The Road Forward

A Vision for Net Zero Carbon Emissions for the Asphalt Pavement Industry

Balanced Mix Design: Resource Guide and Implementation Working Group

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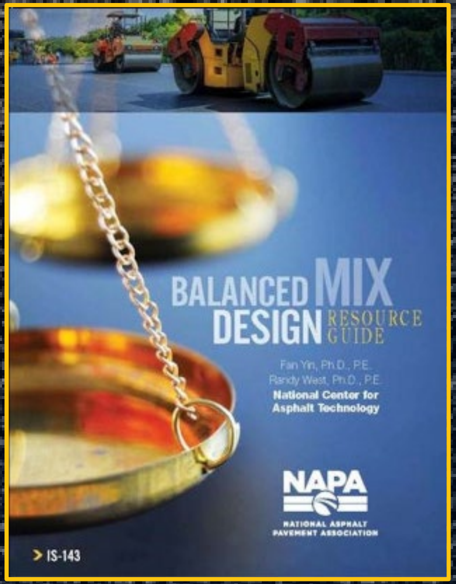
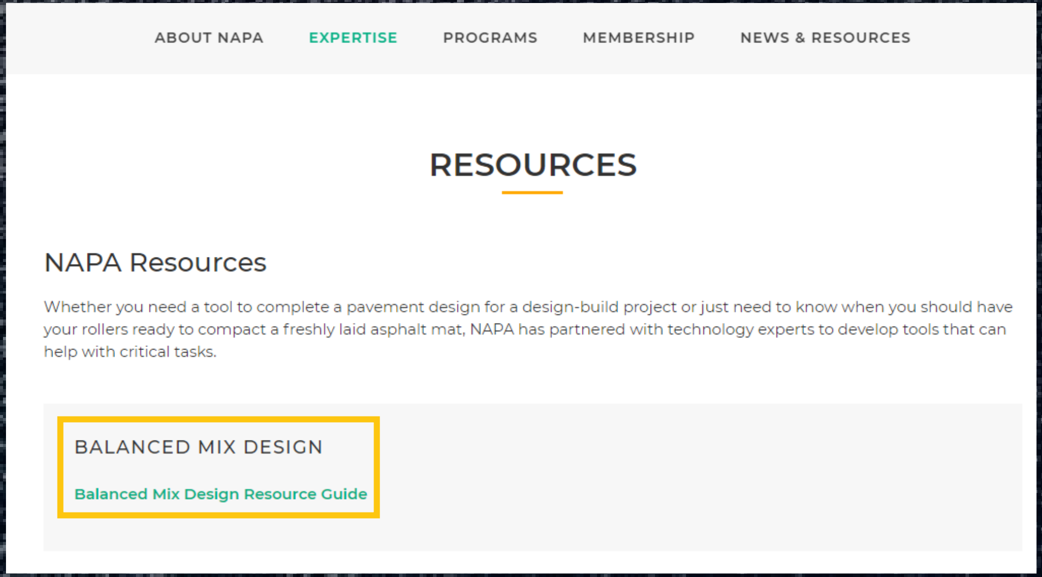
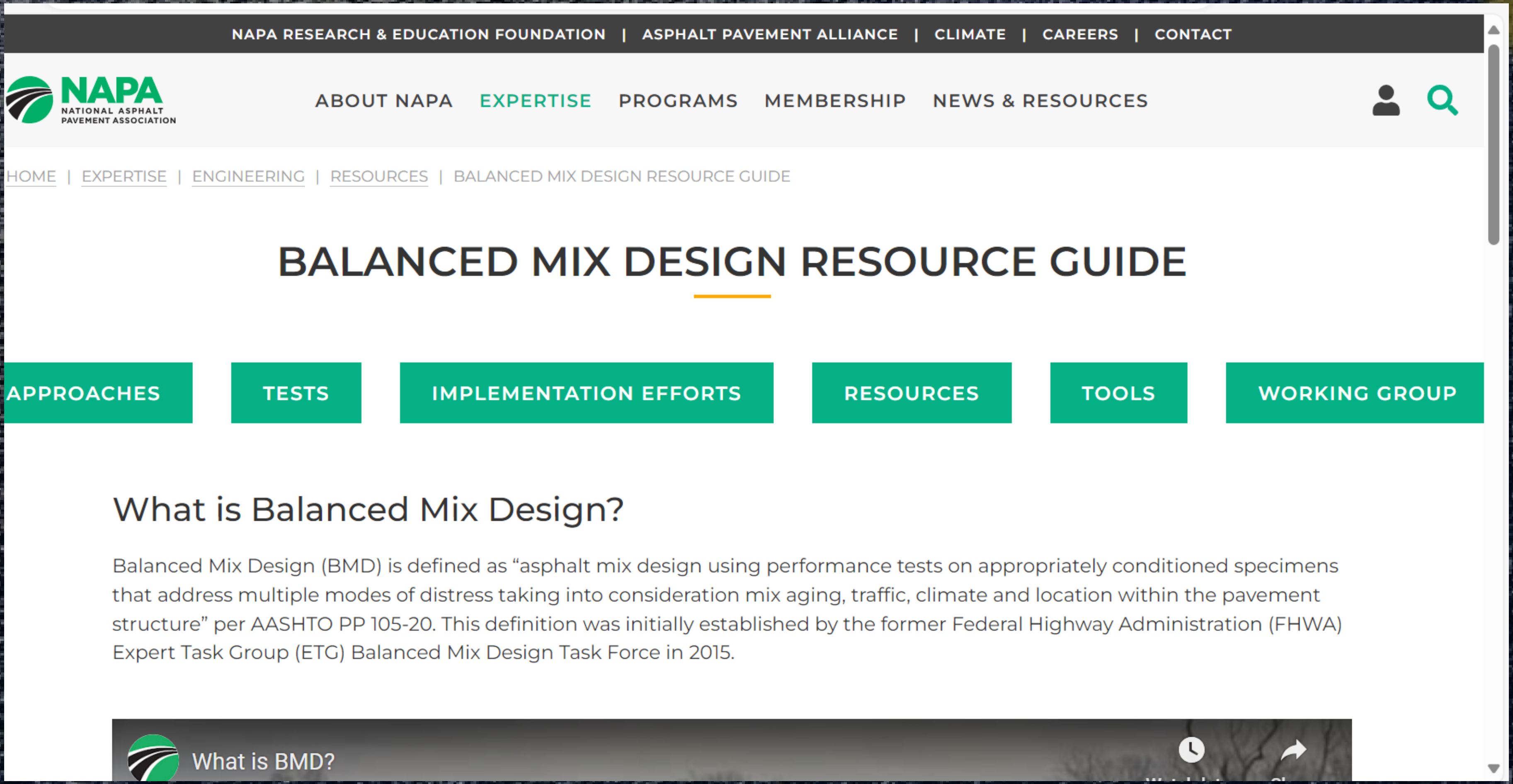
BMD Support from NAPA

