A Publication of the National Center for Asphalt Technology, Auburn University Volume 14, Number 1 SPRING 2002

DEVELOPMENT OF NEW ASPHALT TEST METHODS AT NCAT

One of the objectives of applied research efforts made at the National Center for Asphalt Technology (NCAT) is to provide simple testing tools to the hot mix asphalt (HMA) industry for enhancing the HMA quality. Since its inception in 1986, NCAT has developed or is in the process of developing such tools which will be discussed later.

First, NCAT develops a concept and then a prototype test equipment for a specific purpose in its laboratory. Once the prototype shows good promise, NCAT invites equipment manufacturers to develop commercial versions of the test equipment.

So far, NCAT has not held any patent for its concept and/or prototype so that any manufacturer can fabricate it, thus encouraging competition. The equipment manufacturers use their own ingenuity in making the test device automated and user-friendly. After the commercial version(s) of these test devices is developed, NCAT checks the reliability and repeatability of the testing device within its laboratory. If found satisfactory, NCAT organizes a round robin testing in which at least 10 laboratories all across the United States (involving state DOTs, FHWA, and contractors) participate. The round robin results in the development of a precision statement (in terms of repeatability and reproducibility) which is necessary for the approval of the new test method as AASHTO and ASTM standards.

Since NCAT personnel are involved in the ASTM activities, they usually serve as task force chair to get the new standards adopted by the ASTM as quickly as possible. In the past, many new methods initiated by NCAT have been approved by the ASTM in less than two years, which is exceptional. These new test methods are usually initiated in the AASHTO by NCAT through a state department of transportation.

The following new test methods have been developed or are being developed at NCAT to assist the HMA industry in improving the quality of HMA mixtures.

(continued on page 2)

NCAT workability device for HMA

In This Issue

Development of New Asphalt Test Methods at NCAT — **Page 1**

NCAT Test Track Update — **Page 4**

Hot Mix Asphalt Technology - *50 Years Ago* — **Page 5**

Performance Testing For Hot Mix Asphalt — **Page 6**

Putting Research into Practice — **Page 8**

Asphalt Forum — **Page 11**

Asphalt Forum Responses — **Page 12**

Specification Corner — **Page 15**

National Center for Asphalt Technology
NCAT
AUBURN UNIVERSITY

—New Asphalt Test Methods

(continued from page 1)

• Ignition test for asphalt content

Prior to the 1990s, asphalt content of HMA mixtures was most commonly determined with solvent extraction methods using chlorinated solvents. Due to human health and environmental considerations the chlorinated solvents were banned by environmental agencies in the early 1990s. Some highway agencies started to use nuclear gage to determine the asphalt content in HMA mixtures. However, it is not possible to determine the aggregate gradation in the mix when nuclear gage is used. Non-chlorinated (terpene type) solvents were used by some agencies, but the extraction method with these solvents is time-consuming and disposal of the spent solvent was still a problem.

There was a need to develop a test method for determining asphalt content, which was environmentally acceptable and also recovered aggregate for further gradation testing. To meet this challenge NCAT developed the ignition method in which HMA mixture is heated to about 1000°F to ignite it and burn off the asphalt binder. After automated commercial version of this device was available, NCAT conducted a round robin study. The precision of the ignition method was significantly better than that of extraction method. This test method was adopted by ASTM (D6307) and

NCAT ignition oven for determining asphalt content

AASHTO (T308). The method has gained popularity throughout the world.

• Automated aggregate gradation device

After the ignition test, the recovered aggregate has to be subjected to sieve analysis to determine its gradation. The conventional sieve test is very time consuming because the technician has to weigh the aggregate retained on each sieve by emptying and brushing it and then calculate the gradation. There was a need to develop an automated gradation device to free the technician to conduct other QC/QA tests. NCAT found a source for this automated equipment from a company which manufactured sieving devices for grading materials other than aggregates. The aggregate is simply fed into the device which shakes the aggregate on the desired sieves, determines the weight of the aggregate retained on all sieves (also brushes each sieve), and calculates the gradation which is plotted and displayed on the monitor of a PC through a data acquisition system.

• Draindown test for SMA and OGFC

Draindown of asphalt binder is a potential problem when gap-graded stone matrix asphalt (SMA) and open-graded friction course (OGFC) mixtures are transported from the HMA facility to paving site. When SMA was introduced in the U.S. in the early 1990s, several versions (including German) of draindown tests were in use, which gave different results. There was a need to develop a standard draindown test for these mixtures, which could be used in conjunction with a national specification on maximum permissible draindown. Through reseach NCAT developed a standard draindown test which is now an ASTM standard (D6390). Without NCAT's efforts, there would have been a proliferation of draindown test and related specification across the U.S.

National Center for Asphalt Technology, 277 Technology Parkway, Auburn, Alabama 36830
Phone: (334) 844-NCAT (6228) Fax: (334) 844-6248

ASPHALT TECHNOLOGY NEWS (Library of Congress Catalog No. ISSN 1083-687X) is published by the National Center for Asphalt Technology (NCAT) of Auburn University. Its purpose is to facilitate the exchange and dissemination of information in hot mix asphalt technology, trends, developments and concerns. Opinions expressed in this publication by contributors and editors, the mention of brand names, the inclusion of research results, and the interpretation of those results do not imply endorsement or reflect the official positions or policies of NCAT or Auburn University.

E. Ray Brown, *Director*
Prithvi (Ken) Kandhal, *Associate DirectorEmeritus/ Editor*
James S. Killian III, *Associate Editor, College of Engineering*

• Field permeability test device

Prior to Superpave, most HMA mixtures were relatively dense-graded and usually did not present a permeability problem in the field. Superpave encouraged the use of relatively coarse-graded mixtures with relatively larger maximum nominal sizes. Some of these mixtures started to exhibit permeability problems, which led some state DOTs to specify higher compaction levels and/or permeability tests on the pavement core samples conducted in the laboratory. There was a need to develop a field permeability device so that the problem can be detected and controlled during construction. NCAT developed a field permeability device which is now used by several states. The round robin testing of this device has now been completed and the precision statement developed to facilitate its adoption as a national standard.

