Testing in progress

Research tries to find way to check asphalt performance

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At present, the asphalt material specifications for many state and local agencies rely primarily on volumetric properties to ensure good field performance.

The current asphalt material specifications do not put due emphasis that is needed for mechanical testing of asphalt concrete. There have been considerable amounts of research efforts undertaken to develop so-called asphalt performance tests that can link laboratory-measured parameters to actual pavement performance. Some research efforts also are undertaken to refine the asphalt-mix design method so that laboratory tests and procedures can be incorporated as part of material specification. Research efforts are needed to explore availability of such asphalt performance tests, their suitability and their use by other agencies. This article briefly describes a recently finished research project that focused on answering these questions and developing plans for future development on this topic. The research project was sponsored by the Minnesota Department of Transportation (Mn/DOT).

The research study described in this article primarily focuses on review of literature and material specifications. The project was approached in a three-pronged manner. The efforts included:

- Review of material specifications from various departments of transportation (DOTs);
- Review of technical literature on asphalt-performance tests; and
- Preliminary review of previous research projects conducted or funded by Mn/DOT that dealt with asphalt-performance tests.

The available information was synthesized to make a variety of recommendations. These include: suitability of including mechanical test in material specifications; identification of potential laboratory tests that have been used by other DOTs as performance indicators; and recommendations for future studies that can be undertaken to evaluate suitability of a performance test and develop implementation plans.

Practice time

The first research task that was undertaken in this project was to determine the current state of the practice by state highway agencies in the routine use of asphalt-performance tests. This evaluation was conducted through a comprehensive review of the Standard Bridge and Road Construction Specification manuals for 51 agencies. The review included DOTs from all 50 states as well as the District of Columbia. The following set of conditions were focused on in order to conduct the review in a timely fashion:

- The most current version of the standard specifications was reviewed. Older versions

were referenced in some instances, such as citation in the reviewed literature;
- The thrust was on the standard specifications and not the provisional specifications. However, if other literature indicated that provisional specifications are requiring performance testing then those were reviewed; and
- Testing requirements were focused on plant-produced asphalt concrete. Other asphaltic materials such as surface treatments or emulsified tack coats were not focused upon in this project.

The first key observation is that most standard specifications describe method and quality control/quality assurance (QC/QA) specifications and very few use the terminology "performance-related specifications (PRS)." No standard specification was found to explicitly use the term "performance-based specifications (PBS)." Another observation is that all 51 specifications broadly follow Superpave Level I volumetric mix design requirements. The Level II or Level III requirements are not present in any instances.

In terms of the testing necessity, 47 DOTs require at least one mechanical test. Only Delaware, Maine, Massachusetts and New Mexico DOTs are the exception. A majority of the testing requirements are to evaluate the moisture-damage susceptibility of the asphalt mixture. The requirements span a variety of tests, such as tensile strength ratio (TSR), indirect tensile strength, Hamburg wheel tracking test, asphalt-pavement analyzer (APA), Marshall flow and stability tests, and others. Figure 1 shows the breakdown of various testing requirements. As evident from this figure, a majority of DOTs require tests to evaluate the moisture-damage susceptibility (total of 57%). A majority of the DOTs use TSR as the moisture-damage test. While the testing procedures for TSR vary in small amounts between various agencies, in broader sense they follow the AASHTO T-283 specifications. Other than moisture-damage tests, the APA testing for rutting performance is the next prevalent test, with a 10% share.

The breakdown of the remaining 21 mechanical-testing requirements other than the traditional moisture damage tests is shown in Figure 2. Since these tests are usually required to evaluate the potential field performance of the pavement, these are referred to as performance-test requirements from here onwards in this article. Of these 21 requirements:

- 6 are tensile strength limits (determined and reported along with TSR);
- 15 are rutting or rutting and stripping testing requirements, with breakdown of:
  - 3 for Hamburg wheel tracking test;
  - 8 for APA test; and
  - 4 Marshall flow and stability requirements; and
- 6 DOTs require other nonrutting and nonmoisture damage mechanical tests; these are usually cracking-related performance tests.