- Recognized the need to move to BMD for innovation
- Supported Regional BMD Implementation Workshops





What's In the Guide?



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BALANCED MIX DESIGN RESOURCE GUIDE

APPROACHES TESTS IMPLEMENTATION EFFORTS RESOURCES TOOLS WORKING GROUP

What is Balanced Mix Design?

Balanced Mix Design (BMD) is defined as "asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure" per AASHTO PP 105-20. This definition was initially established by the former Federal Highway Administration (FHWA) Expert Task Group (ETG) Balanced Mix Design Task Force in 2015.

What is BMD?

Approaches

Volumetric Design with Performance Verification

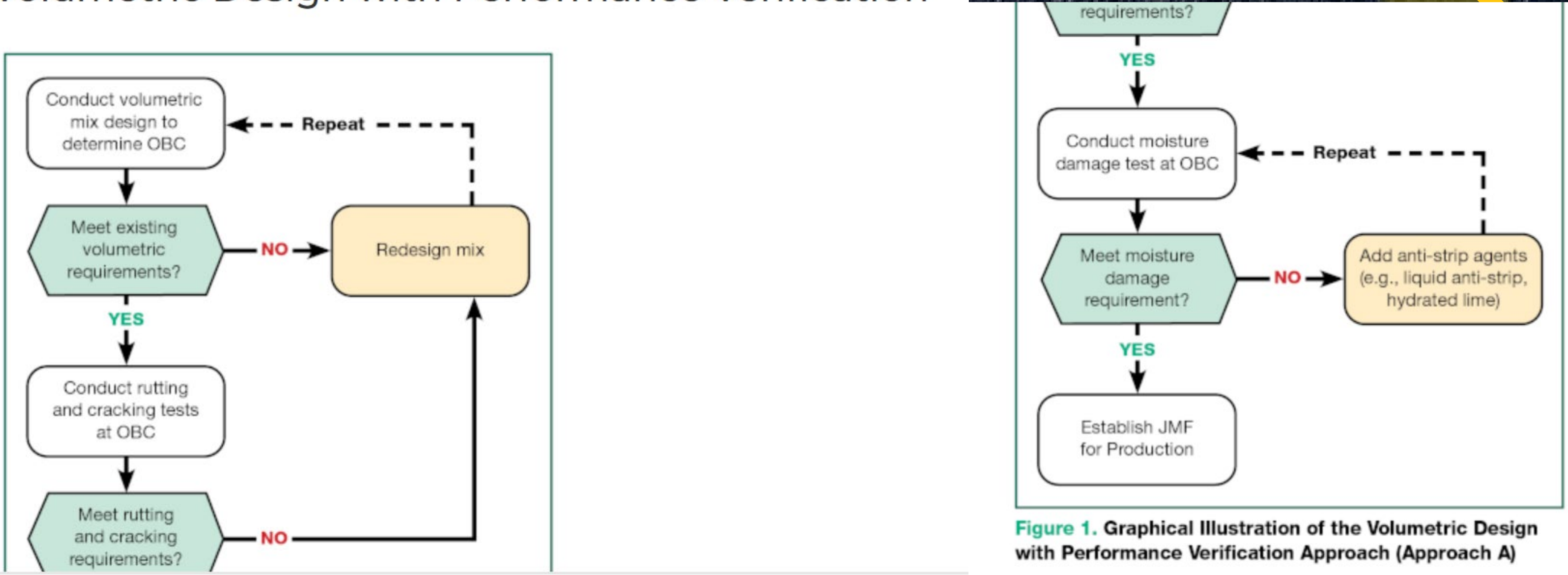
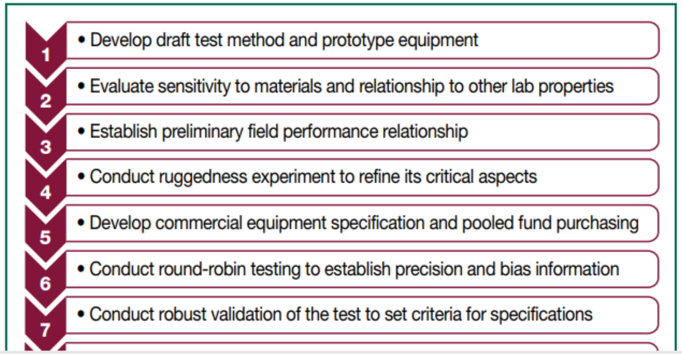


Figure 1. Graphical Illustration of the Volumetric Design with Performance Verification Approach (Approach A)

Performance Testing Resources

GUIDANCE FOR SELECTING MIXTURE PERFORMANCE TESTS

NCHRP Project 20-07/Task 406 identified nine critical steps needed to move a test method from concept to full implementation (West et al., 2018); they are graphically illustrated in Figure 6. Although the order of these steps is the logical sequence, some tests have been developed in different orders. It should also be noted that the results of a step may indicate that the test method needs significant refinement, and the preceding steps need to be repeated. Therefore, an objective review of the test method should be made after each step to determine whether the process should proceed.



agency, the contracting industry, or both. In addition to the steps in Figure 6, two important factors that should be considered when selecting mixture performance tests for BMD are the complexity of test method and the cost of test equipment. Mixture performance tests requiring expensive equipment, tedious specimen fabrication, long testing time, and complicated data analysis may not be appropriate for use in quality control and acceptance testing because of lack of practicality. On the other hand, mixture performance tests that are simple, quick, repeatable, and robust are preferred because they can be implemented for mix design and production testing to ensure balanced rutting and cracking resistance of both laboratory-produced and plant-produced mixes.

