

ASPHALT TECHNOLOGY NEWS

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DEDICATION OF NCAT'S NEW BUILDING AND TEST TRACK FACILITIES

October 23 was a historic day for the National Center for Asphalt Technology (NCAT) when the dedication ceremonies for the new offices, laboratories, and test track facilities took place. Over 550 people from all over the United States were in attendance. The dedication ceremony was presided over by Mac Badgett, chairman, NAPA Research and Education Foundation. Remarks were made by William Muse, president, Auburn University; Hon. Don Siegelman, governor, State of Alabama; Hon. Spencer Bachus and Bob Riley, U.S. House of Representatives; Hon. Jeff Sessions, U.S. Senate; Mike Mangum, chairman, National Asphalt Pavement Association; Paul Parks, provost emeritus, Auburn University;

Mack Roberts, transportation director, State of Alabama; Byron Lord, Federal Highway Administration; and James Samford Jr., president pro tempore, Auburn University Board of Trustees.

The dedication ceremonies surrounding the new offices, laboratories, and test track facilities represented the culmination of a vision that a group of hot mix asphalt industry leaders first discussed in the late 1970s and brought to Auburn University in the mid 1980s. It was then that the leadership of the National Asphalt Pavement Association (NAPA) raised \$10 million to provide an endowment to be used to sponsor research and outreach activities at the
(Continued on page 2)



NCAT's new facilities in Auburn Technology Park

In This Issue

Dedication of NCAT's New Building and Test Track Facilities



— Page 1

Loading of NCAT Test Track Begun



— Page 4

Asphalt Forum Responses

— Page 6

Asphalt Forum

— Page 9

Specification Corner

— Page 11

Putting Research Into Practice

— Page 12



*Visiting the NCAT Test Track
(L to R): Bob Thompson,
Ned Bechthold, John Spangler,
Mike Acott, Don Brock,
and Ben Brock*



—Dedication

(continued from page 1)
newly formed National Center for Asphalt Technology (NCAT).

In 1986 the NAPA Research and Education Foundation signed a cooperative agreement with Auburn University that set the stage for today's wide spectrum of NCAT activities, ranging from on-campus classroom seminars that "teach the teachers"—college-level faculty from throughout the nation—to state of the art testing of asphalt mixes at the center's 1.7-mile test track in neighboring Opelika.

Several individuals have had leadership roles in establishing and guiding NCAT since 1986; they include John Gray, past president, NAPA; Ron Kenyon, director emeritus, NCAT Board; Harry Ratrie, chairman, NCAT Board, 1986-1989; Bob Thompson, chairman, 1989-1991; Ned Bechthold, chairman, 1991-1994; Roger

Yarbrough, chairman, 1994-1996; Charlie Potts, chairman, 1996-1998; and Don Gallagher, chairman, 1998-present. There are many more individuals that have played key roles in establishing NCAT and providing direction to NCAT that are not mentioned here.

NCAT's Beginnings

The NCAT staff has grown from a group of four in 1987 to the 20 staff members that are currently involved with the center. Oversight is handled by a board of directors that consists of seven members from industry and six from the university, in addition to ex-officio members from the Transportation Research Board, American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration.

The first director of NCAT, Freddy Roberts, began work in October, 1986, and in 1987 Ray Brown was hired as assistant director. In 1988 Ken Kandhal was hired as assistant director, along with Doug Hanson in 1992; Bill Deyo filled out the final assistant director position in 1999.

Brown, who currently serves as NCAT director, was named to the position in 1990, following Roberts' decision to move to Louisiana. Brown, Kandhal, Hanson, and Deyo are joined by eight additional engineers and three technicians, as well as an office staff of five. There are also 15 part-time and temporary staff members, which include graduate students and cooperative education students.

NCAT began its operation with a budget of approximately \$500,000 annually; by 1990 that figure had grown to \$1 million per year, and by 1995 to \$1.5 million per year. The budget for fiscal year 2001 is

(continued on page 3)



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

—**Dedication** (continued from page 2)
 expected to be approximately \$3.5 million.

Development of Facilities

NCAT, which began its program at Auburn with a one-man office in the Harbert Engineering Center, has grown rapidly in an effort to fulfill its missions. Before its consolidation in the new offices in Auburn's Technology Park, it had facilities in three separate buildings.

By 1990, NCAT operations were carried out from five offices located in Ramsay Hall and 4,000 square feet of laboratory space in the Harbert Engineering Center. In 1993, NCAT was provided with two more offices in Ramsay Hall, as well as a conference room/library facility.

Fewer than five years later, the growth of the program dictated that four new offices be added, this time in Auburn Research Park because there was no additional room in Ramsay. And while 3,000 additional square feet of laboratory space was made available in Harbert, several storage facilities were being rented at locations in Auburn to handle NCAT's needs.

With the move to its new building at Auburn Technology Park, NCAT's facilities have finally been centralized, with adequate office space, teaching and research laboratories, storage and related facilities. The new center comprises 40,000 square feet and will allow room for growth in its programs.

The center, which is located three miles south of the Auburn campus, will serve as a national clearinghouse for teaching and research. Classes for NCAT's Professor

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.

Training Courses, which have already graduated more than 200 college-level faculty, will be held in the facility, as well as classes for working professionals and technicians. NCAT instructors teach more than 40 short courses annually.

NCAT's research component has already become widely respected among the nation's asphalt industry. Research has been conducted with a dozen state departments of transportation, the Federal Highway Administration, and the National Cooperative Highway Research Program. Probably the most well-known accomplishment by NCAT researchers has been the development of an environmentally-friendly asphalt content tester that has allowed the use of solvents to be greatly reduced or eliminated; this device is now used widely not only in the U.S., but also internationally. NCAT also developed the first-ever textbook on hot mix asphalt technology which is used in several universities.

Test Track Facilities

The most talked about component of the dedication ceremonies is already up and running—NCAT's 1.7-mile asphalt test track, which has been designed and built to predict the performance of roadway surfaces, and as a result increase cost savings, safety and comfort on asphalt highways.

Located about 15 miles east
 (continued on page 10)



James Samford Jr., president protempore, Auburn University Board of Trustees (second from left) presented a resolution to the representatives of the NAPA Education and Research Foundation (L to R: Tim Doctor, Mac Badgett, and Don Gallagher) in appreciation of their support to NCAT.

