Asphalt Content Test Offers Improvement Over Solvents

The National Center for Asphalt Technology (NCAT) has developed a test method to determine the asphalt content of hot-mix asphalt (HMA) mixtures by ignition. The test method is based on research started in 1990 at NCAT and sponsored by the Federal Highway Administration, the Alabama Department of Transportation, the National Asphalt Pavement Association (NAPA), and the NAPA Research and Education Foundation.

PROBLEM

Many agencies currently use chlorinated solvents—such as 1,1,1-trichloroethane—to dissolve and remove asphalt cement from aggregate. Such solvent extraction methods provide knowledge of two important properties: asphalt content and aggregate grading of HMA mixtures. However, the United Nations Environmental Programme has identified chemicals such as trichloroethane as ozone-depleting compounds. The U.S. Environmental Protection Agency's final ruling on Section 606 of the 1990 Clean Air Act Amendments mandates the discontinuation of trichloroethane production after December 31, 1995. In addition to the environmental risks associated with them, these solvents are expensive and difficult to dispose. These concerns have been major factors in the search for alternative methods to determine asphalt content.

Some agencies have evaluated and used biodegradable solvents to replace chlorinated solvents. Biodegradable solvents, however, require a time-consuming modified extraction procedure. The proper disposal of biodegradable solvents containing dissolved asphalt cement is also a problem in some states.

Nuclear asphalt content (NAC) gauges have been substituted for solvent extraction in several states. NAC gauges can rapidly measure the asphalt content of HMA mixtures with the required accuracy. NAC gauge methods do not allow for the determination of aggregate grading, however, and the solvent extraction test is still required to determine the asphalt content of reclaimed asphalt pavement materials. Because neither NAC gauges nor biodegradable solvents have successfully eliminated the use of chlorinated solvents, other test methods have been sought to determine asphalt content.

SOLUTION

More than 25 years ago Antrim et al. developed a procedure to determine the asphalt cement content of asphalt mixtures. The procedure, developed as a part of a National Cooperative Highway Research Program project on rapid test methods for field control of highway construction, involved igniting the asphalt cement with a butane burner with the addition of oxygen. These researchers concluded in *NCHRP Report 103: Rapid Test Methods for Field Control of Highway Construction*, published in 1970, that the accuracy and precision of the method could be improved through investigation of factors such as aggregate weight loss, operator effect, and mix combinations. Although it follows a similar format, the NCAT method offers significant improvements in accuracy and precision.

In the NCAT ignition method (finalized in 1994), about 1200 grams of HMA mixture is subjected to an elevated temperature of 538°C (1,000°F) in a furnace to ignite and burn the asphalt cement. NCAT's work has resulted in a test procedure and equipment that automatically measures the asphalt content in 30 to 40 minutes. The grading of the aggregate can then be determined using standard sieve analysis. Larger HMA samples (2400 grams) can also be tested.

The HMA test sample is divided into two portions and placed in two stainless steel No. 8 mesh trays stacked on top of each other in the NCAT asphalt content tester. The unit has a built-in scale with a digital readout underneath the furnace to weigh the sample continuously during ignition. A built-in filter eliminates the smoke in the exhaust. After the asphalt binder is completely burned and the sample achieves a constant weight, the buzzer in the oven goes off. A built-in printer prints the asphalt content on completion of the test. The ignition test, unlike solvent extraction tests, need not be attended by the technician at all times.

Twelve units of the NCAT asphalt content tester were distributed for multilaboratory testing to determine the accuracy and precision of the ignition test method. These units were provided along with laboratory-prepared HMA samples to laboratories throughout the United States. Each laboratory received sixteen samples (four replicates of four HMA mixtures containing different aggregate types and asphalt contents). The participating laboratories—FHWA Office of Technology Applications; departments of transportation in Georgia, Alabama, Virginia, Michigan, Washington, Arizona, and Illinois; Industrial Asphalt in California;

Payne and Dolan in Wisconsin; and Heritage, Inc., in Indiana—had no knowledge of the asphalt content or aggregate gradation contained in the four HMA mixtures. Testing was completed in early 1995 and the results were analyzed by NCAT.