Step 1. Develop draft test method and prototype equipment

The motivation to develop a new test method is generally born from recognition of an important material characteristic (typically a material deficiency) that is not

GUIDANCE FOR ESTABLISHING MIXTURE PERFORMANCE TEST CRITERIA

In addition to the lab to field validation experiment previously discussed in Step 7 of Guidance for Selecting Mixture Performance Tests, a statewide benchmarking experiment is also highly recommended to help establish appropriate mixture performance test criteria. The objective of the benchmarking experiment is to test existing mix designs being designed and produced in the state using the selected mixture performance tests to determine the distribution of test results. When selecting asphalt mixtures for the benchmarking experiment, priority should be given to those with a known history of field performance. Ideally, the benchmarking experiment would include testing of laboratory-mixed laboratory-compacted (LMLC) specimens for mix design approval and PMLC specimens for production acceptance. Comparing the test results of LMLC versus PMLC specimens will provide insights on how mix quality can change from mix design to production. There are many factors that may contribute to the difference in the test results between these two types of samples, which include changes in the binder content and aggregate gradations due to normal production variability, differences in asphalt aging and absorption,

When selecting the preliminary performance criteria, one of the questions that SHAs need to answer is, “are you satisfied with the current pavement performance in the state?” If the answer is “yes”, then the preliminary performance criteria should be selected so that they can pass most of the existing mix designs but fail those with known quality issues. If the answer is “no”, then the criteria should be set at a higher level with expectations that the overall mix quality and pavement performance would be improved upon execution of a BMD specification. Several recently completed or ongoing research studies have provided useful guidance on setting performance test criteria based on a benchmarking experiment; they are briefly discussed as follows.

- Researchers at the Illinois Center for Transportation developed a set of preliminary criteria for I-FIT to discriminate asphalt mixtures from good-, intermediate-, and poor-performing pavement sections in Illinois (Al-Qadi et al., 2015). These criteria were then further refined with additional field performance data collected since they were first developed. Based on these efforts,