LOADING OF NCAT TEST TRACK BEGUN

The 1.7-mile oval NCAT Test Track was completed in August, and loading began during the third week of September. The track has 26 test sections (each 60 m long) on the tangents, sponsored by the Federal Highway Administration and nine states (Alabama, Florida, Georgia, Indiana, Mississippi, North Carolina, Oklahoma, South Carolina, and Tennessee). Additionally, 20 test sections are located on the curve as shown in the layout of the test sections in Figure 1. Test sections consist of 2 inches (50 mm) of binder course and 2 inches (50 mm) of wearing course. All test sections are underlaid with 24 inches (610 mm) of HMA base course and 4 inches (100 mm) of permeable asphalt base. Rutting is most likely to be the primary distress expected in some test sections. Because of the thick structure fatigue cracking is not expected to be a problem. The following are specific mix attributes whose performance will be compared on the test track:

- Coarse-graded, fine-graded, and through the restricted zone gradation of Superpave mixes
- Neat versus modified asphalt binder at optimum asphalt content as well as optimum plus 0.5 percent
- Stone matrix asphalt (SMA) versus Superpave mix using granite aggregate

- 12.5 mm versus 9.5 mm nominal maximum size Superpave designed mixes

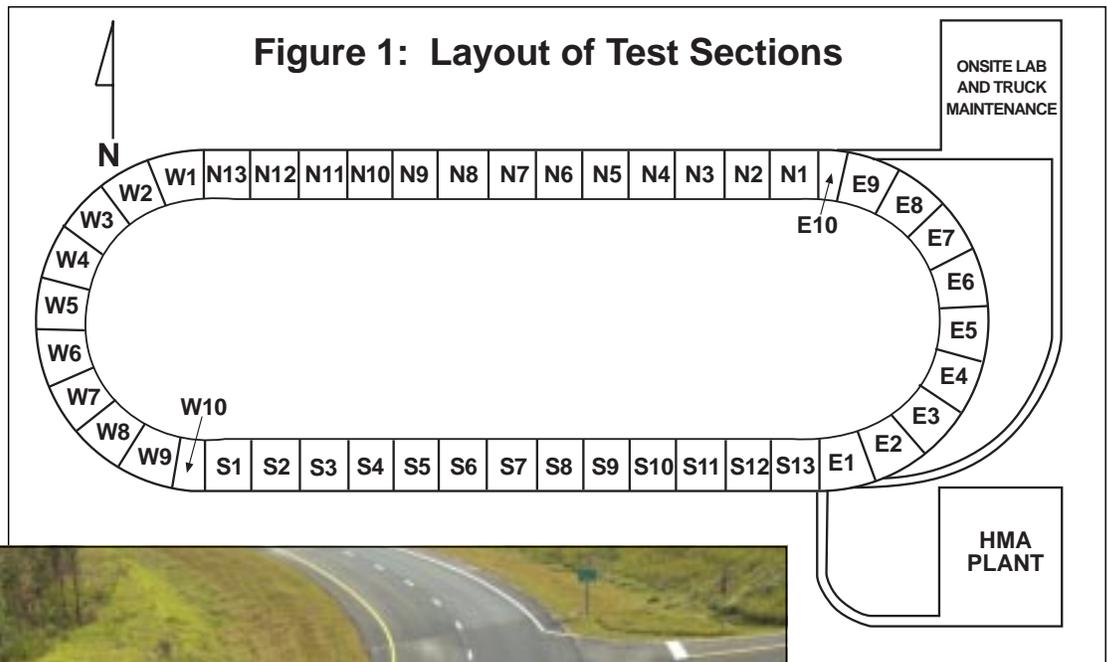
Table 1 gives the information on mix type, aggregate type, and binder type used in the 26 tangent sections.

The Test Track will be subjected to 10 million ESALs with four tractor/trailers over a period of two years. Each tractor will pull three fully loaded trailers. (*Editor: It should be noted that a total of about 5 million ESALs were applied to WesTrack in Nevada, although some test sections were taken out of service due to deep ruts after only 1.5 million ESALs. Additional test sections failed after 2.8 million ESALs.*)

The following test data will be available for all test sections:

- Static and repeated load creep (confined and unconfined)
- Gyrotory shear analysis (with Superpave gyrotory compactor)

(continued on page 14)



Loading of the NCAT Test Track began in September. Four tractor/trailers like the one shown here will be used to apply 10 million ESALs in two years.

Table 1: Details of NCAT Test Track Tangent Sections

Section	Mix Type	Aggregate Type	Binder Type*
N1	9.5 mm dense-graded ARZ	limestone/slag	SBS Modified PG 76-22
N2	9.5 mm dense-graded ARZ	limestone/slag	SBS Modified PG 76-22+
N3	9.5 mm dense-graded ARZ	limestone/slag	PG 67-22+
N4	9.5 mm dense-graded ARZ	limestone/slag	PG 67-22
N5	12.5 mm dense-graded BRZ	limestone/slag	PG 67-22+
N6	12.5 mm dense-graded BRZ	limestone/slag	PG 67-22
N7	12.5 mm dense-graded BRZ	limestone/slag	SBR Modified PG 76-22+
N8	12.5 mm dense-graded BRZ	limestone/slag	SBR Modified PG 76-22
N9	12.5 mm dense-graded BRZ	limestone/slag	SBS Modified PG 76-22
N10	12.5 mm dense-graded BRZ	limestone/slag	SBS Modified PG 76-22+
N11	12.5 mm dense-graded	granite	SBS Modified PG 76-22
N12	Stone matrix asphalt	granite	SBS Modified PG 76-22
N13	Stone matrix asphalt	gravel	SBS Modified PG 76-22
S1	12.5 mm dense-graded	granite (high LA)	SBS Modified PG 76-22
S2	9.5 mm dense-graded	chert gravel	SBS Modified PG 76-22
S3	9.5 mm dense-graded	limestone/gravel	SBS Modified PG 76-22
S4	12.5 mm dense-graded	quartz gravel	SBS Modified PG 76-22
S5	12.5 mm dense-graded	limestone	SBS Modified PG 76-22
S6	12.5 mm dense-graded ARZ	limestone/RAP	PG 67-22
S7	12.5 mm dense-graded BRZ	limestone/RAP	PG 67-22
S8	12.5 mm dense-graded	granite	SBS Modified PG 76-22
S9	12.5 mm dense-graded BRZ	granite	PG 67-22
S10	12.5 mm dense-graded ARZ	granite	PG 67-22
S11	9.5 mm dense-graded	granite	PG 67-22
S12	12.5 mm dense-graded (Hveem design)		limestone PG 70-28
S13	12.5 mm dense-graded ARZ	granite	PG 70-28

* Plus sign designates approx. 0.5% higher asphalt content than the optimum.

