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.

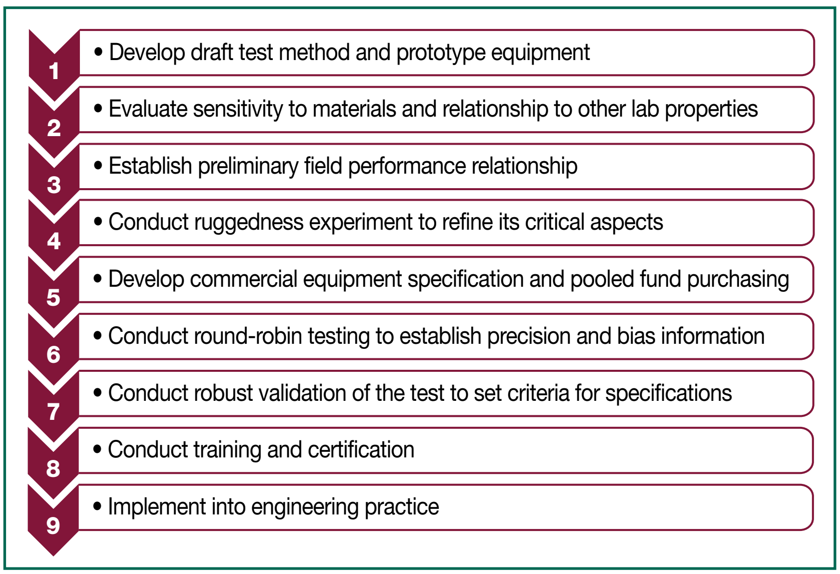

Figure 6. Nine Steps Needed to Advance Mixture Performance Tests from Development to Implementation

Although this is a long and expensive process to complete, SHAs interested in the implementation of BMD are highly recommended to consider these steps when selecting mixture performance tests. Performance tests that have completed these important steps through collaborative research, training, and implementation efforts are considered the most robust and readily implementable for BMD. Using performance tests that fail to complete these steps could ultimately lead to the implementation of a poor BMD specification that is costly to the highway 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 detected by existing methods or from a desire to correct flaws in an existing method. Researchers often look to the technical literature in the same or related fields for inspiration and guidance on how to measure the desired characteristic. In some cases, researchers may develop a test that attempts to simulate the critical condition at which the material deficiency occurs. Developing prototype equipment for the new test can be an arduous process with numerous iterations and refinements. Drafting of a written method often occurs when it is necessary for someone other than the original developer(s) to perform the test. Several revisions of the draft procedure are typically necessary to refine a method so that an independent technician or engineer can use it.

Step 2. Evaluate sensitivity to materials and relationship to other lab properties

Early research with a new test method often includes evaluating how the test results are affected by the changing properties of the material. For example, how sensitive is the test to materials variables considered in asphalt mix design including asphalt content, grade of asphalt binder, aggregate gradation, aggregate type, recycled materials contents, air voids, and possibly other factors? Early experiments often also compare or contrast results of the new test to an existing method(s). Caution should be exercised in relying on another existing laboratory test to justify the results of a new test since the existing test may lack proper field validation.

Step 3. Establish preliminary field performance relationship

For a test method to be seriously considered for use in specifications, there must be a clear relationship between its results and field performance. However, this is a very difficult step to successfully accomplish. Challenges in this step can include obtaining materials used in field projects, confounding factors that impact field performance, and the long period of time necessary to obtain meaningful field performance data, especially for distresses that take more than just a few years to develop. Therefore, most tests have a very limited amount of data to relate results to field performance in the early stages of development. At best, these initial studies are typically based on limited data from a single state. Regardless of how well the test results match or correlate with observed field performance, those findings should still be published so that all stakeholders are aware of the outcomes and possible test limitations. If the test is subsequently improved, another lab-to-field study should be conducted. For load related distresses (i.e., rutting and fatigue cracking), an experiment using an accelerated pavement testing facility may be ideal for establishing preliminary relationships between lab tests and field performance because these facilities are able to test multiple cells/lanes/sections under the same loading, environments, and support conditions. However, since loading systems such as an accelerated loading facility (ALF) or heavy vehicle simulator (HVS) operate at much slower speed than highway traffic, such results are not applicable for setting criteria for typical pavement specifications.