The performance-test requirements can be further divided by the type of pavement distress that they are applicable to, and in a broader sense this division is done as: rutting or permanent deformation-related tests and cracking-related tests. The breakdown of 18 rutting-test requirements are presented in Figure 3, and the seven cracking-related tests are in Figure 4. A majority of the cracking-performance

Figure 1. Mechanical testing requirements by DOTs.

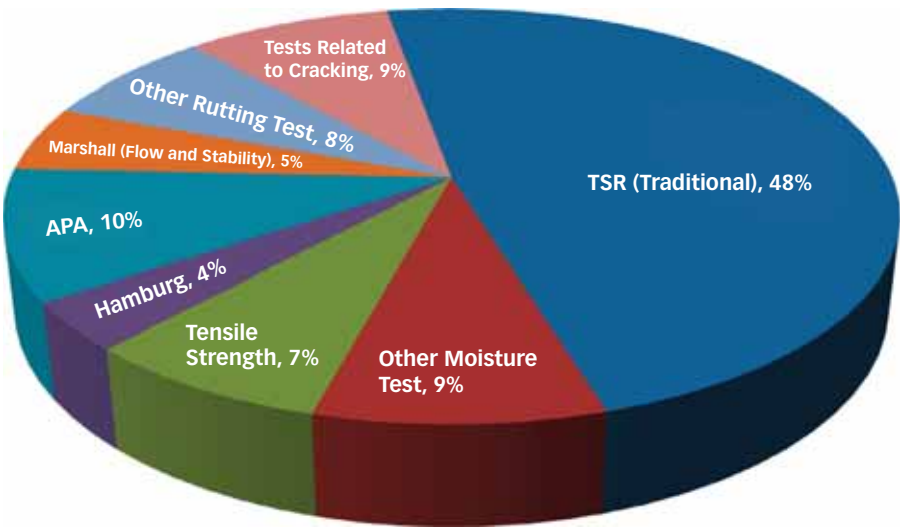


Figure 2. Breakdown of the performance testing requirements by DOTs.

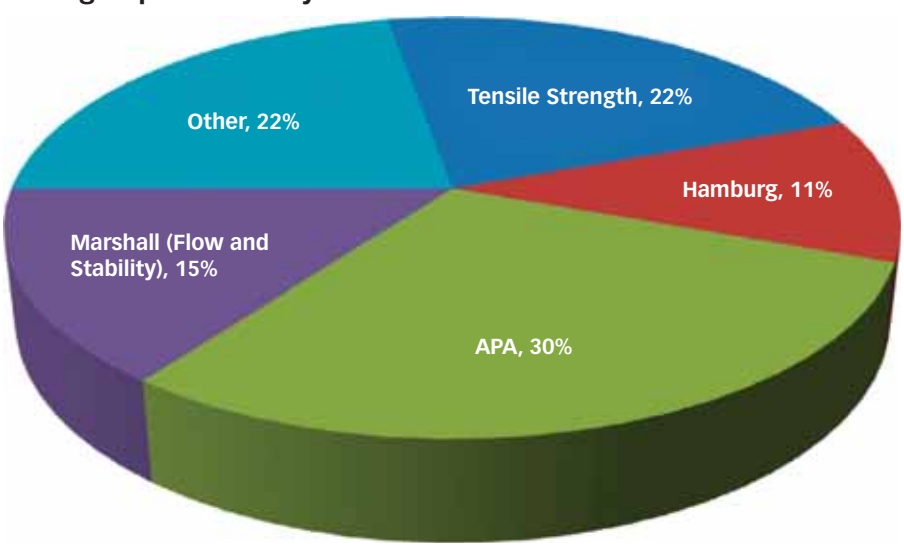


Figure 3. Rutting performance tests used by DOTs.