ARZ = above restricted zone gradation.

BRZ = below restricted zone gradation.

A SHORT COURSE IN ASPHALT TECHNOLOGY

This training course has been developed by NCAT for practicing engineers who are involved with hot mix asphalt (HMA). The purpose of this one-week intensive course, which will be held on February 12-16, 2001 and March 5-9, 2001, is to provide a general understanding of all phases of HMA technology. Upon completion, the participant will be able to make knowledgeable decisions related to HMA pavements and communicate effectively with asphalt specialists when the need arises. NCAT will accept applications

from practicing engineers from both private and public sectors in the United States and abroad. This includes personnel from the FHWA, state DOTs, FAA, Corps of Engineers, Air Force, Navy, county engineers, city engineers, consulting engineers, and contractors. Please call (334) 844-6241 or visit our web site at <<http://www.eng.auburn.edu/center/ncat>> (Click on "Education" at the top of the page, then click on "Upcoming Training Courses") for a brochure or information.

ASPHALT FORUM RESPONSES

The following responses have been received to questions raised in the Spring 2000 Asphalt Forum.

Have other states experienced problems with AASHTO T 283 "Resistance of Compacted Bituminous Mixture to Moisture Induced Damage?" What percent water saturation is used for the test specimen? Is freeze and thaw conditioning used? (Gale Page, Florida DOT)

Colorado (Tim Aschenbrener, Colorado DOT)

Our saturation levels are generally about 85-90 percent. These are at levels similar to Bob Lottman's when he developed the test. We use one freeze and thaw cycle. We require a minimum TSR (tensile strength ratio) of 0.80 during design and 0.70 during plant production. We also require 1 percent hydrated lime. We have not had a problem with failing test results. Field performance also indicates no evidence of moisture damage. In the rare cases that hydrated lime is not added to the HMA, the test results readily identify the situation.

Georgia (Lamar Caylor, Georgia DOT)

Georgia did not believe AASHTO T283 was severe enough and, therefore, did not switch to it when Superpave was implemented. A modified Lottman procedure is used that has been effective for determining moisture susceptibility of asphalt mixtures for 20 years. The method does not require a certain range of saturation, but requires a 30-minute vacuum saturation period. It also requires a freeze/thaw cycle as part of the conditioning process.

Kansas (Glenn Fager, Kansas DOT)

The Kansas DOT has adopted its own version of AASHTO T283. The specified level of saturation in T283 is too broad (55 to 80 percent). We limit the level of saturation from 55 to 65 percent. Also, the target air voids is still 7 percent, but the range has been reduced to 6.5 to 7.5 percent. The gyratory compactors in use today have no problem making the specimens to closer air void contents.

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

Kentucky presently uses ASTM D4867 as the moisture-susceptibility test. We adopted the ASTM version due to our dissatisfaction with the time required to perform AASHTO T283. We are not convinced that either test accurately corresponds to stripping in the field, but at present, we are not aware of a better alternative. We require a saturation level of 65 ± 5 percent and one freeze/thaw cycle.

Louisiana (Chris Abadie, Louisiana DOT)

The Louisiana DOT requires a saturation level of 55 to 75 percent and one freeze/thaw cycle.

Michigan (Mike Frankhouse, Michigan DOT)

The Michigan DOT has not had any problems with this test method and currently requires that samples be 55 to 80 percent saturated. However, we will be narrowing this range along with the air void content in the future to help improve testing consistency. We also use freeze and thaw conditioning of the samples.

Ohio (Dave Powers, Ohio DOT)

The Ohio DOT has used AASHTO T283 and has several concerns. It is not appropriate for 150 mm (6 in) diameter specimens. Saturation level, vacuum level, and time need to be better controlled. We have begun a research project to address this. We use freeze and thaw cycle.

Vermont (Timothy Pockette, Vermont Agency of Transportation)

Vermont has not experienced any problems with AASHTO T283 testing. The department requires that the saturation levels fall within the specified range of 55 to 80 percent. A freeze/thaw cycle is required.

Virginia (Bill Maupin, Virginia Transportation Research Council)

The Virginia DOT undertook a statewide coring several years ago to determine if stripping found in a previous small-scale study was widespread. Examination of the cores revealed visual evidence of significant stripping in many of the pavements. Distress, if present, was usually in the form of cracking. VDOT used AASHTO T283 without the freeze cycle for quality control and assurance during construction for those pavements but has added the freeze cycle since the survey. The percent saturation was 55-80 as specified by the test method. All mixes were supposed to be tested routinely during the design phase with the TSR test and reportedly achieved passing values of 0.75 (spec at that time). Our results leave some doubt about the effectiveness of T283 in predicting long-term stripping, but we have had cases when we know it has identified mixtures where antistripping additive was inadvertently left out. We are currently doing some research to try to determine how detrimental to performance is the degree of stripping that was observed.

(continued on page 7)



Mac Roberts, transportation director, Alabama DOT (right) receiving a resolution from James Samford Jr., Auburn University Board of Trustees (center) in appreciation of Alabama DOT's support of NCAT Test Track. They are joined by Hon. Don Siegelman, governor, State of Alabama (left).

The Kentucky DOT currently specifies a 9.5 mm ($\frac{3}{8}$ in) nominal surface mixture for highways corresponding to the first two gyrations ($N_{design} = 50$ and 75) and a 12.5 mm ($\frac{1}{2}$ in) nominal surface mix for the last two levels ($N_{design} = 100$ and 125). Do any other states have evidence or an opinion that the larger size of surface mix will provide greater rut resistance? What about higher levels of permeability?

