4	5
CTIndex	13	1
DCT	13	0
DTCF	11	1
E*	24	2
FBF	12	1
HWT	23	0
IDT	18	1
RLPD	17	0
SCB	24	2
SSG DTCF	5	2
SSG E*	5	2
SSG RLPD	4	0
TxOT	12	0
Other-1	10	2
Other-2	6	0

Question 16: "Please provide information regarding the target air void level requirement during fabrication of laboratory performance test specimens. (If requirements are in the AASHTO/ASTM specification, please select in first column and leave the rest blank. Fill in all information that applies and leave blank if no requirements are in place.)"

	T
Test	Requirements as per
1000	Specification
APA	5
Cantabro	1
CTIndex	10
DCT	10
DTCF	8
E*	19
FBF	11
HWT	18
IDT	14
RLPD	15
SCB	20
SSG DTCF	3
SSG E*	3
SSG RLPD	3
TxOT	11
Other-1	7
Other-2	3
	-

Requirements Not Detailed in		Requirements Not Detaile	
from Test Specification: Targ		Deviated from Test Specification: Target Air Void Required	
Compacted Sample Prior to Te		on Finalized Test Specimen (e.g., after all necessary cutting	
prior to cutting or coring)		or co	
Target Air Void Level (%)	Allowed Variation (+/- %)	Target Air Void Level (%)	Allowed Variation (+/- %)
	Asphalt Pavemen		
7	0.5	4,7	0.5
	0.5		
	Cantabro		
Nde, 4, 7	1	7	0.5
7		4	1
	Direct Tension Cyclic Fa	atigue Test (S-VECD)	
7	0.5	7	0.5
~8.0	0.5	7	0.5
	0.5	4	0.5
		7.0	0.5
	Disk-Shaped Compact	Tension (DCT) Test	
7	0.5	7	0.5
7	0.5	7	0.5
7.0	1		
	0.5		
	Dynamic (Complex)	Modulus Testing	1
4	.5	7	
7	0.5	7.0	
~8.0	0.5	7	
7.0	0.5	4	
7.0	0.5	7.0	
	Flexural Beam		<u> </u>
7.0	1.0	7.0	1.0
7.0	0.5	7	1.0
	Flow Number (	-	1.0
~8.0	0.5	7	0.5
0.0	0.5	7.0	0.5
	0.5	7.0	0.5
		7.0	0.5
	Hambura Whaal	I .	0.5
7.0	Hamburg Wheel 0.5	7	0.5
		7	
7	0.5	<u> </u>	.5
7	0.5	7.0	0.5
~8.0	0.5		
7	0.5	T	
7.0	CTIndex		
7.0	0.5	7.0	0.5
7	0.5	7	0.5
5.5	0.5		
	Semi-Circular Bend (SC		
5.5	0.5	7	0.5
~8.0	0.5	7	0.5
7.0	0.5	7.0	0.5
	0.5		
	Small-Scale Geometry Direct	Tension Cyclic Fatigue Test	
~8.0	0.5	7	0.5
	0.5	7	0.5
	1	7.0	0.5

Table continued from previous page.

Table continued from previous p	Jage.				
Requirements Not Detailed in T	Test Specification or Deviated	Requirements Not Detailed in Test Specification or Deviated			
from Test Specification: Targe	t Air Void Required on Bulk	from Test Specification: Target Air Void Required on			
Compacted Sample Prior to Tes		Finalized Test Specimen (e.g.	, after all necessary cutting or		
prior to cuttin	g or coring)	cori	ng)		
Target Air Void Level (%)	Allowed Variation (+/- %)	Target Air Void Level (%)	Allowed Variation (+/- %)		
	Small-Scale Geometry Dyna	mic (Complex) Modulus Test			
~8.0	0.5	7	0.5		
	0.5	7	0.5		
		7.0	0.5		
	Small-Scale Geometry Fl	ow Number (RLPD) Test			
~8.0	0.5	7	0.5		
	0.5	7.0	0.5		
	Superpave Indirect Tensile Strength and Creep Test				
7.0	0.5	7.0	0.5		
7	0.5	7	0.5		
7.0	0.5	7	0.5		
	0.5				
	Texas Overlay Test				
	0.5	7	0.5		
		7	1.0		
	Other Test-1				
4	0.5	7	0.5		
	Other	Test-2			
4	0.5	7	0.5		