Performance Test Resources

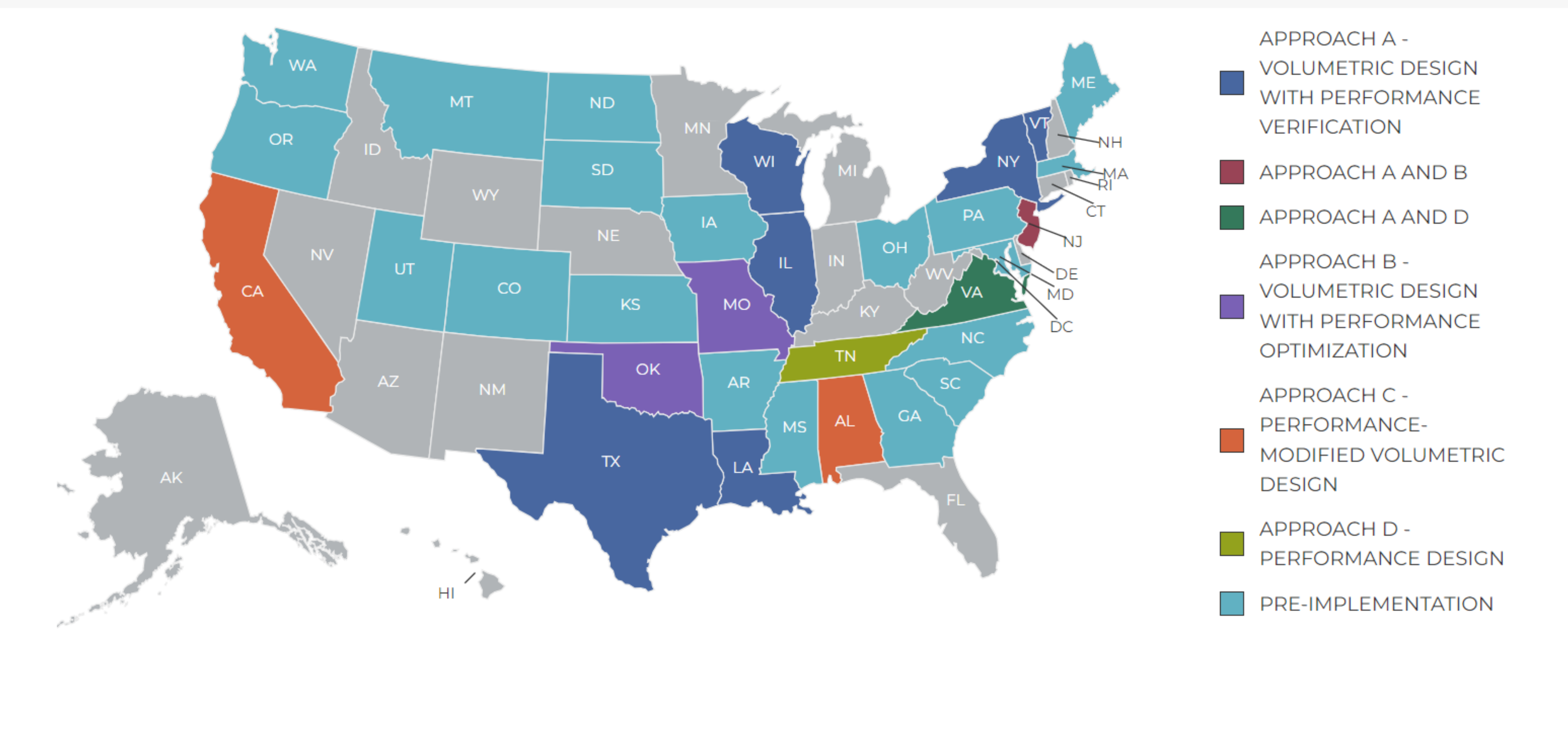
ASPHALT PAVEMENT ANALYZER

Name of Test **Asphalt Pavement Analyzer**	Developer(s) Lai and Co-workers Georgia DOT
Test Method(s) AASHTO T 340-10 (2019)	Adoption by Agencies Alaska, Alabama, Arkansas, North Carolina, New Jersey, South Carolina, South Dakota, Virginia
Description The asphalt pavement analyzer (APA) is a second-generation device that was originally developed as the Georgia Loaded Wheel Tester. The APA tracks a loaded wheel back and forth across a pressurized linear hose over an asphalt mixture sample. A temperature chamber is used to control the test temperature. Rut depths along the wheel path are measured for each wheel pass. The sample is typically loaded for 8,000 wheel passes.	Photographs/Illustrations 
Test Results Rut depths	Test Temperature(s) Selected based on the high temperature binder grade
Equipment & Approximate Cost Asphalt Pavement Analyzer or APA Jr.	$60,000 - 125,000
Specimen Fabrication Gyratory specimens (most common) or slab specimen	Number of Replicate Specimens Between 4 and 6 specimens – model dependent
Specimen Conditioning Conditioning for 6 to 24 hours at the test temperature	Testing Time 2.25 hours
Data Analysis Complexity Simple	Test Variability Medium (20% COV)
Field Validations Good (pavement sections on FHWA ALF, WesTrack, NCAT Test Track, MnROAD, and in Georgia and Nevada)	Overall Practicality for Mix Design and QA Good for mix design Fair for QA