The Kentucky DOT observes the recommendation of the Superpave Mixture Expert Task Group concerning the use of reclaimed asphalt pavement (RAP). This policy allows a reduction in the PG grade of the virgin binder (e.g., PG 76-22 reduced to PG 70-22) for higher levels of RAP usage. Do any other states observe this recommendation, and if so, do any concerns exist? In other words, is a virgin mixture containing PG 76-22 binder equivalent to a mixture containing 16 percent RAP and PG 70-22 binder? (Allen Myers, Kentucky Department of Highways)

Florida (Gale Page, Florida DOT)

Limited testing with the Asphalt Pavement Analyzer has indicated that 12.5 mm mixes rut less than 9.5 mm mixes and coarse-graded rutted less than fine-graded for a particular nominal maximum aggregate size.

Iowa (Michael Heitzman, Iowa DOT)

In theory, the size of the mixture should not be relevant to the rutting performance of the mix, provided the mix can retain the required volumetric properties following the prescribed level of gyratory compaction. (APA advocates would probably disagree.) However, there are other factors that should be considered.

Economically, larger size mixes will be less expensive, particularly if they are coarse graded. There is more aggregate volume and less surface area to cover with asphalt binder, therefore less binder in the mix. In terms of constructability smaller size mixes are easier to place and compact, although some poorly graded fine mixes are more likely to exhibit tenderness. The location of the project is also a factor. Urban

projects with pedestrians and slower traffic speeds should meet a desirable level of visual appearance. Most small size mixes are more appealing. The issue of permeability is just now being studied. In Iowa, the current guidelines call for 9.5 mm surface mixes on low volume routes, 12.5mm surface mixes on most state routes, and 19 mm surface mixes on high traffic state and all interstate routes. We have been experiencing some problem with longitudinal screed segregation and have discussed the possibility of reducing the surface mix sizes if the problem persists.

Michigan (Mike Frankhouse, Michigan DOT)

Michigan DOT (MDOT) has not observed rutting so far with either 9.5 mm or 12.5 mm nominal maximum size specification mixes. Less segregation occurs in the 9.5 mm mixture, therefore, decreasing the permeability.

We plan to start limiting the amount of RAP allowed in top course mixes for the 2001 construction season. MDOT uses a modified form of the Mix Expert Task Group (ETG) recommendation on RAP. It is also a three tiered system but it is based on the percentage of RAP binder rather than RAP itself:

- **Tier 1 (0-17 percent RAP binder by weight of total binder in the mixture).** No binder grade adjustment.
- **Tier 2 (18-27 percent RAP binder by weight of total binder in the mixture).** The selected binder grade is one grade lower for the high temperature than the binder grade required for the specified project mixture type (for example, if PG 58-28 was required it would be dropped to PG 52-28).

- **Tier 3 (more than 28 percent RAP binder by weight of total binder in the mixture).** The binder

(continued on page 8)

grade is selected using a blending chart for high and low temperatures. The selection will be based on the RAP test data provided by the contractor.

The following is an example of the above system. If the mixture contained 5 percent total asphalt content and 20 percent RAP, and the RAP had an average binder content of 4.7 percent, then the percentage of binder contributed by the RAP to the mixture would be 18.8 percent by weight of total binder. Therefore, Tier 2 which would allow a reduction of the high temperature PG grade by one grade, will be used.

Ohio (Dave Powers, Ohio DOT)

Although WesTrack experience says otherwise, in general, larger stone size in a properly designed mix provides better overall rut resistance. It is as well more permeable. The difference between most 9.5 and 12.5 mm mixes in this regard is small as the 12.5 mm grading band can produce gradations with a little larger stone size compared to 9.5 mm mixes. However, lift thickness and compaction are very important. If these are proper then the difference is not enough to be concerned about.

In case of recycling we use a higher level of RAP before allowing a change to a softer binder than the ETG recommends. This is due to experience where poor blending of virgin and RAP binder in some cases can allow the soft virgin binder to determine the strength of the mix. This is undesirable in a surface course where we allow up to 20 percent RAP for some mixes.

How do other states control deleterious materials, particularly shale, in their fine aggregates such as manufactured sand and screenings? Missouri DOT currently uses the Plasticity Index to determine deleterious material. What has been the experience of other states using Methylene Blue or other test methods?
(Jim Campbell, Missouri DOT)

Georgia (Lamar Caylor, Georgia DOT)

Georgia requires that fine aggregate be produced from coarse aggregate which has no more than 2 percent deleterious material. This is monitored through quality assurance programs based on production controls where the smallest size coarse aggregate produced is tested after the material finer than 4.75 mm (No. 4) sieve is removed. The petrographic analysis procedure referenced in ASTM C295 is used. We have a minimal amount of data that suggests both the Micro-Deval and California Durability Test have merit for controlling shale although we have not conducted enough tests to set specification requirements using those procedures.

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

Kentucky requires a 5.0 percent maximum on “coal

plus lignite” and 1.0 percent maximum on “friable particles” for fine aggregate. The “coal plus lignite” test is performed by an in-house method; the “friable particles” test is performed using AASHTO T112. We also require sand equivalent testing as specified in AASHTO MP2. We do not yet have much experience with the methylene blue or Micro-Deval tests.

Michigan (Mike Frankhouse, Michigan DOT)

Michigan DOT uses the sand equivalency test for determining if detrimental amounts of clay are present in the fine aggregate. There are only two problem locations in Michigan. During design verification all submitted mix design material samples are picked by the staff geologists for determining deleterious material and soft particles. During hot mix asphalt production those mixtures using certain pits that have a history of high deleterious content are flagged by the mix design staff and belt samples are picked by field personnel during quality assurance (QA) testing of the mixture.

Minnesota (Greg Johnson, Minnesota DOT)

The Minnesota DOT is evaluating the Micro-Deval test as a quality test for the coarse aggregate (more than 9.5 mm or 3/8 in.) for hot mix asphalt. Our work has focused on limestone aggregates. There is a Micro-Deval test for the fine aggregate, but Minnesota has not done any work in that area.

New Jersey (Joseph Merlo, New Jersey DOT)

New Jersey performs the Sodium Sulfate test on both coarse and fine aggregates. A fine aggregate containing shale will tend to have higher sodium sulfate loss numbers. Additionally, we allow a maximum of 2 percent cold water absorption.

Pennsylvania (Paul Ingram, Pennsylvania DOT)

We recently purchased the Micro-Deval test equipment in the interest of determining whether or not it was a viable method of determining deleterious shale. The present test utilized by the department is somewhat subjective and we have been working with the industry to see if a solution to this problem could be found. We have run a few Micro-Deval tests and found the results to be very repeatable and consistent. We have just initiated a short-term work plan which includes conducting the Micro-Deval test on about eight sources which have shown to have problems with excessive deleterious shale. We will also conduct the Micro-Deval test on about eight sources we consider to have excellent material. We hope to get a quick grasp on what the numbers mean. This testing should be completed by the end of this year.