# "Other" (such as more than one target air void level) responses and descriptions.

Asphalt Pavement Analyzer (APA)	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Direct Tension Cyclic Fatigue (S-VECD)	Depending on research, air voids have ranged from 3.5 to 10% (all with +/- 0.5% tolerance). SMAs typically done at 6% +/- 0.5%.
	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
	Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
Disk-Shaped Compact	Depending on research, air voids have ranged from $3.5$ to $10\%$ (all with $\pm 0.5\%$ tolerance). SMAs typically done at $6\% \pm 0.5\%$ .
Tension (DCT)	Slice air voids (post-slice from bulk gyro, pre-notch and pre-core) 7.0% +/- 0.5%; SMA = 6.0% +/-
	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
	Depending on research, air voids have ranged from 3.5 to 10% (all with +/- 0.5% tolerance). SMAs typically done at 6% +/- 0.5%.
Dynamic (Complex)	SMA=6.0% +/-
Modulus Testing	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
	Varies depending on construction specification—e.g., rich bottom or enhanced compaction.  Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
	SMA = 6.0% +/-
Flexural Beam Fatigue	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Tiexurai Beam Tatigue	Varies depending on construction specification—e.g., rich bottom or enhanced compaction.
	Depending on research, air voids have ranged from 3.5 to 10% (all with +/- 0.5% tolerance). SMAs typically done at 6% +/- 0.5%.
Flow Number (RLPD)	SMA = 6.0% +/-
	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
	Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
Hamburg Wheel	SMA = 6.0% +/-
Tracking	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
COTT 1	SMA = 6.0% +/-
CTIndex	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
G ' G' 1 D 1	Slice air voids (post-slice from bulk gyro, pre-half and pre-notch) 7.0% +/- 0.5%; SMA = 6.0% +/-
Semi-Circular Bend (SCB) (any version)	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
(SCB) (ally version)	Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
Small-Scale Geometry	Depending on research, air voids have ranged from $3.5$ to $10\%$ (all with $\pm 0.5\%$ tolerance). SMAs typically done at $6\% \pm 0.5\%$ .
Direct Tension Cyclic Fatigue (S-VECD)	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Tungue (b VECD)	Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
Small-Scale Geometry	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Dynamic (Complex)	Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
Modulus	Depending on research, air voids have ranged from 3.5 to 10% (all with +/- 0.5% tolerance). SMAs typically done at 6% +/- 0.5%.
Small-Scale Geometry	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Flow Number (RLPD)	Sometimes 4% +/- 0.5% or 5% +/- 0.5% for research.
Superpave Indirect Tensile Strength and Creep	Depending on research, air voids have ranged from 3.5 to 10% (all with +/- 0.5% tolerance). SMAs typically done at 6% +/- 0.5%.
	SMA = 6.0% +/-
-	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Texas Overlay	Will target 7 percent air voids unless testing materials with a significantly different known in-place density.
Other Test-1	Depending on research, air voids have ranged from 3.5 to 10% (all with +/- 0.5% tolerance). SMAs typically done at 6% +/- 0.5%.
Other Test-2	Varies depending on construction specification—e.g., rich bottom or enhanced compaction.

Question 17: "Identify equipment that is used in your laboratory to fabricate test specimens for laboratory performance tests (check all that apply)."

Test	Mix Splitter (e.g., quartermaster)	Superpave Gyratory Compactor	Oven(s)	Rotary Saw(s)	Coring Drill	Core Drying Device	Gluing Templates (e.g., template for marking location of gage points or to attach gage points)	Gluing Jigs (e.g., specimen holding devices to glue loading platens to test specimen)	Temperature Conditioning Chamber(s)	Vacuum Bag Sealing Devices (such as CoreLok)
Asphalt Pavement Analyzer Test	2	6	5	1	1	3	0	0	5	3
Cantabro Test	2	8	9	1	1	5	0	0	4	5
Direct Tension Cyclic Fatigue Test (S- VECD)	6	12	11	11	11	9	11	11	11	8
Disk-Shaped Compact Tension (DCT) Test	7	13	12	12	9	5	10	2	12	5
Dynamic (Complex) Modulus Testing	10	26	25	24	22	17	18	14	24	15
Flexural Beam Fatigue Test	8	5	12	12	2	5	5	1	12	3
Flow Number (RLPD) Test	8	17	16	15	15	11	8	6	15	8
Hamburg Wheel Tracking Test	9	23	22	21	2	9	2	1	17	8
CTIndex Test	6	14	14	6	2	7	0	0	14	8
Semi-Circular Bend (SCB) Test (any version)	9	26	25	25	4	15	6	3	25	11
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)	4	6	5	6	6	6	6	6	6	3
Small-Scale Geometry Dynamic (Complex) Modulus Test	4	6	5	6	6	6	6	2	6	3
Small-Scale Geometry Flow Number (RLPD) Test	2	4	3	3	3	3	3	1	3	1
Superpave Indirect Tensile Strength and Creep Test	7	19	18	17	6	9	14	7	17	9
Texas Overlay Test	3	12	11	11	2	7	5	8	11	4
Other Test-1	3	9	10	10	7	8	5	3	9	8
Other Test-2	1	3	4	3	2	3	0	1	4	3