NCAT automated aggregate gradation device

• Bulk specific gravity of fine aggregate

Bulk specific gravity of coarse and fine aggregates need to be determined in Marshall or Superpave volumetric mix design. These test values are used to calculate the voids in the mineral aggregate (VMA) and the amount of asphalt binder absorbed by the aggregate. The bulk specific gravity of the fine aggregate is also used to calculate uncompacted void content in the fine aggregate angularity (FAA) test which is an important element of Superpave mix design. It is necessary to obtain a saturated surface dry (SSD) condition of both coarse and fine aggregates to determine their bulk specific gravity. Whereas obtaining the SSD condition of coarse aggregate particles is relatively easy, it is very difficult in case of fine aggregates. At the present time SSD condition of the fine aggregate is established by tamping it in a conical mold with a tamper and then removing the mold (refer to ASTM C128). If the cone remains completely intact it is assumed that the surface is not completely dry. The SSD condition is established when some aggregate particles dislodge and slide downwards from the compacted cone. It is a very subjective test. There was a need to develop an automated SSD device. NCAT developed a prototype device to achieve the SSD condition without any subjective observation (see NCAT Report 99-7). Equipment manufacturers were invited to develop commercial versions of this device. NCAT is evaluating promising devices from three manufacturers at the present time. Round-robin tests will follow once the devices are found to be reliable and repeatable in the NCAT laboratory.

• Workability of hot mix asphalt

Prior to Superpave, the mixing and compaction temperatures of dense-graded HMA mixtures were established based on neat asphalt binder viscosities of 170 and 280 centistokes, respectively. This system performed satisfactorily and the mixtures generally did not have workability or compactibility problems. However, things have changed now. Relatively coarser gradations in the Superpave or gap-graded SMA mixtures are being used. The use of polymer-modified asphalt binder is becoming quite common. Also, fibers are used in SMA mixtures. Therefore, it is no longer possible to rely on the neat binder viscosity to establish mixing temperatures which will result in satisfactory workability in terms of mix placement. Suppliers of polymer-modified asphalt binders recommend mixing temperatures based on experience usually without any rational testing of the mixtures. Quite often, this results in unusually high mixing temperatures which may not be needed. There was a need to develop a device to quantify the workability of HMA mixture and establish the mixing temperature based on a threshold workability value. This is logical because the workability is influenced by the aggregate type (particle shape, angularity, and surface texture), gradation (dense, gap, or open-graded), binder (modified or unmodified), and

(continued on page 4)

NCAT field permeability device

—New Asphalt Test Methods

(continued from page 3)

mix additives (such as fiber or fillers). A prototype workability device has been developed by NCAT and appears very promising in discerning the effect of aggregate type, gradation, and binder type on workability. A report is being finalized and will be available soon.

NCAT aggregate bulk specific gravity device

NCAT will continue to develop simple and practical testing devices and test methods in the future to assist the HMA industry towards automation and enhancing the quality of HMA production and placement.

NCAT TEST TRACK UPDATE

Loading of the 1.7-mile oval NCAT Test Track is continuing on schedule. Trucking began on September 19, 2000. As of February 26, 2002 a total of 6.22 million ESALs (equivalent 18 kip single axle loads) have been applied to the test sections. This value represents 62 percent of the planned 10-million ESAL goal to be applied in two years.

Total rutting on 26 tangent sections as of October 1, 2001 was reported in the fall issue of the Asphalt Technology News. As was the case during the first winter after the loading began, no significantincrease in rut depths has occurred during this winter.

As one would intuitively expect, the two mixes with the most rutting at the end of the hottest months of 2001 both contained unmodified binder at optimum plus one-half percent. This information will be useful for life cycle cost analyses and cost-based computations for production pay factors.

Final conclusions will consider all information generated through the end of trucking operations in November of 2002; however, several **preliminary** findings of interest to the pavement industry may be

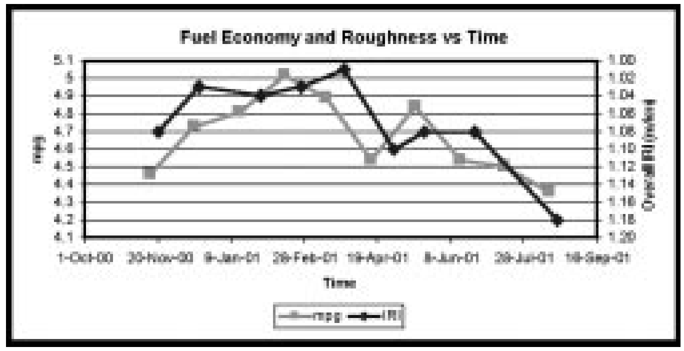


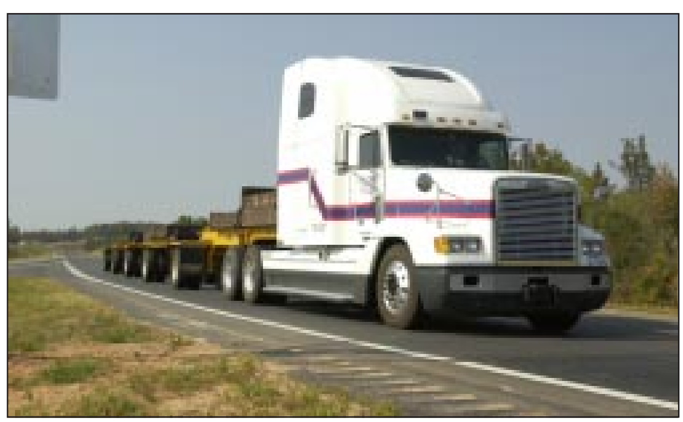
Figure 1: Effect of Roughness on Fuel Consumption

summarized as follows:

- Evidence suggests the existence of a quantifiable relationship between pavement roughness and fuel consumption in trucking operations. As pavements get rougher, an increase in fuel consumption has been observed (see Figure 1).
- Generally, coarse-graded mixes have rutted slightly less than fine-graded mixes (by about 21 percent overall) over the first half of traffic.
- In comparison studies where different binder grades were used to produce mixes with the same aggregate blends, an average decrease in rutting of 37 percent has been observed in mixes with higher PG grades.
- Although gradation type affects initial coefficient of friction measurements, the differences diminish as traffic accumulates in mixes with similar aggregates.
- Mats with coarser surface textures are more effective at removing rainwater. Coarse mixes are more efficient than fine mixes, and SMAs are more efficient than coarse mixes, but open-graded mixes are the most effective in reducing road spray.

Construction and performance information on the Test Track is available online at:

<http://www.pavetrack.com>



NCAT Test Track

HOT MIX ASPHALT TECHNOLOGY *- 50 YEARS AGO*

The following are excerpts from the Proceedings of the Association of Asphalt Paving Technologists (AAPT), Volume 21, 1952. We hope you will find them interesting. The comments in parentheses are those of the editor.