(continued on page 14)

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.*

Alabama (Randy Mountcastle, Alabama DOT)

We have developed special provision specifications to use roofing shingles (both post consumer waste and manufacturing waste) in HMA. We are using both fiber and polymer in all our SMA and OGFC mixes. We would like to develop a method to detect and quantify temperature segregation in HMA right behind the paver. We also are considering using the NCAT method to determine how permeable pavements are.

Arkansas (Terry Hardison, Arkansas State Highway and Transportation Department)

What results/conclusions have other DOTs or agencies drawn concerning wet (stripping) testing using the APA (Asphalt Pavement Analyzer)? Is there a correlation between dry rutting and wet rutting and/or stripping?

Connecticut (Keith Lane, Connecticut DOT)

A project is scheduled for next year, utilizing both Superpave and white topping technologies. It involves two intersections which currently exhibit severe rutting due to high and severe traffic loads (ESALs). This project will be monitored to determine the effectiveness of each technology.

Florida (Gale Page, Florida DOT)

Higher nominal size aggregates do typically result in higher permeability mixes, but more significant is the coarse-graded versus the fine-graded issue. Coarse-graded mixes are significantly more permeable than the fine-graded mixes. The Florida DOT requires 93.5 percent minimum roadway compaction for coarse-graded mixes and 92 percent minimum compaction for fine-graded mixes based on the theoretical maximum density (G_{mm}).

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

At what frequency do other states check the moisture content of plant-produced HMA? Is the asphalt binder content adjusted when the moisture content reaches a specified level?

One of the primary concerns of Kentucky's HMA industry is the number of possible mixture combinations. Given four design ESAL ranges, five nominal maximum aggregate sizes, five polish-resistance aggregate categories, and three PG binder grade possibilities, we can generate quite a number of

combinations. Do any other states have this concern, and if so, what steps are taken to address it?

For states that require a minimum VMA value for plant-produced HMA, what value is specified? Kentucky uses the minimum VMA values from AASHTO MP2 for both laboratory and field criteria. Should a reduction in the minimum VMA be allowed for plant-produced HMA?

Ohio (Dave Powers, Ohio DOT)

Can anyone comment or provide experience on the use of a 4-inch specimen adapter in the gyratory compactor as I understand Colorado is doing? I see the advantages to it but what about possible disadvantages like variability in voids, stone size, etc.?

Tennessee (Greg Duncan, Tennessee DOT)

The ability of the Saturated Surface-Dry test method (AASHTO T166) to accurately measure the bulk specific gravity (G_{mb}) of compacted asphalt mix samples is critical in determining HMA volumetric properties. AASHTO T166 states, "This method should not be used with samples that contain open or interconnecting voids and/or absorb more than 2 percent of water by volume." The most notable weakness of AASHTO T166 is its inability to accurately measure the exterior volume of a compacted asphalt mix sample with air voids accessible from the specimen surface. This weakness was demonstrated by a group of Tennessee Technological University researchers working on a Tennessee Department of Transportation project aimed at finding a more widely applicable G_{mb} determination method.

Four aluminum alloy cylinders were machined to 4-in. in diameter and 2.5-in. in height. Each contained a varying number of 0.25-in. holes drilled through the depth of the cylinder. Air voids were calculated using the known volume of the cylinders and holes. The four aluminum cylinders were then evaluated by the AASHTO T166 test method and air voids were determined using the alloy's known specific gravity.

Unfortunately, but not unexpectedly, AASHTO T166 was unable to detect these voids accessible to the surface. Practitioners and researchers alike should be aware of this weakness and seek an alternate method for determining the G_{mb} of HMA mixes with open, interconnecting, or surface accessible voids.

(continued on page 10)

Virginia (Bill Maupin, Virginia Transportation Research Council)

Does anyone have a strong opinion about the tack coat under hot-mix concerning the type, amount, etc., for different situations? If you use asphalt cements for tack coat how much does this add to the cost over emulsions and is it worth it?

Ontario (K.K. Tam, Ontario Ministry of Transportation)

Our Ministry is currently participating with the industry in a project to develop a replacement test in lieu of testing the properties of recovered asphalt binder. This effort is being made to address the situations when the recovered binder fails quality assurance tests, but contractor claims that the samples were either contaminated or were not representative of the material incorporated into the work. Any comments as to how to deal with this situation?

Australia (John Bethune, Australian Asphalt Pavement Association)

There has been considerable discussion recently on "Binder/Filler Ratios" in Australia. In our Asphalt mix Design Guide we have in part the following text: "The filler ratio is defined as the percentage by mass of the aggregate passing the 75 micron sieve to the effective binder content expressed as a percentage by mass of the total mix and is generally in the range 0.6 to 1.2. These limits have been established to provide a balance between too little filler, which leads to a mix with low strength, and too much filler, which reduces the voids in the mineral aggregate to a level at which sufficient binder for a durable mix cannot be added. The appropriate proportion for a particular asphalt mix is, however, very dependent on the size, surface area and particle density of the filler." I would appreciate any comments on the importance of binder filler ratios and appropriate limits for mix design and specifications. (Editor: A recent National Asphalt Pavement Association (NAPA) Publication titled "Evaluation of Baghouse Fines for Hot Mix Asphalt," NAPA Information Series 127 (February 1999) authored by Prithvi (Ken) Kandhal discusses the importance of binder/filler ratios and their appropriate limits for mix designs based on the characteristics of the filler.)

JOIN US!

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

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—Dedication

(continued from page 3)

of the Auburn campus on 310 acres, the track is designed so that individual state departments of transportation sponsor track sections composed of their own locally available aggregates and asphalt binders, mixed and laid to their specifications.

Trucks pulling three trailers loaded to 20,000 pounds per axle are driven over the test sections 16 hours a day, six days a week, allowing the lifetime of an asphalt surface to be telescoped into a two-year period. This traffic, which represents 10 million axle loads over the track surface, will quickly answer questions about the performance of the pavement mixtures.

A 4,700-square foot testing laboratory and a 2,600-square foot truck maintenance facility is on location.