Key References

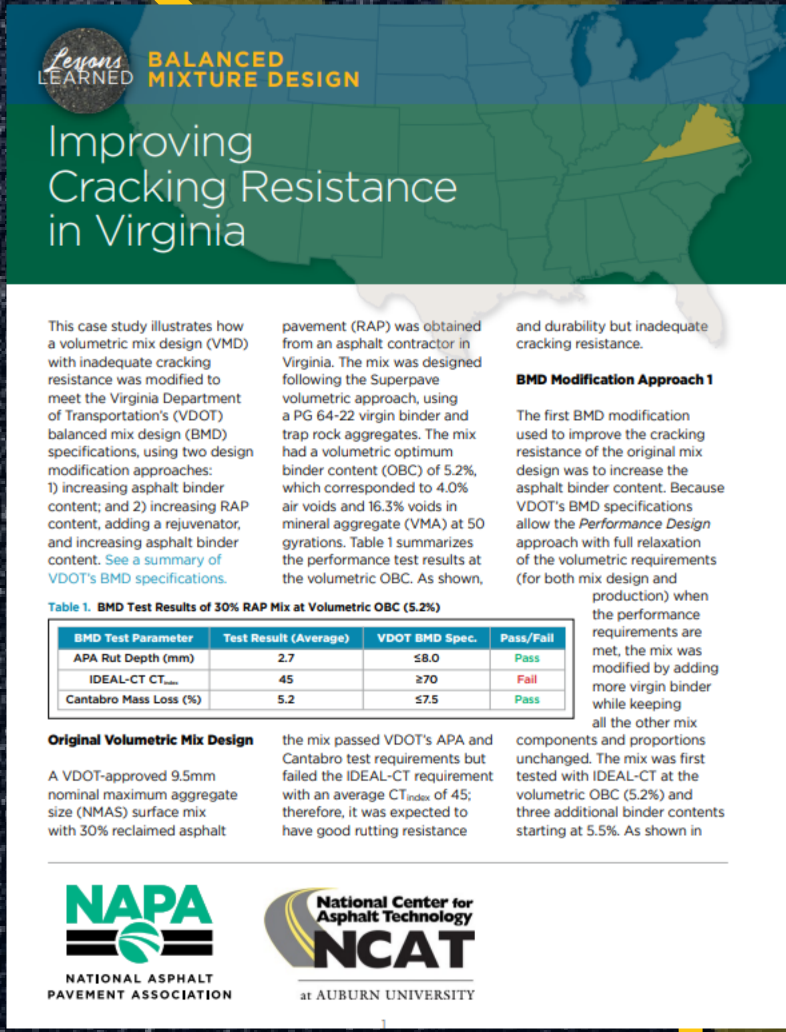
- Lai, J.S. (1986). "Development of a Simplified Test Method to Predict Rutting Characteristics of Asphalt Mixes," Final Report, Research Project No. 8503, Georgia DOT.
- Cooley, L.A., Kandhal, P.S., Buchanan, M.S., Fee, F., and Epps, A. (2000). "Loaded Wheel Testers in the United States: State of the Practice," NCAT Report No. 2000-4, Auburn, AL.
- Kandhal, P.S., and Cooley, L.A. (2003). "Accelerated Laboratory Rutting Tests: Evaluation of the Asphalt Pavement Analyzer," NCHRP Report 508, Washington, D.C.
- West, R., Timm, D., Willis, R., Powell, B., Tran, N., Watson, D., Sakhaeifar, M., Brown, R., Robbins, M., Nordcbeck, A.V. and Villacorta, F.L. (2012). "Phase IV NCAT Pavement Test Track Findings," NCAT Report 12-10, Auburn, AL.

Implementation Efforts



Tools

- Trial Weight Estimation Spreadsheet
- BMD Lessons Learned
  - Improving cracking resistance in Alabama
  - Improving cracking resistance in Illinois
  - Improving cracking resistance in Virginia
  - Improving rutting and moisture resistance in Wisconsin



Lessons LEARNED BALANCED MIXTURE DESIGN

Improving Cracking Resistance in Virginia

This case study illustrates how a volumetric mix design (VMD) with inadequate cracking resistance was modified to meet the Virginia Department of Transportation's (VDOT) balanced mix design (BMD) specifications, using two design modification approaches: 1) increasing asphalt binder content; and 2) increasing RAP content, adding a rejuvenator, and increasing asphalt binder content. See a summary of VDOT's BMD specifications.

Table 1. **BMD Test Results of 30% RAP Mix at Volumetric OBC (5.2%)**

BMD Test Parameter	Test Result (Average)	VDOT BMD Spec.	Pass/Fail
APA Rut Depth (mm)	2.7	≤8.0	Pass
IDEAL-CT CT_{index}	45	≥70	Fail
Cantabro Mass Loss (%)	5.2	≤7.5	Pass

Original Volumetric Mix Design

A VDOT-approved 9.5mm nominal maximum aggregate size (NMAS) surface mix with 30% reclaimed asphalt pavement (RAP) was obtained from an asphalt contractor in Virginia. The mix was designed following the Superpave volumetric approach, using a PG 64-22 virgin binder and trap rock aggregates. The mix had a volumetric optimum binder content (OBC) of 5.2%, which corresponded to 4.0% air voids and 16.3% voids in mineral aggregate (VMA) at 50 gyrations. Table 1 summarizes the performance test results at the volumetric OBC. As shown, the mix passed VDOT's APA and Cantabro test requirements but failed the IDEAL-CT requirement with an average CT_{index} of 45; therefore, it was expected to have good rutting resistance and durability but inadequate cracking resistance.