1. **L. Ortolani and H.A. Sandberg, "The Gyratory-Shear Method of Molding Asphaltic Concrete Test Specimens: Its Development and Correlation with Field Compaction Methods."**

"In 1939, the Texas Highway Department initiated an extensive research program on the design and control of bituminous mixtures. Previous methods were a hit-and-miss proposition, often depending on the looks, the feel of the mixture under the heel, or the opinion of an experienced asphalt man. While the latter might have been well and good, there were not enough experienced men to go around. First things come first. Before a satisfactory design method could be determined or a dependable control technique developed, it was necessary to develop the methods and equipment that would most nearly simulate road conditions and at the same time give accurate reproducible results. The procedure for molding asphaltic concrete test specimens was necessarily one of the first problems to be investigated.

Several criteria were set up as required of any molding method evolved; first, the method must be equally adaptable to the field control of the mix as to the design. An excellent but lengthy design procedure would be useless in the field as a control test. Second, the method should yield essentially the same density, or voids ratio, as that obtained in the finished pavement. Since the life of the pavement must be taken into account, and realizing that density increases to a maximum with time and traffic, the desired density to be obtained with any molding procedure should approximate that of the pavement after some time in the road. This final pavement density is referred to as ultimate density and is the goal of any compaction method. The aggregate will breakdown under field compaction methods, thus, a third requirement of the molding method was to approximate as nearly as possible, the aggregate degradation obtained under field conditions.

Numerous machines were constructed, tested in the laboratory, and rejected for various reasons. The Gyratory Molding machine was the ninth such machine to be investigated and has since been incorporated in a standard procedure by the Texas Highway Department."

(It is interesting to note that some 50 years and millions of dollars later, we have selected the use of gyratory-shear method of compaction for HMA specimens in Superpave mix design.)

2. **N.W McLeod, "Presidential Address at the Annual Business Meeting."**

(Dr. McLeod mentioned the following about the state of HMA technology at that time.)

"In papers published in 1926 and 1933, Westergaard provided a rational method of design for rigid pavements, which has since been very widely accepted. Thus far, however, a similar job with similar general acceptance has not been possible with flexible pavements, and our approach to their design remains today almost as empirical as it was at the time of the first meeting of the A.A.P.T. in 1924."

(We are <u>now</u> getting ready to implement a rational, mechanistic method of designing flexible pavements through AASHTO 2002 Pavement Design Guide.)

"All the common currently used stability tests, Hubbard-Field, Hveem Stabilometer, and Marshall, have been devised since 1924, together with the triaxial test which holds considerable promise of making a rational method of design for bituminous pavements possible for the first time."

(It is unfortunate that the triaxial test was not pursued vigorously during the last 50 years; we continued to use Marshall or Hveem test.)

"Some of the newer problems that have arisen in the field of flexible pavements are the influence of faster, denser, and heavier traffic on roads and streets, the

(continued on page 10)

NATIONAL TRANSPORTATION SYMPOSIUM

The National Center for Asphalt Technology invites you to attend and participate in a National Transportation Symposium to be held on November 13 and 14, 2002 at Auburn University Hotel and Dixon Conference Center. This two-day symposium will feature research results from the first loading cycle at the 1.7-mile NCAT Test Track—the most advanced and comprehensive facility of its kind in the world. Please call Carol Tapley at (334) 844-6228 or email <ctapley@eng.auburn.edu> for details.

PERFORMANCE TESTING FOR HOT MIX ASPHALT

Background

The Superpave Mixture Design and Analysis System was developed in the early 1990s under the Strategic Highway Research Program (SHRP). The Superpave design method for Hot-Mix Asphalt (HMA) mixtures was intended to have four parts: (1) materials selection, (2) aggregate blending, (3) volumetric analysis on specimens compacted using the Superpave Gyratory Compactor (SGC), and (4) analysis of the selected mixture properties to determine its performance potential. However, the fourth part is not yet available for adoption. Most highway agencies in the United States have now adopted the Superpave volumetric mixture design method but there is no strength test to complement the mix volumetrics. The traditional Marshall and Hveem mixture design methods had associated strength tests. Even though the Marshall and Hveem stability tests were empirical they did provide some measure of the mix quality.

Research from WesTrack, NCHRP 9-7 (Field Procedures and Equipment to Implement SHRP Asphalt Specifications), and other experimental construction projects have shown that controlling volumetric properties alone is not sufficient to ensure reliable mixture performance over a wide range of materials, traffic, and climatic conditions. There is much work going on to develop a strength test (for example NCHRP 9-19), however, one has not been finalized for adoption at the present time and it will likely be several months to years before one is recommended nationally. Considering that approximately 2 million tons of HMA is placed in the U.S. during a typical construction day, contractors and state agencies must have some means as soon as practical to better evaluate performance potential of HMA. These test methods do not have to be perfect but they should be available in the immediate future for assuring good mix performance.

Asphalt Pavement Analyzer

There are five areas of distress for which guidance is needed: fatigue cracking, rutting, thermal cracking, friction, and moisture susceptibility. All of these distresses can result in loss of performance but rutting is the one distress that is most likely to be a sudden failure as a result of unsatisfactory hot mix asphalt. Other distresses are typically long term failures that show up after a few years of traffic.

Due to the immediate need for some method to evaluate performance potential, the NCAT Board of Directors requested that NCAT provide guidance that could improve mixture analysis procedures. It is anticipated that this guidance can be adopted until something better is developed in the future through projects such as NCHRP 9-19 and others. However, partly as a result of warranty work, the best technology presently available needs to be identified and adopted.

Objective

The purpose of this NCAT project was to evaluate available information on permanent deformation, fatigue cracking, low-temperature cracking, moisture susceptibility, and friction properties, and as appropriate recommend performance test(s) that can be adopted immediately by the industry to ensure improved HMA performance. Emphasis was placed on permanent deformation (rutting).

Test Methods Evaluated for Determining Rutting Potential

The test methods that were evaluated in this study can be classified as one of the following six types of tests.