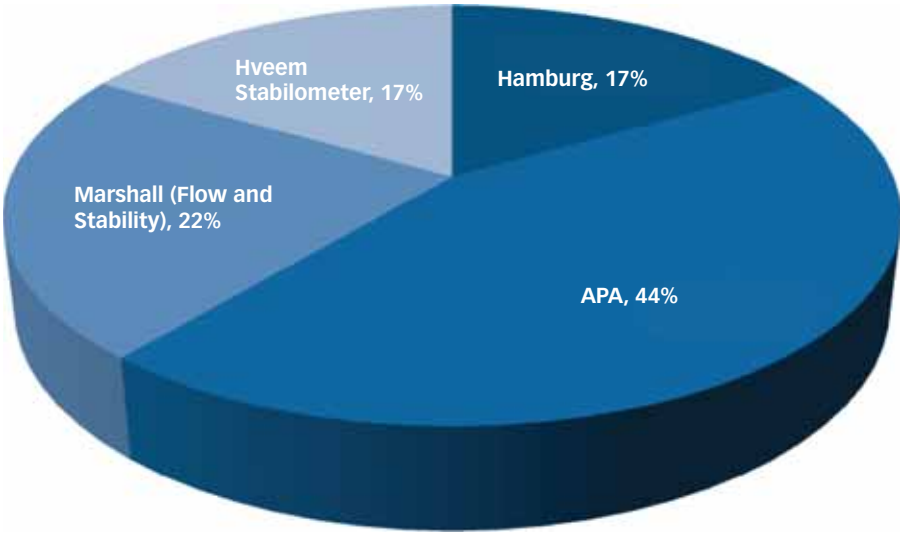
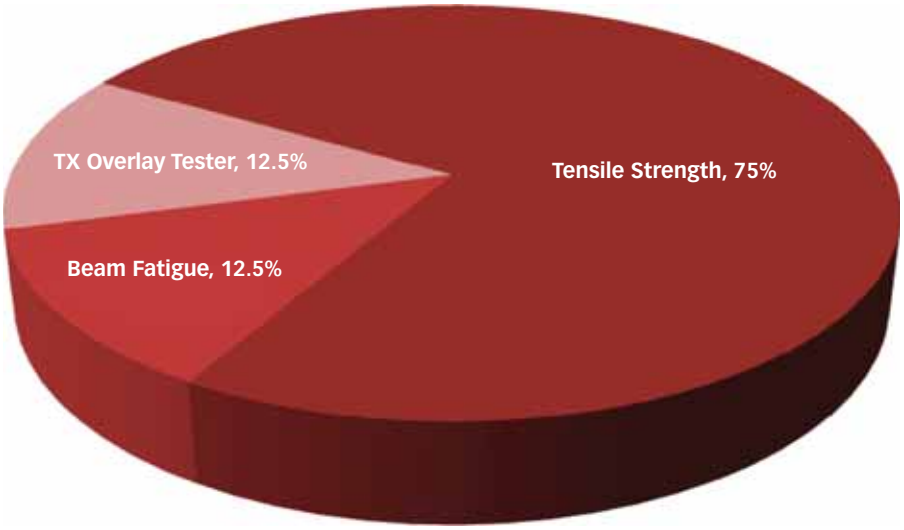


Figure 4. Cracking performance tests used by DOTs.



requirements are in the form of tensile strength, and it should be noted that this tensile strength is usually available from the TSR test and does not require additional testing and specimen procurement and preparation. The other two cracking tests described in the DOT specifications are the flexural beam fatigue test and the Texas overlay test. While the Texas overlay test is required for asphalt mixtures placed on existing deteriorated pavements in Texas, the flexural beam fatigue requirement of the Georgia DOT is a recommended test that may be conducted as part of the mix-design process.

Through the review of DOT specifications as well as review of technical literature, the current state of the practice on the asphalt-performance tests can be synthesized into the following points:

- Moisture damage and rutting performance tests are most prevalent;
- Dry tensile strength requirement is the most commonly used cracking-related performance measure;
- Few pilot studies have shown that cracking-performance test requirements are feasible; and
- A review suggests that an extensive performance-test requirement such as the flexural beam fatigue test, or APA, should be targeted to limit the testing burden in routine practice.