# Other equipment identified:

Test	Other(s) (briefly describe)					
Asphalt Pavement Analyzer Test	Core dryer & CoreLok used in special circumstances					
Cantabro Test				Core dryer & CoreLok used in special circumstances		
Direct Tension Cyclic Fatigue Test (S-VECD)	Water bath for spe measurement	ecific gravity		Core dryer & CoreLok used in special circumstances		
Disk-Shaped Compact Tension (DCT) Test	Water bath for spe	ecific gravity measu	irement	ement		
Dynamic (Complex) Modulus Testing	Water bath for spe measurement	ecific gravity		Core dryer & CoreLok used in special circumstances		
Flexural Beam Fatigue Test	Slab compactor	ARC slab compactor	Kneading compactor	Controls slab compactor		
Flow Number (RLPD) Test	Core dryer & CoreLok used in special circumstances					
Hamburg Wheel Tracking Test	Slab compact previously		Core dryer & CoreLok used in special circumstances			
CTIndex Test	Core dryer & CoreLok used in special circumstances					
Semi-Circular Bend (SCB) Test (any version)	Core dryer & CoreLok used in special circumstances		Water bath for specific gravity measurement			
Small-Scale Geometry Direct Tension Cyclic Fatigue Test (S-VECD)	Core dryer & CoreLok used in special circumstances					
Small-Scale Geometry Dynamic (Complex) Modulus Test	Core dryer & CoreLok used in special circumstances					
Small-Scale Geometry Flow Number (RLPD) Test	Core dryer & CoreLok used in special circumstances					
Superpave Indirect Tensile Strength and Creep Test	Core dryer & CoreLok used in special circumstances					
Texas Overlay Test	Core dryer & CoreLok used in special circumstances					
Other Test-1	Core dryer & CoreLok used in special circumstances		Water bath for specific gravity measurement			
Other Test-2	Core dryer & Core	eLok used in specia	l circumstances			

# **Operational Constraints and Rejection Rates of Test Specimens**

Question 18: "What is the allowable maximum storage time before, during, and after specimen fabrication for the performance tests that are instituted by your organization? Please use the comments column to provide any additional relevant information (fill all that apply; leave blank if no requirements are in place)."

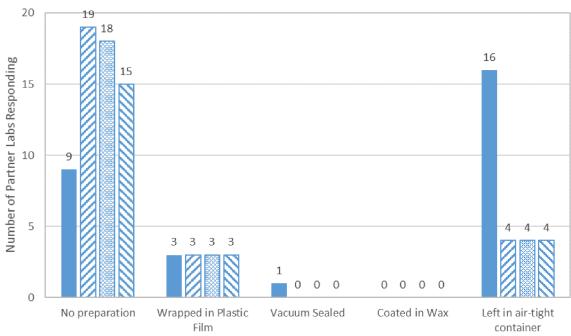
	Allowable Maximum Storage Times Before, During, and After Specimen Fabrication for the Performance Tests					
Test	Between Loose Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (bulk) Specimen and Finalized Test Specimen	Between Finalized Test Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if multiple tests are conducted on same specimens)		
Asphalt Pavement Analyzer Test	30; 3	5	5			
Cantabro Test	5	5; 7	5; 30			
Direct Tension Cyclic Fatigue Test (S-VECD)	180; 3; 30	3; 14; 3	2; 14; 10	2; 14		
Disk-Shaped Compact Tension (DCT) Test	NA; 3	3; 5	10; 3; 2; 30	7		
Dynamic (Complex) Modulus Testing	30; 3; NA; 180; 180	5; 7; 3; 5; 3	10; 5; 3; 3; 3	3; 90; 7; 2; 7		
Flexural Beam Fatigue Test	30; NA; 180; 3; 30	5; NA; 3; 7; 3	10; 5; NA; 2; 30	NA; 14		
Flow Number (RLPD) Test	30; NA; 180; 3; 30	5; 3; 5; 3; 7	10; 5; 3; 3; 2	7; 7		
Hamburg Wheel Tracking Test	30; 3; NA; 180; 3	5; 7; 3; 5; 3	10; 5; 3; 3; 3	7		
CTIndex Test	30; 3; NA; 180; 30	5; 7; 3; 5; 7	10; 5; 3; 3; 1	7; 7		
Semi-Circular Bend (SCB) Test (any version)	30; 3; NA; 180; 3	5; 7; 3; 5; 3	10; 5; 3; 3; 2	7		
Small-Scale Geometry Direct Tension Cyclic Fatigue Test	180; 3	14	14	2		
Small-Scale Geometry Dynamic (Complex) Modulus Test	180; 3	14	14	90; 2		
Small-Scale Geometry Flow Number (RLPD) Test	3					
Superpave Indirect Tensile Strength and Creep Test	5; NA; 3; 30	5; 3; 5; 3; 3	10; 5; 3; 3; 2	7; 14		
Texas Overlay Test	5; 3; 3	5; 7; 5; 3	10; 5; 3; 2; 2			
Other Test-1	180; 30	1; 7; 3	30; 7	7		
Other Test-2	180	3; 7	30			