1. **Diametral tests.** These include diametral static creep, diametral repeated load, diametral dynamic modulus, and diametral strength tests.
2. **Uniaxial tests.** These include uniaxial static creep, uniaxial repeated load, uniaxial dynamic modulus, and uniaxial strength tests.
3. **Triaxial tests.** These include triaxial static creep, triaxial repeated load, triaxial dynamic modulus, and triaxial strength tests.
4. **Shear tests.** These include Superpave Shear Tester (SST), frequency sweep, and repeated shear at constant height tests.
5. **Empirical tests.** These include Marshall, Hveem, Gyratory Testing Maching (GTM), and lateral pressure indicator mounted on SGC mold.
6. **Simulative tests.** These primarily include loaded wheel tracking tests such as Asphalt Pavement Analyzer (APA), Hamburg Wheel-Tracking Device (HWTD), French Rutting Tester (FRT), PURWheel, and Model Mobile Load Simulator.

Hamburg wheel tracking device

Each test method was evaluated in terms of advantages and disadvantages. The following considerations were made in selecting simple performance test(s):

1. Test should be adaptable to Superpave gyratory compactor (SGC) compacted cylindrical specimens so that it can complement the Superpave volumetric mix design and can also be used for QC/QA during mix production in the field.
2. Test should not be so complex to require a very highly skilled technician.
3. Test results should be preferably available on the same day the SGC specimens are compacted. This is especially necessary for QC/QA.
4. The testing equipment should be commerically available and should be relatively inexpensive.
5. A widely used test protocol and test criteria (based on some data correlating the test results to field performance) should be available. A vast majority of tests in the first four types of tests did not satisfy this consideration.

Recommendations

Tests that appear ready for immediate adoption include the following three wheel tracking tests: Asphalt Pavement Analyzer (APA), Hamburg Wheel-Tracking Device (HWTD), and French Rutting Tester (FRT). Several factors were used to select these tests: availability of equipment, cost, test time, applicability for QC/QA, performance data, criteria, and ease of use.

These three wheel tracking tests appear to provide reasonable results and do have some data correlating with performance. Although the wheel tracking tests are not mechanistic they do seem to simulate what happens in the field. Mechanistic tests are being studied by others (NCHRP 9-19) and may be available for adoption in the near future. It is also interesting to point out that most tests that have been evaluated for their ability to predict performance have actually been compared to one of these wheel-tracking devices since they do simulate rutting in the laboratory. Based on all available information it is recommended that the APA, HWTD, and FRT be considered for use in mix design and QC/QA. Sufficient data is available to set criteria which is provided in the table below.

The tests are listed in order of priority for recommended use. It is believed that the FRT is no longer available in the U.S. The information shown in the table is based on limited field results and specific methods of conducting the tests in the laboratory. Any change in test method will likely result in a needed change in criteria. These recommended criteria are developed in general for higher traffic so they are not necessarily applicable for lower traffic areas.

Before adopting the criteria, tests should be conducted with local materials and mixes to develop an understanding of what type of results to expect. The criteria provided are reasonable based on past test results for specific mixes that have been evaluated in the past but may need to be modified slightly based on local experience. There is more experience with wheel tracking tests than with any other type of test to predict rutting. Other tests such as creep and repeated load tests have promise but more work is needed to finalize details before this type of test is utilized for mix control (research is underway to do this).

One recommended approach is to use the APA with cylinders compacted in the Superpave Gyratory Compactor. Samples compacted for volumetric testing could be tested thus minimizing number of samples required. This will allow QC/QA tests to be quickly conducted without requiring additional compacted specimens. Related information such as test protocols on these recommended performance tests for permanent deformation is provided in NCAT Reports 01-05A and 01-05B, which can be downloaded free from the NCAT web site, <http://www.eng.auburn.edu/center/ncat/>; click on Research Reports.

Table: Recommended Tests and Criteria for Permanent Deformation

Performance Tests		Recommended Criteria		Test Temperatures
1st choice	Asphalt Pavement Analyzer (APA)	8 mm	@ 8,000 wheel load cycles	high temperature for selecting PG grade
2nd choice	Hamburg Wheel-Tracking Device (HWTD)	10 mm	@ 20,000 wheel passes	50°C
3rd choice	French Rutting Tester (FRT)	10 mm	@ 30,000 wheel load cycles	60°C

PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of the Transportation Research Board (TRB) held in Washington, D.C. in January. We are reporting observations and conclusions from them which may be of value to field engineers. These comments are obtained mostly from research projects with a limited scope; before application to practice we recommend that you read the entire paper to determine its limitations. Titles of the papers are given, with names of authors in parentheses, followed by a brief summary.

1. EVALUATION OF EIGHT LONGITUDINAL JOINT CONSTRUCTION TECHNIQUES FOR ASPHALT PAVEMENTS IN PENNSYLVANIA (Kandhal, Ramirez, and Ingram)

The National Center for Asphalt Technology (NCAT) initiated a national study of evaluating various longitudinal joint construction techniques in 1992 in an effort to select technique(s) which improve the performance of longitudinal joints. Test sections were constructed in Michigan, Wisconsin, Colorado, Pennsylvania, and New Jersey. This paper gives the 6-year performance evaluation of eight different techniques utilized on a paving project in Pennsylvania in 1995.

The following is a brief description of the eight techniques used:

1. Joint Maker

The joint maker consisted of a boot-like device about 75 mm wide which is attached to the side of the screed at the corner during construction. The device forces extra material at the joint through an extrusion process prior to the screed.

2. Rolling From Hot Side

In this test section, compaction at the joint was done from the hot side of the lane being constructed wherein a major portion of the roller wheel remained on the hot side with about 152 mm (6 inches) overlap on the cold lane .

3. Rolling From Cold Side

Rolling in the first pass was done in the static mode with a major portion of the roller wheel on the cold side with about 152 mm (6 inches) of the roller wheel on the hot side of the joint.

4. Rolling From Hot Side 152 mm (6 inch) Away From Joint

Compaction in this method was started with the edge of the roller about 152 mm (6 inches) from the joint on the hot side during the first pass in vibratory mode. The lateral pushing of the material toward the joint during the first pass of the roller is believed to crowd the mix and produce a high density at the joint. The second pass was made in a vibratory mode with the roller overlapping the cold side by about 152 mm (6 inches).

5. Cutting Wheel

The cutting wheel technique involves cutting 25-50 mm (1-2 inches) of the unconfined, low density edge of the initial lane after compaction, while the mix is still plastic. A 250 mm (10 inch) diameter cutting wheel mounted on an intermediate roller or a motor grader is generally used for the purpose. A roller with a cutting wheel attachment was used on this project.

6. Edge Restraining Device

The restrained edge compaction technique utilizes an edge-compacting device which provides restraint at the edge of the first lane constructed. The restraining device consists of a hydraulically powered wheel which rolls alongside the compactors drum, simultaneously pinching the unconfined edge of the first lane towards the drum providing lateral resistance.