State of the art for asphalt-performance tests

An in-depth review of the asphalt performance tests was conducted in this project. The highlights on the current state of the art are as follows:

- A significant number of mechanical tests have been proposed as asphalt-performance tests, and a relatively low number have actually shown good correlation between the test results and field performance. This is especially true for pavement-cracking distresses;
- Of those tests that have shown good correlation to field cracking distress, very few are used on a routine basis. At present, the beam fatigue and Texas overlay tests are the only ones that are part of standard material specifications for a DOT;
- A large number of tests with good correlation to field performance relies on use of computational and analytical models to achieve these correlations;
- Very few tests fall in the category where they can be used on a routine basis, require minimal data post-processing and show good correlation to field performance;
- The AMPT has been researched very extensively in recent years and is continuing to gain acceptance from researchers and agencies. The test has great potential in predicting pavement-rutting performance and also has good potential in predicting fatigue cracking by means of computational models. The suitability of the test in terms of low-temperature cracking has not been evaluated and thus limits its suitability for use in Minnesota;
- Bulk property tests, such as modulus- or compliance-determination tests, are usually complicated to use in performance-based specifications; they are better suited for pavement-design purposes;
- Some strength tests have good potential for use in performance-based specifications; however, they may be limited due to testing complexities;
- Fracture tests, particularly DCT and SCB, have shown very good correlation with cracking performance of pavements. Significant data is already available for several mixtures and

pavements in Minnesota for both of these tests. These tests also are being recommended for routine use to screen mixtures for thermal-cracking performance. The only limitations for these tests are their complexity, which may hinder their widespread and routine use; and

- Simulative tests may be viable options for use in developing performance-based specifications and to serve as proof tests. A mature and simple simulative test for low-temperature cracking is not available. Furthermore, use of simulative tests will require a local calibration and validation process. Typically testing requirements also are quite elaborate and lengthy.

Allow them to recommend

Based on the synthesis study on laboratory asphalt-performance tests, the following conclusions can be drawn:

- Performance tests are being required by several DOTs on a routine basis through standard material specifications. At present, the performance-test requirements are primarily limited to rutting distress;
- Few pilot studies have shown that use of performance-test-based specifications to reduce risk of pavement cracking is feasible;
- Implementation of application targeted performance-based specifications for asphalt concrete may be suitable. This allows for the focus on a specific performance-test requirement that is most related to the distress that a mix will encounter during pavement service. The application target could be selected on the basis of location of lift in the pavement, type of pavement, traffic level or other variables;
- A significant amount of effort has been put in nationally to develop the AMPT. However, its applicability for direct use to determine pavement-cracking performance is not given priority. This is especially true for thermally induced pavement cracking; and
- A number of cracking performance tests are available; based on the review the tests that show the greatest potential for use in performance-based material specifications are: indirect tensile strength, especially from moisture damage evaluation tests; fracture tests such as semicircular bend tests or disk-shaped compact tension test; Texas overlay tester; and the four-point bending beam fatigue test.

The objective of this research project was to conduct a review of the current state of asphalt performance testing. Apart from the identification of a few candidate performance tests, several recommendations were identified. Several of these recommendations point toward future research efforts that will enable extension of the current effort into a fruitful and implementable outcome. The recommendations from the present research study are:

- The use of indirect tensile strength measure from the moisture susceptibility testing should be evaluated to determine if it can be used as a performance measure. A significant amount of data is already available for this measurement, and minimal research effort will be necessary to determine if this parameter can be used. Furthermore, it is a widely used requirement in DOT specifications;
- Fracture tests (disk-shaped compact tension and semicircular bend tests) show great potential as suitable performance tests. They should be evaluated for asphalt mixtures and field sections where pavement cracking is prevalent;
- The testing requirements in terms of equipment, specimens and data post-processing should be quantified to inform the selection of an asphalt-performance test; and
- Trial projects should be undertaken to evaluate the feasibility of using performance-based specifications. R&B

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