Test	Comments
Asphalt	30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage times exceed 5 days after compaction, we keep them in
Pavement	a freezer at 0°F.
Analyzer	No limit, but typically less than 30 days
Test	No official requirements, but process as quickly as possible
	If any of the storage time exceeds 5 days after compaction, we keep them in a freezer at 0°F
	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Cantabro	No limit, but typically less than 30 days
Test	No official requirements, but process as quickly as possible
	No strict rules
	Testing done in "reasonable" time
Direct	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Tension	No official requirements, but process as quickly as possible
Cyclic	Usually within 1-2 weeks the process is finished
Fatigue	No requirements in place, but certainly not > 30 days
Test (S-	NA .
VECD)	
Disk-	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Shaped	Usually within 1-2 weeks the process is finished
Compact	Try to have no more than 1 week from compaction to final mech testing
Tension	Testing done in "reasonable" time
(DCT)	NA NA
Test	NA
	NA
	3 hours between repeated testing is not a hard rule, typical practice. 30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of
	the storage time exceeds 5 days after compaction, we keep them in a freezer at 0°F.
	Not applicable
Dynamic	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
(Complex)	Try to have no more than 1 week from compaction to final mech testing
Modulus	Follow Note 5 of T342; test within 2 weeks
Testing	No official requirements, but process as quickly as possible
Testing	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room
	Usually within 1-2 weeks the process is finished
	No requirements in place but certainly not > 30 days
	NA
	Testing done in "reasonable" time
	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room
Flexural	Testing done in "reasonable" time
Beam	No official requirements, but process as quickly as possible
Fatigue	NA
Test	30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage time exceeds 5 days after compaction, we keep them in
	a freezer at 0°F.

	MA
	NA
	30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage time exceeds 5 days after compaction, we keep them in
F21	a freezer at 0°F.  We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Flow	
Number	Try to have no more than 1 week from compaction to final mech testing
(RLPD)	No official requirements, but process as quickly as possible
Test	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room
	Usually within 1-2 weeks the process is finished
	No requirements in place but certainly not > 30 days
	Testing done in "reasonable" time
	NA
	30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage time exceeds 5 days after compaction, we keep them in
	a freezer at 0°F.
Hamburg	Not applicable
Wheel	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Tracking	Try to have no more than 1 week from compaction to final mech testing
Test	No limit, but typically less than 30 days
	No official requirements, but process as quickly as possible
	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room
	No requirements in place but certainly not > 30 days
	Testing done in "reasonable" time
	30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage time exceeds 5 days after compaction, we keep them in
	a freezer at 0°F.
CTIndex	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Test	Try to have no more than 1 week from compaction to final mech testing
	No official requirements, but process as quickly as possible
	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room
	NA
	30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage time exceeds 5 days after compaction, we keep them in
	a freezer at 0°F.
Semi-	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Circular	Try to have no more than 1 week from compaction to final mech testing
Bend	No limit, but typically less than 30 days
(SCB)	No official requirements, but process as quickly as possible
Test (any	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room
version)	Usually within 1-2 weeks the process is finished
	No requirements in place but certainly not > 30 days
	NA
	Testing done in "reasonable" time
Small-	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days
Scale	No official requirements, but process as quickly as possible
Geometry	No requirements in place but certainly not > 30 days

Direct Tension					
Cyclic	NA				
Fatigue	IVA				
Test (S- VECD)					
Small-	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days				
Scale	No official requirements, but process as quickly as possible				
Geometry	No requirements in place but certainly not > 30 days.				
Dynamic					
(Complex)	NA				
Modulus Test					
Small-	No official requirements, but process as quickly as possible				
Scale					
Geometry					
Flow Number	No requirements in place but certainly not > 30 days				
(RLPD)					
Test					
	NA				
Superpave Indirect	If any of the storage time exceeds 5 days after compaction, we keep them in a freezer at 0°F				
Tensile	Not applicable				
Strength	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days				
and Creep	Try to have no more than 1 week from compaction to final mech testing				
Test	No official requirements, but process as quickly as possible				
	Usually within 1-2 weeks the process is finished  30 days if materials are stored inside at room temperature (mainly for field mixtures). If any of the storage time exceeds 5 days after compaction, we keep them in				
Texas	a freezer at 0°F.				
Overlay	Not applicable				
Test	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days				
	No official requirements, but process as quickly as possible				
	We don't have a maximum, but time between fabrication and testing is rarely more than 2 days				
Other Test-1	No limit but typically less than 30 days				
	No official requirements, but process as quickly as possible				
	Loose mix samples stored in sealed metal cans; specimens stored in temperature controlled room				
	Usually within 1-2 weeks the process is finished				
	NA We don't have a maximum, but time between fabrication and testing is rarely more than 2 days				
Other	No limit, but typically less than 30 days				
Test-2	No official requirements, but process as quickly as possible				
1550 2	Loose mix samples stored in sealed metal cans; specimens stored in temperature-controlled room				
L	Loose this samples stored in sealed metal cans, specimens stored in temperature-controlled fooli				

Question 19: "How are performance test specimens prepared for storage at your organization? (Select all that apply.)"