7. Rubberized Asphalt Tack Coat

The unconfined edge of the first paved lane adjacent to the joint was formed normally by the paver screed in this experimental section. A rubberized asphalt tack coat (Crafco pavement joint adhesive Part Number 34524) was applied on the face of the unconfined edge of the first paved lane. The thickness of the tack coat was about 3 mm (1/8 inch).

8. New Jersey Wedge (3:1)

In this technique a wedge joint consisting of a 3:1 taper was formed during the construction of the cold side by using a sloping steel plate attached to the inside corner of the paver screed extension. While placing the adjacent lane in the afternoon, an infrared heater was used to heat the edge of the previously placed layer to a surface temperature of about 93°C (200°F).

Visual evaluations of the joints have been conducted annually since the construction of the project in September 1995. The last visual inspection was made by a team of four evaluators on July 2, 2001 about six years after construction. The overall rating considered the percent length of the joint which developed cracking, the average width of the crack, and the percent length and severity of raveling observed in the cold mat just adjacent to the joint usually because of inadequate density. The development and severity of crack at the joint was considered very important in overall rating.

The following conclusions were drawn and recommendations made based on this study in

Pennsylvania and relevant NCAT experience in Michigan, Wisconsin, and Colorado.

- Longitudinal joint constructed using rubberized joint material gave the best performance with no significant cracking, closely followed by the joint made with cutting wheel.
- Test sections using rolling from hot side about 152 mm (6 inches) away from the joint and the New Jersey wedge also performed reasonably well with no significant cracking.
- Remaining test sections using edge restraining device, joint maker, rolling from hot side, and rolling from cold side developed cracking at the longitudinal joint to a different extent.
- It is recommended to use rubberized joint material (Crafco pavement joint adhesive 34524 or equal) or notched wedge joint to obtain consistent performance of longitudinal joint.
- Rolling of the longitudinal joint should be conducted from hot side, preferably 152 mm (6 inches) away from the joint.
- It is recommended to specify minimum compaction level at the longitudinal joint (generally two percent lower than that specified for the mat away from the joint). Compaction levels at the joint need to be determined by taking cores. It is not possible to use nuclear density gauge because of a seating problem on the joint.

2. EVALUATION OF MEASUREMENT TECHNIQUES FOR ASPHALT PAVEMENT DENSITY AND PERMEABILITY (Prowell and Dudley)

The purpose of this project was to evaluate the Pavement Quality Indicator (PQI) device, the Corelok device, and laboratory and field permeability index devices for their potential to improve the Virginia DOT's density specification. Since the Virginia DOT uses nuclear density gauges for acceptance, pavement density was also measured using the nuclear gauge.

All devices were used on six projects representing three nominal maximum aggregate sizes (NMAS) ranging from 9.5 to 19.0 mm. On each project, 60 sites were chosen for density testing with the nuclear gauge and PQI. Field permeability measurements were made and cores were taken at 15 of the 60 nuclear gauge sites. Cores were tested for density using conventional AASHTO T166 which uses saturated surface dry specimens and also by the Corelok device. A laboratory permeameter was then used to measure the permeability of core samples.

The following is a brief description of the different test devices used in this study. A single Troxler model 4640-B thin lift gauge was used for all testing. The PQI is a non-nuclear device which uses an electrical sensing field to measure the pavement density. A single PQI Model 300 was used for all testing. The Corelok device was designed to aid in the density determination of asphalt cores or specimens with water absorption greater than two percent. The device vacuum seals the specimen in a plastic bag so that its bulk volume can be determined. The NCAT field permeameter, which consists of a three-tier standpipe, was used to measure the permeability of the mat in the field. The laboratory permeability was measured using a flexible wall permeameter in accordance with ASTM provisional test method PS 129-01.

The following conclusions were drawn from this study:

- Nuclear gauge densities correlate well with core densities measured in accordance with AASHTO T 166 and the Corelok device. The premise of using a simple offset to calibrate the nuclear gauge to core densities as measured in accordance with AASHTO appears valid.
- PQI readings appear to be repeatable. However, in this study, they generally yielded poor correlations with densities measured in accordance with AASHTO T 166 and the Corelok.
- Both laboratory and field permeabilities correlate with pavement density.
- A good correlation was found between laboratory and field permeabilities. The relationship appears to be linear in the range agencies typically specify.

3. COARSE VERSUS FINE-GRADED SUPERPAVE MIXTURES: COMPARATIVE EVALUATION OF RESISTANCE TO RUTTING (Kandhal and Cooley)

The aggregate gradation used in Superpave hot mix asphalt mix design is required to be within control points at 0.075 mm (No. 200), 2.36 mm (No. 8), and nominal maximum aggregate size. Both coarse- and fine-graded mixtures can be designed within these control points. A majority of states accept both coarse- and fine-graded Superpave mixtures if the Superpave volumetric properties such as voids in the mineral aggregate (VMA) and voids filled with asphalt (VFA) are met. However, some states have begun to specify only fine-graded Superpave mixtures whereas others specify only coarse-graded Superpave mixtures. The states which specify coarse-graded mixtures (defined generally as those mixtures with gradation below the restricted zone) believe the coarse gradation provides a "strong aggregate structure." This belief is not

(continued on page 10)

—Putting Research Into Practice

(continued from page 9)

essentially based on any significant mix strength test data. After some coarse-graded Superpave mixtures exhibited premature and excessive rutting (more than the fine-graded mixtures) on WesTrack and exhibited excessive in-situ permeability in many other states, some states have started to specify only fine-graded mixtures (defined generally as those mixtures with gradation above the restricted zone).

Obviously, the question arises as to which specification is justified. Based on the recommendations from the just-completed NCHRP Project 9-14, "Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification," the restricted zone has been deleted entirely from Superpave. Ironically, that would require a new definition for coarse- and fine-graded mixtures in case some states continue to specify one over the other.

This study was conducted to compare coarse-graded Superpave mixtures with fine-graded Superpave mixtures in terms of resistance to rutting so as to determine whether restrictions on gradation type (either coarse- or fine-graded mixtures) are justified.