The track is fully instrumented for temperature and moisture. At the completion of the two-year test schedule, old sections will be removed and new test sections placed on the track. (Editor: See technical details of the test sections in another article in this issue.)



Ben Brock, Chairman, Hotmixers, presenting a check for \$42,275 to Ray Brown, NCAT Director, in support of NCAT's Professor Training Course

SPECIFICATION CORNER

Arkansas - Since March this year the Arkansas DOT began requiring contractors that submit a mix design that has a job mix gradation through the restricted zone to submit samples for Asphalt Pavement Analyzer (APA) Wheel Track Testing. The APA test is conducted at 64°C with 100-lb load, 100 psi hose pressure and 8,000 cycles on specimens compacted to 7±1 percent air voids. The maximum permissible APA rut depths are: 8 mm for N_{design} of 50 and 75 gyrations, 5 mm for N_{design} of 100 gyrations, and 3 mm for N_{design} of 125 gyrations. Research on APA is in progress and a specification for all mixes will follow in the future.

Connecticut - Superpave designed mixes will be placed on several maintenance overlay jobs next year. Full implementation of the Superpave for maintenance overlays will commence with the 2002 construction season.

Florida - New AASHTO Specifications for Superpave have been adopted. One-hour aging of plant produced HMA mix prior to quality control/quality assurance (QC/QA) testing was implemented.

Iowa - The Iowa DOT specification for HMA was rewritten in November, 1999. Since that time, several additional changes have been made. The specification was revised to relax restricted zone criteria under 10 million ESALs design traffic level, allow fine aggregate angularity (FAA) of 43 for 3-10 million ESALs, design to 3.5 percent voids for base mixes under 3 million ESALs, and allow comparable Marshall mixes on small quantity projects.

Kentucky - Kentucky has implemented a number of supplemental specifications to address various concerns. The gradation of Superpave mixtures placed on routes with a 20-year design ESAL value of less than 300,000 is now permitted to pass through the restricted zone. This revision was made in response to the concern of a coarse-textured mix being used on scratch courses, thin leveling courses, parking lots, etc. Also, there is an option now to waive the sand equivalent requirement of AASHTO MP2 provided the portion of the combined aggregate passing the 0.425 mm (No. 40) sieve is non-plastic according to AASHTO T90. It is hoped to implement a maximum rut specification (as tested with the Asphalt Pavement Analyzer) for high-type facilities in the future.

Louisiana - Superpave mix specification has been revised by changing the percentages passing 2.36 mm (No. 8) and 0.075 mm (No. 200) sieves from a pay item to a control item. This will facilitate change in gradation

as necessary in order to maintain 90 percent within limits (PWL) on VMA and air voids. In case of 75-blow Marshall mix designs, the Asphalt Institute MS-2 method of using G_{mm} and G_{mb} will be used in lieu of apparent specific gravity. Mix design procedures for stone matrix asphalt (SMA) have been revised (a) to require 16 percent minimum VMA, and (b) to eliminate the Marshall stability requirement. SMA designs will be conducted with 100 gyrations of a Superpave gyratory compactor. Fibers are allowed but not required in SMA mixes.

New Jersey - Several new specifications have been implemented or are in the pilot stage of implementation. The use of a materials transfer vehicle is now required during the construction of projects where paving will occur on limited access roads and where a minimum number of megagrams (tons) will be used. Two guidance documents have been implemented for designers, "Interim Guidelines to Designers for Superpave Implementation," detailing the criteria to be applied for determining whether a project should be designed using Superpave as opposed to standard paving mixes, and "Pavement Design Report Requirements for Superpave Projects," which details the additional information to be included in the Pavement Design Report required in the New Jersey DOT Procedures Manual.

New Jersey has also implemented a tarping specification, requiring the tarps to be securely fastened down and overlap 150-200 mm (6-8 in) over the top of the trucks.

North Dakota - The Superpave mix design procedures have been revised by lowering the air void requirement from 3-5 percent to 2-4 percent, in order to obtain higher asphalt binder contents at N_{design} gyrations. The fine aggregate angularity (FAA) requirement for lower traffic has been increased to incorporate more manufactured fines in the HMA. A Superpave mix was produced with aggregate requirements specifying a set percentage of crushed fines. The contractors are increasingly designing their own mixes. The DOT verifies the mix design.

Ohio - The Ohio DOT is currently discussing with industry a change to density acceptance specification to include joint density and incentives. The goal is well compacted joints along with high overall mat densities already specified in the last couple of years. This should improve the quality of the longitudinal joints.

The specification for PG 76-22 grade used in high stress applications is being revised to include a
(continued on page 15)

PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of Asphalt Paving Technologists (AAPT) held in Reno, Nevada in March. We are reporting observations and conclusions from these papers 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. APPLICATION OF ROSAN HIGH FREQUENCY LASER SURFACE TEXTURE MEASUREMENTS TO CONTROL HMA SEGREGATION (Stroup-Gardiner and Law)

Historically, visually identified areas on non-uniform hot mix asphalt (HMA) surface texture have been interpreted as a segregated mix. The subjective nature of this evaluation consistently makes it difficult to reach a consensus between inspectors and contractors as to what is and is not segregation. Upon testing in these suspect areas, some results show a substantial change in gradation but no difference in others. These results indicate that a non-uniform surface texture can be due to concentrations of coarse or fine aggregates as well as simply localized areas of poor compaction.

This research project was undertaken with the following objectives: (a) Evaluate ROSAN, laser surface texture measurements as a means of quantifying segregation; (b) Confirm that changes in surface texture correspond with changes in key performance-related volumetric and mixture properties; and (c) Develop

preliminary specification limits for using texture measurements to control segregation.

The ROSAN (ROad Surface ANalyzer) was developed as a joint effort by the Federal Highway Administration (FHWA), and Surfan Engineering, and Software, Inc. (SES). This technology uses a lightweight, portable, high speed, bumper-mounted laser system to evaluate pavement texture characteristics along a linear path.

This research showed that the ROSAN, laser surface texture measurement system can be used to detect and measure various levels of segregation. A ratio of textures in segregated areas to that in non-segregated areas was used to define texture limits. These ratios were selected based on statistically different changes in mix stiffness, air voids, gradations and asphalt content. These limits were adjusted slightly so that the buyer's and seller's risk were approximately evenly split. While texture changes are usually the result of gradation segregation, changes in the surface texture can also indicate differences in density due to temperature segregation. Segregation as used in this paper includes both gradation and temperature segregation. Destructive testing is required to discern which type of segregation is responsible for the texture anomalies.