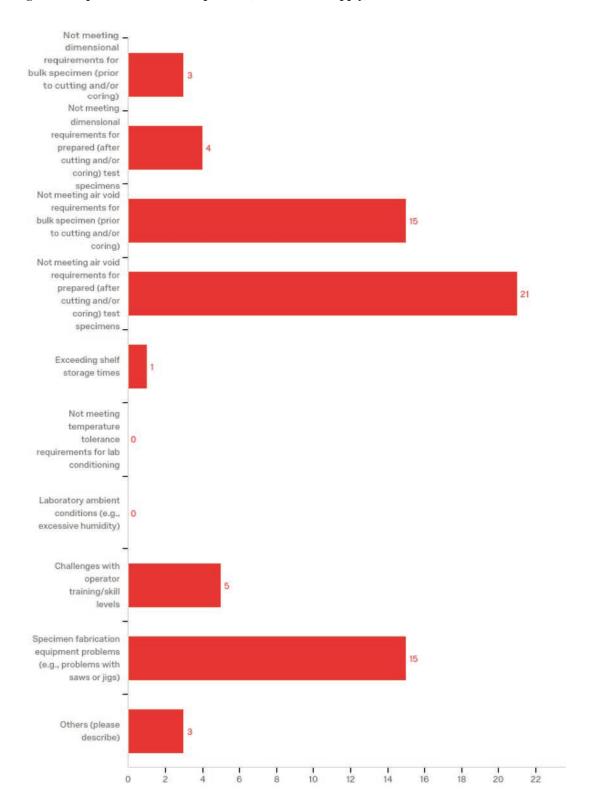


The legend is the same one as for Question 20 in Appendix B.

# "Other" responses and descriptions:

Between Loose Mix Sampling and Laboratory Compaction	Between Preparation of Compacted (bulk) Specimen and Finalized Test Specimen	Between Finalized Test Specimen Fabrication and Mechanical Testing	Between Repeated Mechanical Testing (if multiple tests are conducted on same specimens)
<ul> <li>Placed in wax lined boxes, not sealed</li> <li>Keep them in freezer at 0°F after wrapping with plastic film or sealed in containers</li> <li>We receive some samples in boxes from partner agencies</li> <li>Cardboard box</li> <li>Laboratory ambient conditions</li> <li>Sealed metal buckets</li> <li>In wax-coated boxes with minimal air intrusion</li> <li>In bucket with lid</li> </ul>	<ul> <li>Left in conditioned space</li> <li>Keep them in freezer at 0°F after wrapping with plastic film or sealed in containers</li> <li>We rarely wrap, but try to if we know there's a period of time between testing</li> <li>Laboratory ambient conditions</li> <li>Only for specimens (before saw trimming) that have to be stored for an extended period</li> <li>Kept in cooler</li> </ul>	<ul> <li>Left in conditioned space</li> <li>Keep them in freezer at 0°F after wrapping with plastic film or sealed in containers</li> <li>We rarely wrap, but try to if we know there's a period of time between testing</li> <li>Laboratory ambient conditions; T342 dynamic modulus may be wrapped in plastic film depending on storage time</li> <li>Stored in a temperature-controlled room</li> <li>Specimens are tested as quickly as possible after saw trimming</li> <li>Kept in cooler</li> <li>Temperature-controlled room</li> </ul>	Normally, any specimens subject to multiple tests are run back-to-back; little to no time in between tests  Keep them in freezer at 0°F after wrapping with plastic film or sealed in containers  NA  NA for destructive mechanical tests  Kept in cooler  NA  As directed by client

Question 20: "Please indicate the most frequent causes of operational disruptions that you have encountered during the test specimen fabrication process (check all that apply)."

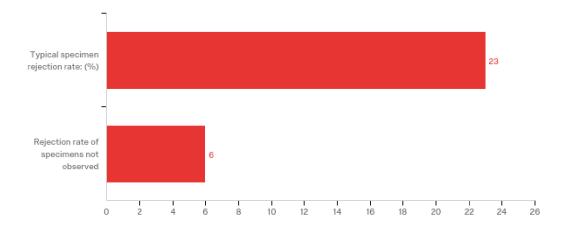


# "Other" responses:

Solid-state relays going bad in ovens, compressors going bad, nothing related to specimens. There is a lot more to this discussion than presented here.

Sometimes with lab mixes, just amount of student time available for agg prep. Premature failures during the testing.

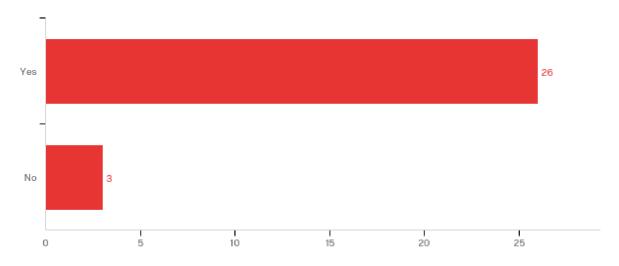
Question 21: "In your experience, what has been the rejection rate of test specimens (i.e., specimens that are not used for testing), due to the fabrication process (e.g., longer shelf storage than allowed, out-of-tolerance dimensions, wrong air void content, etc.) (select one and fill in the blank)."