Fourteen mixtures comprising two nominal maximum aggregate sizes: 9.5 and 19.0 mm; two coarse aggregates: granite and crushed gravel; and four fine aggregates: sandstone, limestone, granite, and diabase, were tested. A PG 64-22 asphalt binder which is one of the most commonly used grades in the U.S. was used in all mixtures. Eight 9.5 mm NMAS mixtures were designed with N_{design}=100 gyrations and six 19.0 mm NMAS mixtures were designed with N_{design} of 75 and 100 gyrations. Both coarse and fine gradations were used for each specific blend of coarse and fine aggregates. Resistance to rutting of both coarse- and fine-graded mixtures was evaluated using three test methods: Asphalt Pavement Analyzer, Superpave shear tester, and repeated load confined creep test.

Statistical analyses of the test data obtained by the three performance tests indicate no significant difference between the rutting resistance of coarse- and fine-graded Superpave mixtures. It has been recommended that mix designs should not be limited to designing mixes on the coarse or fine side of the restricted zone. Regardless of the gradation types, some type of rutting torture test should be used to verify the rut resistance of the mixture.

DOWNLOAD NCAT RESEARCH REPORTS AT NO COST

Over 70 NCAT research reports are now available as PDF (portable document format) files which can be easily downloaded at no cost from our web site. You will need the Adobe Acrobat Reader, which can also be downloaded free from our homepage, to open these files. Visit our web site at http://**www.eng.auburn .edu/ center/ncat** and click on **NCAT Publications.** Previous editions of **Asphalt Technology News** are also available from our homepage.

JOIN US

We at NCAT hope you enjoy this issue of Asphalt Technology News. It is provided free of charge. If you wish to be added to our mailing list, please send your business card or your name and mailing address to:

Prithvi (Ken) Kandhal
Associate Director Emeritus, NCAT
277 Technology Parkway
Auburn, AL 36830

—Hot Mix Asphalt Technology

(continued from page 5)

ever-increasing proportion of heavily loaded trucks and buses, the higher tire pressures of jet aircraft, which already approach several hundred pounds per square inch, spillage of jet aircraft fuels, blast from jet engines, and the use of asphalt paving mixtures for hydraulic and other miscellaneous engineering works. In addition, the possible influence on flexible pavement design in all its phases, of the design of the tires that transmit the loads from vehicles to road or ground surfaces, has received scant attention."

(So what's new!)

Editor - These 50-year old Proceedings of AAPT also contain a symposium on New Jersey Turnpike which had three papers titled: (a) Planning the New Jersey Turnpike, (b) Asphaltic Pavement on the New Jersey Turnpike, and (c) Spreading, Rolling, and Control of Surface Tolerances in Asphaltic Concrete Construction. These papers were prepared by engineers affiliated with the New Jersey Turnpike Authority, which was responsible for the construction of this 118-mile long multilane highway from New York to Delaware. According to the second paper, "the use of Asphalt Concrete was approved after the bids were received, on an alternate bid basis, due to the advantage of low bidder, and arrangements were made by the New Jersey Turnpike Authority to construct the asphaltic concrete pavement giving the highest type construction and design with as many local materials incorporated in the mix as possible."

These three papers make an interesting read, especially after the Asphalt Pavement Alliance gave the first "perpetual" pavement award to the New Jersey Turnpike just last year.

ASPHALT FORUM

NCAT invites your comments and questions. Questions and responses are published in each issue of ***Asphalt Technology News****. Some are edited for consistency and space limitations.*

Iowa (Michael Heitzman, Iowa DOT)

In the Fall 2001 issue, New York noted that they are developing a Superpave mix design for low volume roads. Iowa is also implementing Superpave mix design for low volume roads, but took a different approach. In Iowa, over 100 Local Agency Marshall mixtures were compacted with the Superpave gyratory compactor in an effort to develop Superpave criteria that reflect the acceptable HMA mixtures already being used. Iowa is targeting year 2004 for statewide local agency implementation of Superpave mix design.

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

Has any state purchased the new FHWA device for measuring the internal angle of gyratory compactors? If so, how is it being implemented? What are the preliminary results?

For relatively new coarse-graded HMA pavements placed on extremely steep grades, has any state experienced excessive permeability, even to the degree that water seeps from the pavement down the grade for several days after the last substantial precipitation? If this concern exists, is it worse for treatments involving new HMA base and surface versus just an overlay? What corrective actions have been attempted?

Do any states perform Superpave aggregate consensus-property testing on field materials at the asphalt mixing plant? If so, what requirements are applied? The same values as in the laboratory mix design? How is the aggregate sample obtained (stockpile, extraction, ignition oven, etc.)?

New York (Zoeb Zavery, New York DOT)

Some HMA producers would like to use 100 mm diameter samples to monitor their production of surface course mixes. They believe it takes too long to cool the 150 mm diameter samples and it hinders their ability to control the process during production. Does any state allow the use of 100 mm samples for surface courses to monitor production?

Engineers from DOTs participating in the NCAT pooled fund study on New Generation Open-Graded Friction Courses met at NCAT last October

ASPHALT FORUM RESPONSES

The following responses have been received to questions raised in the Fall 2001 ***Asphalt Forum.***

Is anyone having problems with "delayed setting" of HMA mixes? We use a PG 64-28 binder in our HMA mixes and have experienced some sporadic instances of mixes remaining soft and pliable for a day or more. This goes beyond the standard "tender mix" issues such as moisture in the mix and hump in the gradation. **(Keith Lane, Connecticut DOT)**

Arizona (Julie Nodes, Arizona DOT)

Arizona has experienced "delayed setting" of HMA mixes on a couple of projects using PG 64-28 binder. In every case, the mix did eventually "set up" and has been performing well. The only solution to this problem we have found is time, but since we use very little of this binder grade we haven't had much opportunity to work on the problem.

Idaho (Bob Smith, Idaho DOT)

We have also experienced delayed setting of some mixtures containing both PG 64-28 and 70-28 binders. Some have remained soft for up to three days. One explanation offered by contacts during the TRB meeting was moisture. We allow up to one percent moisture content at laydown, but to our knowledge we have not measured any that high. Some people believe the polymer might be the culprit. However, the delayed setting is not consistent with supplier or grade.

We performed a very informal lab study to look at the indirect tensile strengths of HMA after curing times of 24, 48, and in some cases, 96 hours. The same aggregate and gradation was used in all test specimens. Since we were looking at relative results, the binder content was held constant at 5.5 percent (typical for that aggregate source). Specimens were fabricated using the kneading compactor and cured at room temperature. Indirect tensile tests were performed at 77°F and 125°F after 24 hours curing. Tests at 48 hours and 96 hours were conducted at 125°F. Polymer modified PG 64-28 and 70-28 asphalts appeared to lose strength from 24 to 48 hours and begin to gain it back at 96 hours. In most cases the 96-hour strengths had not returned to the 24-hour values. Non-modified asphalts (PG 58-28) appeared to gain strength from 24 to 48 hours.