A texture ratio of between 0.75 and 1.16 defines a no segregation level. Assuming that proper compaction is attained, then mixtures in these areas will have acceptable air voids, greater than 90 percent of the anticipated mix stiffness, no sieves with 5 percent or more change from the job mix formula and an asphalt content within 0.3 percent of the job mix formula.

A texture ratio of between 1.17 and 1.56 defines a low level of segregation. Mixture properties in areas with low segregation are expected to have a mix stiffness of between 70 and 90 percent of the non-segregated mixture. Air voids will be between 0 and 4 percent higher, gradations will have one or more sieves which are at least 5 percent coarser than the non-segregated areas with a corresponding decrease in asphalt contents of between 0.3 and 0.75 percent.

A texture ratio of between 1.57 and 2.09 defines a medium level of segregation. Mixtures with this level of segregation will have a mix stiffness of between about 50 to 70 percent of the non-segregated mix. Air voids will increase by 2 to 6 percent, gradations will have two or more sieves which are at least 10 percent coarser than the non-segregated areas with a corresponding decrease in asphalt contents of between 0.75 and 1.3 percent.

A texture ratio greater than 2.09 defines a high level of segregation. Mixtures in these areas will have a
(continued on page 13)

WORKSHOPS ON HMA MIX DESIGN INCLUDING SUPERPAVE

Workshops on hot mix asphalt mix designs including Superpave will be held at NCAT on January 23-26, 2001, and March 13-16, 2001. These workshops consist of two and a half days of intensive lecture, demonstration, and hand-on training on HMA mix design procedures. Upon completion the participants will be able to conduct the HMA mix designs in their laboratories.

Please call (334) 844-NCAT (6228), or visit our web site at <<http://www.eng.auburn.edu/center/ncat>> (Click on "Education" at the top of the page, then click on "Upcoming Training Courses") for a brochure or information.

stiffness of less than 30 percent of the non-segregated mix. Cores taken from these areas will tend to fall apart. Air voids will be more than 4 percent higher and gradations will have three or more sieves which are at least 15 percent coarser than non-segregated areas with a corresponding decrease in asphalt contents of more than 1.3 percent.

(Editor: This paper based on research conducted at the National Center for Asphalt Technology has been selected as the best technical paper presented to AAPT in 2000. Authors Mary Stroup-Gardiner and M. Law will receive AAPT's prestigious Emmons Award in March 2001.)

2. DESIGN, CONSTRUCTION, AND PERFORMANCE OF NEW-GENERATION OPEN-GRADED FRICTION COURSES (Mallick, Kandhal, Cooley, and Watson)

Open-graded friction course (OGFC) has been used by several state departments of transportation since 1950. While many DOTs report good performance, many other states stopped using OGFC due to unacceptable performance and/or lack of adequate durability. A vast majority of the states reporting good experience use polymer modified asphalt binders and a relatively coarser aggregate gradation compared to the other states reporting unsatisfactory performance. Obviously, there is a need to develop an improved mix design procedure to help the highway agencies in successful use of OGFC.

The primary objectives of this study were to evaluate the performance of OGFC in the laboratory with different gradations and types of additives, and recommend a rational mix design procedure for the new-generation OGFC mixes. Additionally, the construction and performance of six OGFC pavements are discussed.

The following observations were obtained from the laboratory study:

- A gradation with no more than about 20 percent passing the 4.75 mm sieve is required to achieve stone-on-stone contact condition and provide adequate permeability in OGFC mixes.
- Mixes with 15 percent aggregates passing the 4.75 mm sieve are susceptible to significant draindown of the binder. Therefore, it is necessary to provide a suitable stabilizer such as fiber in the mix to prevent excessive draindown.
- Abrasion loss of OGFC mixes resulting from aging can be reduced significantly with the addition of modifiers. In this study, all of the modified binders (SBS and SB were used for modification) had significantly lower abrasion loss than the unmodified binder. The use of both polymer-modified binder and fiber (cellulose and slag wool used) can minimize the abrasion loss and thus increase the durability of OGFC.
- For the binders used in this study, rut depths as

measured with the Asphalt Pavement Analyzer did not vary over a wide range. However, within the range of rut values obtained, the mixes with modified binders had significantly less rutting than mixes with unmodified binders. A higher PG binder grade seems to have a greater effect in reducing rutting than a lower PG binder grade. A polymer-modified asphalt with fiber gave the least amount of rutting.

- Moisture susceptibility, as measured by TSR values, is lower for mixes with modified binders than mixes with unmodified binders. All of the modifiers except slag wool (with PG 64-22) produced mixes which had TSR values in excess of 80 percent. Again, both polymer-modified binder and fiber should be most effective especially in cold climates with freeze/thaw cycles.

A tentative mix design system for the coarse new-generation OGFC has been recommended. Based upon the evaluation of six OGFC field pavements in Georgia, it has also been shown that OGFC mixes meeting the new mix design criteria will provide acceptable performance.

3. AN EVALUATION OF SELECTED METHODS FOR MEASURING THE BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT (HMA) MIXES (Buchanan)

The measurement of the bulk specific gravity of compacted hot mix asphalt (HMA) mixes is the basis for volumetric mix design and quality process control procedures. Among the items which are dependent upon the measured mix bulk specific gravity (G_{mb}) are air voids and voids in the mineral aggregate.

Among the currently used methods to determine the G_{mb} of compacted samples is the water displacement method. In this method a sample is weighed in air, then submerged in water, and finally weighed in saturated surface-dry (SSD) condition. The water displacement method generally provides acceptable results for the majority of dense-graded mixes. However, as the mix becomes more coarse, or open-graded, errors resulting from the use of the water displacement method have been observed. The primary cause of the errors is the presence of interconnected air voids inside the compacted sample. Other methods, such as dimensional analysis and parafilm are also used today with varying degrees of success.

In this study, four methods for G_{mb} measurement were evaluated. The methods included the water displacement, dimensional analysis, parafilm, and the vacuum sealing method. The evaluation consisted of measuring the G_{mb} of samples of four mix types (fine and coarse Superpave, Stone Matrix Asphalt or SMA, and Open Graded Friction Course or OGFC), three compactive efforts (low, medium, and high), and two

(continued on page 14)

aggregate types (limestone and granite).