BMD Modification Approach 1

The first BMD modification used to improve the cracking resistance of the original mix design was to increase the asphalt binder content. Because VDOT's BMD specifications allow the *Performance Design* approach with full relaxation of the volumetric requirements (for both mix design and production) when the performance requirements are met, the mix was modified by adding more virgin binder while keeping all the other mix components and proportions unchanged. The mix was first tested with IDEAL-CT at the volumetric OBC (5.2%) and three additional binder contents starting at 5.5%. As shown in

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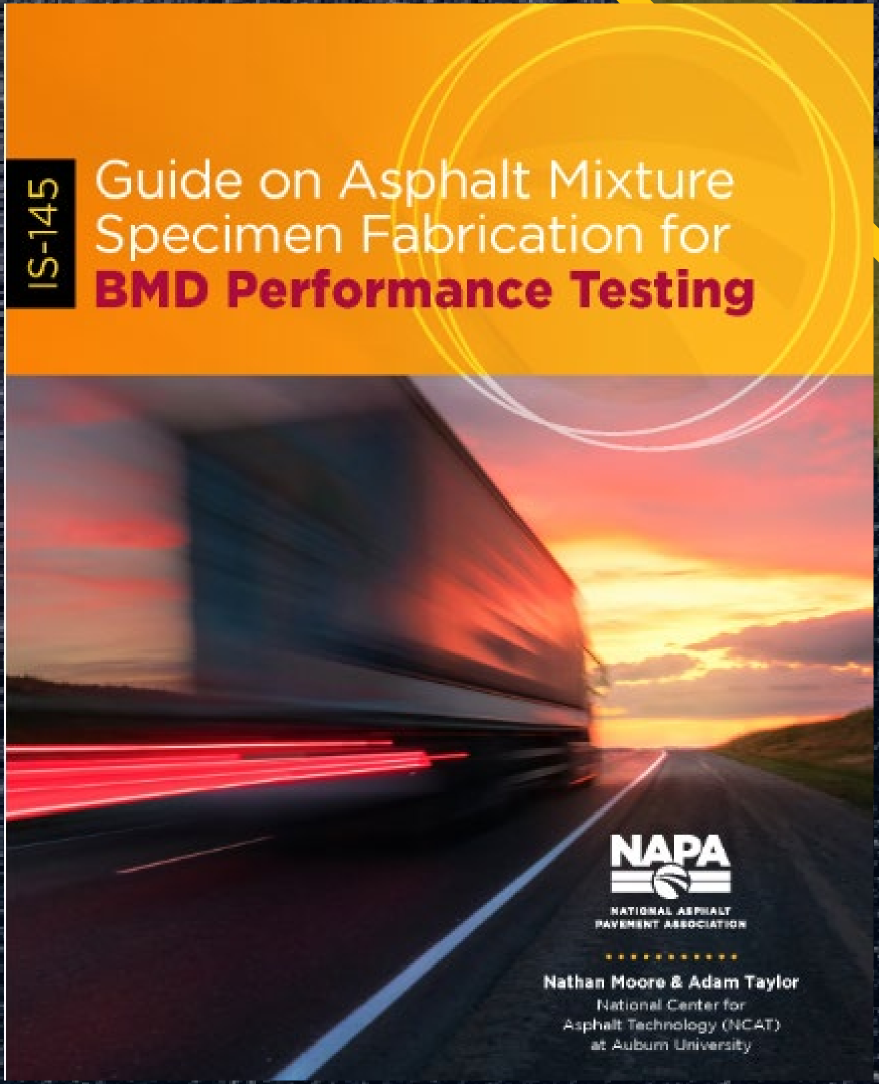
Resources

- Trainings
- CAPRI Documents
- NCAT Documents
- Business Case
  - Industry
  - Agency
- And more!



In the Works

- Guidance on Moving to Approach D
- RAP Handling Document
- Benchmarking for Contractors

Implementation Working Group

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Working Group Governance

Interested in participating? Review the Charter and Guidelines, then Become a Friend of the group.

Questions? Contact the Engineering team.

CHARTER | GUIDELINES | BECOME A FRIEND

Implementation Working Group

- Leadership:
  - Chair: Dave Vanderweele, Reith-Riley
  - Vice-Chair: Angela Beyke, Virginia DOT
  - Secretary: Fan Yin, NCAT at Auburn University
  - FHWA Liaison: Derek Nener-Plante
  - NAPA Support: Brett Williams with Richard Willis
- Members Only Meeting in April
- In-Person Meeting Late Summer