This delayed set is causing some concern. We had one contractor's consultant request to finish compacting (with vibratory roller) three days after laydown (obviously denied).

Iowa (Michael Heitzman, Iowa DOT)

Iowa has also had a few projects with "delayed setting" problem. In general, we found that mixtures with "delayed setting" do not have sufficient mineral filler in the mix. All the problem mixes used a PG 58-28 binder, however, not all projects with PG 58-28 binder exhibited this "delayed setting" symptom.

Louisiana (Philip Graves, Louisiana DOT)

Louisiana has experienced similar problems with mixtures using AC-30 binders. We do not attribute the problem as much to binder as to internal moisture in the aggregate. However, we have not seen this problem as much since our switch to polymer modified asphalts, PG 76-22m and PG 70-22m; but it has been reported.

New York (Zoeb Zavery, New York DOT)

It could be related to the process of producing the asphalt binder. New York has experienced similar problems on two projects. A PG 58-34 binder was used on one job and PG 58-28 was used on the other job. In both cases, it was determined that the PG binders were oxidized (air blown) asphalts. The 12.5-mm surface course mixture was pliable for several days. These projects are holding up well to date.

Texas (Dale Rand, Texas DOT)

We have observed "delayed setting" on 2 or 3 projects. Excessive moisture in the stockpiles (especially RAP stockpiles) is the primary suspected cause in our opinion.

Ontario, Canada (Kai Tam, Ontario Ministry of Transportation)

In northern regions of Ontario, PG 52-34 binders are used. In some cases, a tendency for the mix to "scuff" under truck traffic within a few hours of rolling has been reported.

Don Manchester (Nielsons Skanska, Inc.)

On one of our projects in Colorado last year we experienced very similar complaints that the HMA was not setting-up. We analyzed all the usual factors that would cause a "tender" mix. All HMA samples met the required Superpave criteria. Binder samples were sent to five separate asphalt labs. All of the samples met the Superpave PG binder requirements. We used a PG 58-34 binder that was manufactured by blending two different crude source materials. During our research, we performed a new mix design using an unblended asphalt (PG 58-34) from the same supplier. This binder material was from one of the two crude sources that made up the blend. No other elements were changed. Plant produced material exhibited little or no tenderness.

Additional samples of the PG binder have been sent in for further testing at a sixth lab. The lab is looking at long term aging to determine if the blended binder has similar properties to each of the two component binders.

In the Superpave binder specification, when bumping up the high temperature grade of the PG binder, we inadvertently bump up the test temperature of the dynamic shear rheometer when testing the pressure aging vessel (PAV) residue. What are the states doing about this? This will become crucial when dealing with the modified asphalt binders.

Is the elastic recovery test being used by any states for asphalt binders? Is this an appropriate test for evaluating the elasticity of modified binders, especially at lower temperatures? **(Francis Manning, Rhode Island DOT)**

Alabama (Randy Mountcastle, Alabama DOT)

To avoid bumping up the DSR test temperatures, we test the PAV residue at 25°C. This includes the PG grades 64-22, 67-22, and polymer modified 76-22.

Arizona (Julie Nodes, Arizona DOT)

Arizona has also noted the intermediate temperature bump that occurs when the high temperature is bumped, however, we are not doing anything about it except to limit the use of grade bumping. Arizona DOT uses very few PG graded modified binders. We do not use elastic recovery or any other PG type tests at this time (and have no plans to add them).

Connecticut (Keith Lane, Connecticut DOT)

We agree with Francis Manning of Rhode Island Department of Transportation. When we bump up the high temperature grade for rutting we sacrifice some of our fatigue cracking temperature value; if we bump up two grades we loose 6°C at the intermediate temperature. This resultant relaxation is of considerable concern to us where bumping due to high traffic levels results in less stringent requirements for fatigue resistance.

Kansas (Glen Fager, Kansas DOT)

Kansas requires all of the PG 64-28, 70-22, 70-28, 70-34, 76-22, and 76-28 to be polymer modified. The elastic recovery is also required and it is this test that most likely determines if the binder is indeed modified with polymers.

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

Kentucky is currently investigating the use of a single intermediate DSR test temperature to evaluate performance-graded (PG) binder samples. A temperature of 25°C was selected for our study because PG 64-22, the recommended binder for our climate, requires this temperature. Although our amount of data is currently limited, 98 percent of modified PG 76-22 binders and 87 percent of modified and/or unmodified PG 70-22 binders exhibit a $G^*\sin\delta$ of less than 5000 kPa at this temperature.

Kentucky uses elastic recovery for testing PG 76-22 binders. A recovery limit of 75 percent at 25°C ensures us that enough of an appropriate polymer modifier was added to the virgin asphalt. At lower temperatures a modified binder will exhibit a slower recovery, but its recovery is still significantly more than an unmodified binder.

Louisiana (Philip Graves, Louisiana DOT)

Louisiana has set a uniform intermediate test temperature of 25°C for all PG asphalts. This test temperature is equal to what is recommended for our region (PG 64-22). Therefore, our PG 76-22m requires $G^*\sin\delta$ to be 5000 kPa maximum at 25°C. We also require a force ductility ratio and elastic recovery. We are exploring NCHRP 9-10 and FHWA recommendations on identifying modifiers.

Michigan (Mike Frankhouse, Michigan DOT)

The Michigan DOT uses elastic recovery test conducted at 25°C to identify the presence of polymers.

New York (Zoeb Zavery, New York DOT)

First of all, let us review the requirements for test temperature for DSR testing on PAV residue,

(continued on page 14)

NCAT Applications Steering Committee met at NCAT last December

which is a measure of fatigue resistance. The test temperature appears to be based on the average temperature of the PG + 4°C.

Examples:

PG 64-28
average temperature = (64+(-28))/2 = 18°C
test temperature = 18°C+4°C = 22°C

PG 70-28
average temperature = (70+(-28))/2 = 21°C
test temperature = 21°C+4°C = 25°C

For each high temperature grade bump, the test temperature is increased 3°C.

New York DOT is not concerned about the increased dynamic shear rheometer (DSR) test temperature on pressure aging vessel (PAV) residue. Most of our PG binder results for DSR testing on PAV residue are well below the 5000 kPa maximum. DSR tests on PAV residue at a temperature 3°C lower would typically still meet the specification requirement. Additionally, the majority of our paving in a given year consists of single and two course overlays. Our experience has been that the distress in the existing pavement is a bigger factor in the performance of the overlay than the stiffness of the PG binder.