Step 4. Conduct ruggedness experiment to refine its critical aspects

A ruggedness experiment is critical to refining a test procedure to establish appropriate controls/limits for factors that significantly affect the test's results. For example, test methods typically state specific dimensions for the specimens. Some dimensions may affect the test results, so tolerances (e.g., X.X ± X.X mm) must be established to minimize such undesired sources of variability. Other examples of test controls that likely need to be evaluated in a ruggedness experiment include mixture aging temperature and time, specimen relative density, preconditioning time, test temperature, loading plate/strip geometries, loading frame compliance, loading/displacement rate, and data acquisition rate. For asphalt materials tests, ruggedness experiments should be conducted in accordance with ASTM E1169 (or ASTM C1067). Historically, few tests used in asphalt specifications have had formal ruggedness experiments conducted prior to the test's use in routine practice.

Step 5. Develop commercial equipment specification and pooled fund purchasing

For labs to purchase equipment for preparing test specimens and conducting the test, detailed specifications are needed for that equipment. In some cases, a standardized program or worksheet should also be developed to ensure that results are calculated/analyzed in a consistent manner. A ruggedness experiment conducted prior to writing the equipment specification will help set tolerances for the equipment. When several equipment manufacturers produce the equipment, it is recommended to conduct an experiment with units from each manufacturer to verify that results from each unit are similar. When a large number of labs need to purchase the equipment, there may be significant advantages to purchasing a large number of units at the same time, such as with a pooled-fund equipment purchase.

Step 6. Conduct round-robin testing to establish precision and bias information

For tests whose results are used for materials approval and/or acceptance, it is necessary to establish the method's precision and bias information. The standard for conducting a round-robin (a.k.a. interlaboratory) study is ASTM E691. An interlaboratory study is used to establish the acceptable range of two test results from a single operator (i.e., within-lab) and the acceptable range of split-sample results from two different laboratories (i.e., between-lab). Knowing the within-lab and between-lab test variabilities of different candidate tests determined using ASTM E691 is useful information to help select the most preferred test option.

Step 7. Conduct robust validation of the test to set criteria for specifications

Before the test is used in a specification, an agency should have confidence that the criteria used for a material's approval and/or acceptance are appropriately set. Criteria that are too strict will increase contractor risks and eventually increase bid prices. Criteria that are too lenient will ultimately lead to accepting poor performing materials. Robust validation of a test is a more rigorous experiment or group of experiments to make sure that the test provides results that provide a strong indicator of field performance. As with Step 3, there are numerous challenges to establishing a relationship between lab test results and pavement performance. The ideal validation experiment would include sites with moderate to high traffic levels and in different regions of the country with each site having five to ten test sections with mixtures expecting to have a range of performance from bad to good for the distress being evaluated. It is recommended for the validation experiment to include mixtures containing typical materials in the state. Tight controls on the construction of the test sections are critical to avoid undesired or confounding effects. To eliminate potential bias, the laboratory testing for the validation effort should be completed such that the results of the field performance of the test sections are unknown and preferably by an organization other than the test's primary developer. The desired result for each site is a strong correlation between the measured field distress and the laboratory test results from which a limit or limits can be established for specification purposes. In other words, it is necessary to have some poor-performing test sections in the field so that the criteria can be set to exclude such mixtures in the future.

Another option for robust validation is to test mix designs that already have known field performance. This has been referred to as benchmarking. The challenges with this approach are (1) if the mix designs contained recycled materials, those materials may no longer be available, and (2) field performance is likely to be influenced by other factors that differ from project to project (e.g., traffic, underlying conditions), which confound an analysis of field to lab correlations.

Step 8. Conduct training and certification

Training of engineers and technicians on the test procedure and analysis of its results is vital to the successful implementation of a new test method. Agencies should facilitate the development of a training course and require participation by all personnel who are involved in specimen preparation, testing, and analysis of results. Periodic retraining is also appropriate as a test method is revised. Workshop type courses where participants are given hands-on time with sample preparation, testing, and analysis are preferred.

Step 9. Implement into engineering practice

Industry-agency task groups can be helpful in establishing an implementation plan. It is generally considered a best practice to begin implementation of a new specification through a series of shadow projects and pilot projects using a phased-in approach. The first phase is typically a limited number of shadow projects that add the new test(s) for information only and are helpful to work out sampling and testing logistics, assess how results compare to the proposed criteria, and make adjustments. Shadow projects may be added to existing contracts to facilitate early buy-in. The second phase is a series of pilot projects that use the test results for approving and accepting materials. The number of pilot projects should start out with just a few in the first year, then one to two projects in each district the second year, and so on. Adjustments may be made to each round to improve the processes and criteria. These projects enable more stakeholders to become more familiar with the test and how its results will impact the design and acceptance of their materials. Some agencies have also added a pay item to pilot projects for the purchase of new test equipment. The agency or the task group should consider whether the new tests and specifications should apply to all asphalt paving projects or only apply to certain roadway classifications and projects of a minimum size. Overall, it may take four to five years to reach full implementation.