# Typical specimen rejection rates reported:

Typical specimen rejection rate: (%)
20 to 30% due to % air void rejection
5
25
Changes depending on the quantity in one production, experience of students, type of asphalt mixture, test method, etc. T 378 samples have very low rejection rate (10 to 15%) compared to T321 samples (20 to 25%).
5
10
10%
Less than 5%
10
30
20
5
15
5
10
50
Wrong air void content
~10%?
20
20
5
10
20

Question 22: "Is your organization satisfied with your performance test specimen rejection rate? (Select one and fill in the blank.) If no, what rejection rate (%) would you consider as acceptable/satisfactory?"

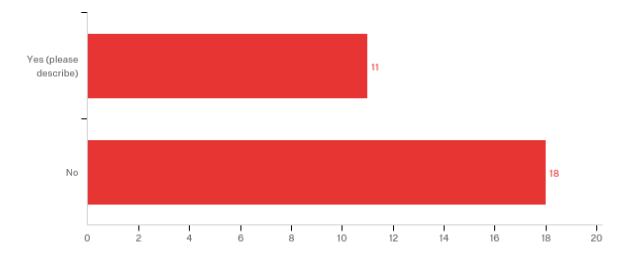


Responses to "If no, what rejection rate (%) would you consider as acceptable/satisfactory?"

Responses
10
5
20

#### **Suggestions for Future Research**

Question 23: "Have you observed any gaps in knowledge that have made it challenging for your organization to start (or continue) successfully fabricating performance test specimens?"



#### Yes (please describe)

Hands-on training is paramount, especially with transient workers or students.

Some of the tolerances are unrealistically tight for standard equipment. High-precision cutting equipment is very expensive.

There is not a firm understanding of the impact of storage on specimen properties, such as oxidation in buckets, boxes, or between compacted state and cut-and-cored state.

The multiple cuts involved with many of these specimens introduce variability. Need to assess if the test and such an involved procedure is adding value.

A trial-and-error process is initially required to fabricate specimens to target densities (e.g., Va = 7.0% + (-0.5%)). This is a function of aggregate gradation, specimen preparation, etc.

Long-term aging; current spec does not simulate real long-term aging and there are several strategies out there suggested by different research groups. We need a unified long-term aging protocol.

Air void distribution within gyratory compacted samples

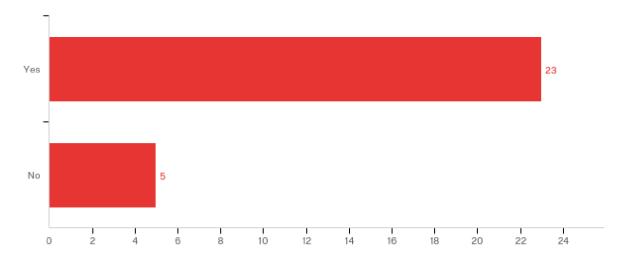
Determining appropriate masses for trial specimens to meet air void targets - mass-volume relationships are not always accurate. Maintaining qualified personnel to perform testing.

Getting repeatable compaction. We use core-locked air voids to be able to catch high air void content that are unmeasurable using SSD. Think that a lot of folks fooling themselves with repeatable compaction using SSD, which we think cannot measure air voids well above about 7 percent because of internal connectivity of air voids makes definition of volume no good. Having a more repeatable version of CoreLok on rough-surfaced specimens needed.

Saw blade tolerance for notch is 1.5 mm +/-0.1 is too tight. Does it make a difference?

Staff training

Question 24: "The synthesis will also include case examples illustrating practices on asphalt performance-test specimen fabrication. The development of the case example(s) may require an additional follow-up interview. Organizations will be provided the opportunity to review the case example write-up for accuracy. Would your organization be interested in participating in a case example?"



Question 25: "If you have any additional information or thoughts you would like to share regarding this topic, please share them here."

Feel free to contact for follow-up.

Sample preparation is a critical step to reduce test variability and it also becoming an obstacle for DOTs, contractors and even researcher[s] to run some performance tests.

We also do direct tension monotonic testing in the AMPT on small specimens (38-mm diameter by 110-mm height).

The survey took about 1.5 hours for two people to do. Once the data is gathered it took about 20 minutes to enter.