We pose the following questions: Will high traffic volume increase the average pavement temperature? Why is the test temp (average PG temp + 4°C)?

Texas (Dale Rand, Texas DOT)

Texas DOT will include an elastic recovery requirement for PG binders in 2003 Standard Specifications.

Wisconsin (Tom Brokaw, Wisconsin DOT)

Concerning the grade bumping, we have decided to use the current specification "as is" until a research project currently underway at University of Wisconsin (Madison) to look into the PG grading issues, is completed.

We do not utilize elastic recovery in Wisconsin. On a few selected projects we have used a PG+ specification which requires a maximum phase angle to ensure use of modifiers.

Ontario (Kai Tam, Ontario Ministry of Transportation)

Ontario does not use elastic recovery test. A new test based on fracture toughness and Young's Modulus is being developed to better quantify binder low temperature performance.

RESEARCH IN PROGRESS

We have discontinued the publication of this column in this newsletter because it can now be accessed on NCAT's homepage (http://www.eng.auburn.edu/center/ncat). Click on "Information" at the top of the page, then "Research in Progress." It is updated frequently based on the information received from the Departments of Transportation and other sources.

SPECIFICATION CORNER

Alabama - Alabama has adopted NCAT's recommended gradation for the OGFC specification. Cationic slow set emulsions are no longer allowed to be used for tack coat during the winter or night time paving operations. The gradation for upper binder course and wearing course HMA must be selected above or through the restricted zone (to lower permeability).

Hawaii - PG 64-16 binder has been specified for all projects since January 2001. Superpave specifications are currently being used on about 10 percent of the paving projects. Smoothness requirements along with incentives have been incorporated in the specifications for improving pavement smoothness.

Idaho - Idaho's first Superpave project will be constructed in 2002. Contractor quality control was added to the specifications two years ago, which also includes contractor-furnished HMA mix design. The Materials Section confirms the mix designs to ensure compliance with the specified tolerances. The results have been mixed because there is little impetus to optimize the mix designs, resulting in an increase of marginal mix designs.

Kentucky - Kentucky is presently considering a number of specification issues in preparation for a new specifications book in 2003. These issues include:

(1) clarifying the specification regarding the acceptance of HMA with poor volumetric properties at a reduced pay factor versus removing and replacing the material;

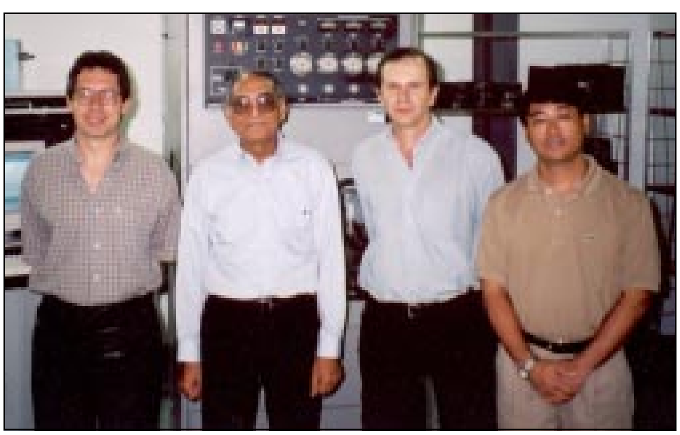
(2) refining and "tweaking" the HMA acceptance program, specifically the Department's verification tolerances for the contractor's HMA acceptance tests;

(3) implementing a laboratory rut-depth specification using the Asphalt Pavement Analyzer;

(4) evaluating the RAP specifications to determine if the existing "tiers" of RAP usage are appropriate and if a need exists to drop both the high and low-temperature grade of the PG binder when RAP is used;

(5) implementing a sampling frequency and acceptance payment schedule for density cores obtained at, or very near, the longitudinal joint in asphalt pavements; and

(6) evaluating the feasibility of incorporating AASHTO MP1a and the Direct-Tension Tester into the PG binder specifications.



Brazilian engineers visited NCAT last fall (left to right: Romulo Constantino; Prithvi Kandhal, NCAT; Ilonir Tonial; and Ademar Horiuchi)

Louisiana - The following revisions have been made to HMA specifications: (1) Permeability requirements have been added with the permeability not to exceed 125×10^{-4} cm/sec when tested in accordance with ASTM PS 129-01; (2) Acceptance limit for VMA of plant produced mixtures has been reduced by 0.5% from Superpave mix design limits; and (3) 15 percent RAP will be allowed in wearing course (none is allowed at present).

New York - The 2002 Standard Specifications now include the Superpave design system for all HMA mixtures. The Standard Specifications will be effective for all New York DOT projects let on or after July 11, 2002.

Texas - The proposed 2003 hot mix specifications will have more stringent construction requirements to address problems with segregation, joint density, debonding, etc. A new ride quality specification based on inertial profiler has been adopted.

Ontario, Canada - Ontario is updating the Provincial Standard Specification on materials and construction for hot mix with an objective to improve the consistency between municipal and provincial specifications/ practices. The special provision for compaction at the longitudinal joint has been drafted for review. For smoothness, it is proposed that day and night paving will be combined into a single specification. The type and amount of repairs by diamond grinding or shave and pave has been restricted. A draft end-result specification for acceptance of surface course thickness using a nondestructive method been developed and is under review.

ASPHALT 100% RECYCLABLE

NCAT's Asphalt Technology Course,
February 4-8, 2002

Front Row, L-R: Jeremy Hughes, Scott White, Jimmy Donnici, Bob Rothwell, Andra Gentry, Wally Hendricks, Ed Ladd, Pierce Flanigan
Second Row, L-R: Ramona Dammerman, Trace Curd, Brian McReynolds, Randall Armstrong, Todd Just, Ryan Begue, John Rocchio, Kurt Grabow, Ted McAnany
Back Row, L-R: Doug Hanson, Pat Hill, Rich Katzer, David Faughn, Rob Nation, Todd Kirk, Alan Orvin, Greg Wilkinson, Mike Huner
Not Pictured: John O'Donnell

National Center for Asphalt Technology
NCAT
AUBURN UNIVERSITY
277 Technology Parkway
Auburn, AL 36830

Presorted
Standard
Non-Profit Organization
Auburn University, AL 36849
PERMIT NO. 9