The tests helped determine how close the test results were to the true properties of the HMA (accuracy) and how variable the test results were within a laboratory and among different laboratories (precision). Tables 1 and 2 provide the information on accuracy and precision, respectively. It is evident that the NCAT asphalt content tester can accurately measure the asphalt content of HMA mixtures, and the precision of this method is greater than that of solvent extraction methods (standard deviation is reduced by approximately 75 percent). As shown in Table 1, the tester also does not alter the aggregate grading.

APPLICATION

An increasing number of state departments of transportation are adopting quality control and quality assurance procedures for HMA mixtures, which require increased testing of the composition of the mixtures during production. The NCAT ignition test is being received very favorably by the DOTs and the HMA industry. This method has been proposed by Alabama DOT as an AASHTO standard test method. States such as Virginia have already adopted the ignition test as a standard. Numerous HMA contractors have purchased the NCAT asphalt content tester.

BENEFITS

Use of the NCAT asphalt content test will provide health and environmental benefits, cost savings, shorter test times, and more accurate test results. For example, serious health and environmental concerns are associated with the use of chlorinated solvents in extraction tests for determining asphalt content in HMA mixtures. The use of the NCAT test will eliminate these concerns.

The cost savings shown in Table 3 are calculated on the basis of 500 extraction tests per year. It is also assumed that equipment maintenance is 20 percent of annual equipment costs. Calculations show expected savings for the first year and subsequent years using the NCAT asphalt content test, the centrifuge extraction test without recycling solvent, and the centrifuge extraction test with recycling solvent. Using the assumptions indicated, the NCAT asphalt content tester will provide a savings of up to approximately $8,000 the first year but even more for each year after that, up to approximately $16,000.

The NCAT test offers time savings and more accurate results. The asphalt content can be determined in 30 to 40 minutes with the NCAT asphalt content test, compared with 1 to 2 hours for centrifuge extraction. The test results have indicated that the variability of the asphalt content by the NCAT test method is reduced by approximately 75 percent when compared with the variability of the centrifuge extraction.

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TABLE 1
Accuracy of NCAT Asphalt Content Tests.

	HMA MIX TYPE			
Test	Gravel	Granite	Limestone	Truprock
% Asphalt Content Actual	6.00	6.00	5.00	5.50
% Asphalt Content Measured	5.98	5.99	4.97	5.53
%Passing No. 4 Actual	71.6	66.8	61.4	57.0
% Passing No. 4 Measured	71.5	66.6	61.4	56.6
% Passing No. 200 Actual	6.0	7.7	6.7	5.3
% Passing No. 200 Measured	5.6	7.7	7.2	5.1

NOTE: Each number shown is the average of 48 test results (12 laboratories × 4 replicates). Asphalt content is by weight of the total mix.

TABLE 2
Precision of NCAT Asphalt Content Test Results

Test Property	Standard Deviation, Percent		Acceptable Range of Two Test Results, Percent	
	Within Lab	Between Labs	Within Lab	Between Labs
Asphalt Content (NCAT Tester)	0.04	0.06	0.11	0.17
Asphalt Content (Solvent Extraction)	0.21	0.22	0.59	0.62

TABLE 3
Potential Cost Savings

FIRST YEAR

Breakdown of Costs	NCAT Asphalt Content Test	Centrifuge Extraction without Recycling Solvent	Centrifuge Extraction with Recycling Solvent
Equipment	$11,000	$2,500	$7,000
Utilities	1,500	500	800
Materials	1,000	15,000[a]	2,000
Labor[b]	2,500	7,500	10,000
Maintenance[c]	2,200	500	1,400
TOTAL	$18,200	$26,000	$21,200

[a]Assume $7.50/test for solvent and $22.50/test to dispose solvent [b]Assumes $15/hour for cost of labor [c]Assumes 20 percent of initial equipment costs

SECOND YEAR

Breakdown of Costs	NCAT Asphalt Content Test	Centrifuge Extraction without Recycling Solvent	Centrifuge Extraction with Recycling Solvent
Utilities	1,500	500	800
Materials	1,000	15,000[a]	2,000
Labor[b]	2,500	7,500	10,000
Maintenance[c]	2,200	500	1,400
TOTAL	$7,200	$23,500	$14,200

[a]Assume $7.50/test for solvent and $22.50/test to dispose solvent [b]Assumes $15/hour for cost of labor [c]Assumes 20 percent of initial equipment costs