# APPENDIX D

# List of Survey Respondents

Complete responses to the Agency Survey received from

- Alabama Department of Transportation (AL)
- Alaska Department of Transportation (AK)
- Arizona Department of Transportation (AZ)
- Arkansas Department of Transportation (AR)
- California Department of Transportation (CA)
- Colorado Department of Transportation (CO)
- Connecticut Department of Transportation (CT)
- Delaware Department of Transportation (DE)
- Florida Department of Transportation (FL)
- Georgia Department of Transportation (GA)
- Illinois Department of Transportation (IL)
- Indiana Department of Transportation (IN)
- Iowa Department of Transportation (IA)
- Kansas Department of Transportation (KS)
- Maine Department of Transportation (ME)
- Maryland Department of Transportation–State Highway Agency (MD)
- Massachusetts Department of Transportation (MA)
- Michigan Department of Transportation (MI)
- Minnesota Department of Transportation (MN)
- Mississippi Department of Transportation (MS)
- Missouri Department of Transportation (MO)
- Montana Department of Transportation (MT)
- Nevada Department of Transportation (NV)
- New Hampshire Department of Transportation (NH)
- New Jersey Department of Transportation (NJ)
- New Mexico Department of Transportation (NM)
- New York State Department of Transportation (NY)
- North Carolina Department of Transportation (NC)
- North Dakota Department of Transportation (ND)
- Ohio Department of Transportation (OH)
- Oklahoma Department of Transportation (OK)
- Rhode Island Department of Transportation (RI)
- South Carolina Department of Transportation (SC)
- South Dakota Department of Transportation (SD)
- Tennessee Department of Transportation (TN)
- Texas Department of Transportation (TX)

- Utah Department of Transportation (UT)
- Vermont Agency of Transportation (VT)
- Virginia Department of Transportation (VA)
- Washington, D.C., U.S. Department of Transportation (D.C.)
- Washington Department of Transportation (WA)

Complete responses to the Partner Laboratories Survey received from

- American Engineering Testing, Inc.
- Arizona State University
- Braun Intertec Corporation
- Connecticut Advanced Pavement Lab-University of Connecticut
- Federal Aviation Administration–GDIT [General Dynamics Information Technology]
- Federal Highway Administration
- Heritage Research Group
- Louisiana State University
- Mizzou Asphalt Pavement and Innovation Laboratory (MAPIL)
- Michigan State University
- MTE Services, Inc.
- North Carolina State University
- National Center for Asphalt Technology (NCAT)
- North Central Superpave Center, Purdue University
- Oregon State University
- Pennsylvania State University
- Texas A&M Transportation Institute
- Thunderhead Testing
- University of Arkansas
- University of California Pavement Research Center, Davis
- University of Florida
- University of Illinois–Illinois Center for Transportation
- University of Minnesota
- University of Nevada, Reno
- University of New Hampshire
- University of Texas at El Paso
- University of Utah
- U.S. Army Engineer Research & Development Center
- Virginia Transportation Research Council



# APPFNDIX F

# Sample Documents that Exhibit Standard Procedures Used for Fabrication of Specimens for Performance Testing

This appendix presents examples of documents and links to resources identified from both the survey and case example interviews.

#### Asphalt Pavement Analyzer Test (AASHTO T340)

 $\bullet \quad http://dot.alaska.gov/stwddes/desmaterials/mat\_waqtc/assets/pdf/testman/atm\_2018.pdf$ 

#### Cantabro Test

- https://apps.dtic.mil/dtic/tr/fulltext/u2/a590558.pdf
- http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F\_series/pdfs/bit245.pdf

#### Dynamic (Complex) Modulus Testing (AASHTO T342)

 http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf

#### Flexural Beam Fatigue Test (AASHTO T321)

http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf

#### Flow Number (RLPD) Test (AASHTO T378)

 http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf

# Hamburg Wheel Tracking Test

- http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/testproceduresmanual2015.pdf
- https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302
- http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F\_series/pdfs/bit242.pdf
- https://www.codot.gov/business/designsupport/matgeo/manuals/2015-cdot-lab-manual-test-procedures-rev-2019/cpls/cp-ls-5100/%2808%29%20CPL%205112-15/view

#### Cracking Tolerance Index Test

https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302

#### Semi-Circular Bend (SCB) Test (any version, I-FIT, LTRC, Minnesota)

https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302

#### Superpave Indirect Tensile Strength and Creep Test

http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F\_series/pdfs/bit226.pdf

# Texas Overlay Test

• http://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F\_series/pdfs/bit248.pdf

#### Other Tests

- https://apps.dtic.mil/dtic/tr/fulltext/u2/a590740.pdf
- http://www.dot.ca.gov/d3/projects/subprojects/0H10U/files/pdfs/LLP-AC3\_Sample\_Preparation\_for\_LL\_HMA-Pavement\_I-5%20Sacramento\_2018-07-20.pdf
- https://www.udot.utah.gov/main/f?p=100:pg:0::::V,T:,302
- https://www.nevadadot.com/doing-business/about-ndot/ndot-divisions/operations/materials-section/materials-test-manual
- https://extranet.ddot.dc.gov/QAQC.Web/LoginNew.aspx?ReturnUrl=%2fQAQC.Web%2fMaterialTests%2fManageLogs.aspx%3fCat%3d10&Cat=10
- http://www.virginiadot.org/business/resources/Materials/bu-mat-VTMs.pdf, VTM-128
- http://infonet.dot.state.fl.us/materials/administration/resources/library/publications/fstm/Methods/ fm5-599.pdf
- http://www.arkansashighways.com/materials\_division/A--FIELDMAN.pdf
- https://apps.dtic.mil/dtic/tr/fulltext/u2/a590740.pdf
- http://infonet.dot.state.fl.us/materials/administration/resources/library/publications/fstm/Methods/fm1-t283.pdf

# Files were uploaded by the following entities:

- Arkansas Department of Transportation
- Colorado Department of Transportation
- Georgia Department of Transportation
- Maine Department of Transportation
- Montana Department of Transportation
- Texas Department of Transportation
- Vermont Agency of Transportation
- Washington, D.C., U.S. Department of Transportation
- American Engineering Testing
- Braun Intertec
- Arizona State University
- University of New Hampshire
- VTRC

# Links from Arizona Case Example

https://apps.azdot.gov/files/materials-manuals/materials-testing/ariz-416e.pdf

# Links from Illinois Case Example

http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/testproceduresmanual2015.pdf

http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/Hot-Mix-Asphalt/IL%20mod%20AASHTO%20T%20283-14%20Rev%2002-28-19.pdf

http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/Hot-Mix-Asphalt/IL%20mod%20AASHTO%20TP%20124-18%20%20Rev%2002-28-19.pdf

http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/Hot-Mix-Asphalt/IL%20mod%20AASHTO%20R%20 30-02%20(2015)%20%20Rev%2002-28-19.pdf

http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-Handbooks/Highways/Materials/Manual%20of%20Test%20Procedures%20for%20Materials%20December%202018.pdf

https://www.lakelandcollege.edu/wp-content/uploads/2019/02/CET%20029%20Hot-Mix%20 Asphalt%20Level%20I%20Technician%20Course%20Manual%201819%20Revised%20 022119%20for%20Website.pdf

# Links from Maine Case Example

https://www.maine.gov/mdot/contractor-consultantinformation/2007 Maine DOTHMAPolicies and Procedures Manual.pdf

# **Links from Montana Case Example**

https://www.mdt.mt.gov/other/webdata/external/materials/materials\_manual/303.pdf

https://www.mdt.mt.gov/other/webdata/external/materials/materials\_manual/334.PDF

 $https://urldefense.proofpoint.com/v2/url?u=https-3A\__www.mdt.mt.gov\_other\_webdata\_external\_materials\_materials-5Fmanual\_335.PDF&d=DwIFAg&c=c6MrceVCY5m5A\_KAUkrdoA&r=juFJTKjXS6HKhThzyhyo9Q&m=-VD3DhSQBptYkLTDQt-qF-UldD_iJ7IW2wWOsy\_5Dzc&s=Gpb39UZQTdOHO4GkbZrVdooY4WhS2GLmWCh7JF0fZKY&e=$ 

## **Links from Texas Case Example**

https://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F\_series/pdfs/bit200.pdf

https://ftp.dot.state.tx.us/pub/txdot-info/cst/TMS/200-F\_series/pdfs/bit206.pdf

 $https://www.txdot.gov/business/resources/testing.html? CFC\_target=http\%3A\%2F\%2Fwww.dot.state.tx.us\%2Fapps-cg\%2Ftest\_procedures\%$ 



ADA

Abbreviations and acronyms used without definitions in TRB publications:

A4A Airlines for America

AAAE American Association of Airport Executives AASHO American Association of State Highway Officials

Americans with Disabilities Act

AASHTO American Association of State Highway and Transportation Officials

ACI–NA Airports Council International–North America ACRP Airport Cooperative Research Program

APTA American Public Transportation Association
ASCE American Society of Civil Engineers
ASME American Society of Mechanical Engineers
ASTM American Society for Testing and Materials

ATA American Trucking Associations

CTAA Community Transportation Association of America CTBSSP Commercial Truck and Bus Safety Synthesis Program

DHS Department of Homeland Security

DOE Department of Energy

EPA Environmental Protection Agency FAA Federal Aviation Administration

FAST Fixing America's Surface Transportation Act (2015)

FHWA Federal Highway Administration

FMCSA Federal Motor Carrier Safety Administration

FRA Federal Railroad Administration FTA Federal Transit Administration

HMCRP Hazardous Materials Cooperative Research Program
IEEE Institute of Electrical and Electronics Engineers
ISTEA Intermodal Surface Transportation Efficiency Act of 1991

ITE Institute of Transportation Engineers

MAP-21 Moving Ahead for Progress in the 21st Century Act (2012)

NASA National Aeronautics and Space Administration
NASAO National Association of State Aviation Officials
NCFRP National Cooperative Freight Research Program
NCHRP National Cooperative Highway Research Program
NHTSA National Highway Traffic Safety Administration

NTSB National Transportation Safety Board

PHMSA Pipeline and Hazardous Materials Safety Administration RITA Research and Innovative Technology Administration

SAE Society of Automotive Engineers

SAFETEA-LU Safe, Accountable, Flexible, Efficient Transportation Equity Act:

A Legacy for Users (2005)

TCRP Transit Cooperative Research Program TDC Transit Development Corporation

TEA-21 Transportation Equity Act for the 21st Century (1998)

TRB Transportation Research Board
TSA Transportation Security Administration
U.S. DOT United States Department of Transportation

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