The following conclusions were drawn from this study:

- The vacuum sealing and the water displacement methods provided similar results for fine and coarse-graded Superpave mixes.
- A good relationship between the percent absorbed water and the differences between the vacuum sealing and the water displacement methods was observed. Significant errors in the calculated air voids can result by using the water displacement method even though the percent absorbed water is less than the currently specified maximum limit of 2 percent. These errors were shown to be as much as approximately 1 percent for 0.5 percent absorbed water and as high as 6 percent for 2 percent absorbed water.
- For coarse, open-graded mixes, such as SMA and OGFC, the difference between the vacuum sealing and the water displacement methods were generally greater, with the vacuum sealing method yielding higher air void contents. This is due to the sealing of the sample during the vacuum sealing method which prevents water penetration.
- The use of the dimensional analysis method resulted in the highest air voids of all methods for the majority of samples evaluated. The difference between the dimensional analysis and the other methods generally increased as the surface texture of the sample became rougher.
- Significant errors in the calculated air void contents can result from only small errors in the volume calculation using dimensional analysis. A 1 percent error was shown to yield a 1 percent error in air voids.
- The parafilm method provided similar results as the water displacement and the vacuum sealing methods for the fine and coarse-graded Superpave mixes, but tended to overestimate the air voids for the SMA and OGFC, primarily due to bridging of the parafilm over the surface voids.
- The vacuum sealing method appears to most accurately measure the G_{mb} of all the samples evaluated; regardless of mix type, aggregate type, compaction level, or sample state (uncut or cut). The accurate measurement of the G_{mb} by the other methods evaluated is more dependent on the mix parameters.

—Test Track *(continued from page 4)*

- Indirect tension with temperature sweep
- Shear testing (repeated shear with constant height)
- Frequency sweep shear testing at three temperatures
- Fatigue testing on rectangular beams
- Asphalt Pavement Analyzer (loaded wheel tester)

Researchers involved in various NCHRP projects are expected to test the materials used on some of the test sections.

It is planned to put all test and performance data on the test track web site <www.pavetrack.com>.

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Over 55 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.

—Forum Responses,

(continued from page 8)

Vermont (Timothy Pockette, Vermont Agency of Transportation)

Vermont uses AASHTO T104 “Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.” The weighted average of loss is not allowed to exceed 8 percent, by mass, when subjected to five cycles of sodium sulfate soundness test.

Now that most states use dense-graded HMA base courses whose maximum aggregate sizes seldom are more than 25 mm, are binder courses necessary?

Superpave makes no recommendation on maximum aggregate size. How should the maximum aggregate size be selected for each layer? For example, Superpave would seem to allow a pavement consisting of a 9.5 mm aggregate base course, 19 mm aggregate binder course, and a 25 mm aggregate surface course. This is contrary to normal past practice and conventional engineering judgment. (Francis Manning, Rhode Island DOT)

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

Kentucky presently utilizes very few binder courses. Typically, we specify some combination of base courses and a surface course. The base courses may consist of a 37.5, 25, or 19 mm nominal maximum size mixture. For pavement design, we attempt to specify a lift thickness of at least three times the nominal maximum size. The individual base course thickness is sometimes “juggled” to satisfy the total base course thickness, and the nominal maximum size is often selected from the lift thickness.

Michigan (Mike Frankhouse, Michigan DOT)

The Michigan DOT uses an intermediate size base course, typically with a 19 mm nominal maximum size aggregate. Michigan chooses HMA mixtures based on structural design thickness and a minimum layer thickness of four times the nominal maximum size. Also using a 9.5 mm mixture for a base course would be cost prohibitive because of the asphalt demand caused by the increased surface area.

(continued on page 15)

Vermont (Timothy Pockette, Vermont Agency of Transportation)

You are correct in stating that Superpave does not specify what nominal size mix to use for base, binder, or wearing courses. But we must remember that Superpave is just a new design process and that we can not forget what we have learned in the past. Therefore, we must use past experience and continue to build upon what we already know.

We use lower than recommended N_{design} gyrations to achieve higher binder content and durability. No problems have been experienced to date. Do other states have similar experience? (Dave Powers, Ohio DOT)

Kentucky (Allen Myers, Kentucky Transportation Cabinet)

Kentucky follows the gyration levels specified in AASHTO PP28. For the most part, we are pleased with the asphalt binder contents normally achieved. Our optimum asphalt binder contents started to increase prior to Superpave when we implemented an acceptance program based on plant-produced mixture properties. This change demanded cleaner aggregates, and those cleaner aggregates resulted in higher optimum binder contents.

Michigan (Mike Frankhouse, Michigan DOT)

The Michigan DOT uses slightly higher gyration levels at $N_{initial}$, N_{design} , and $N_{maximum}$ except for roads with greater than 30 million design ESALs where our $N_{maximum}$ is slightly less at 204 instead of 205.

North Dakota (Joe Davis, North Dakota DOT)

We are also experiencing lower than desired asphalt contents at Superpave recommended N_{design} gyrations and 4 percent air voids. We are considering lowering air void requirements for Superpave mixes, or changing the number of gyrations at N_{design} .

—Specification Corner (continued from page 11)

minimum level polymer requirement by test.

To date about 60 Superpave projects totaling over 2 million tons have been awarded or constructed. A goal for full implementation of Superpave on high volume roads is being scheduled in 2001.

In FY 2000, four 3-year, ten 5-year, and seven 7-year asphalt warranty projects have been awarded. In FY 2001, thirteen 3-year, twelve 5-year, and nine 7-year warranty projects are planned for bidding.

South Carolina - South Carolina DOT has completed its 2000 edition of the Department's Standard Specifications. South Carolina has begun implementing

the use of an "Open Graded Friction Course with Rubber Modified Asphalt Binder and Mineral Fibers" specification on all interstate projects.

Ontario, Canada - End-result specification combining asphalt content, gradation, compaction, and air voids based on percent within limits has been revised and was included in this year's contracts. Major changes include: (a) Quality assurance (QA) testing will be carried out for audit purposes and for trigger-in referee testing; (b) Ten quality control (QC) results will be compared to five QA results and the trigger value has been increased to 2 percent from 1.5 percent in payment factor for most mixes (2.5 percent for Heavy Duty Binder Course); (c) Requirements for "certified technician" to do all lab testing; and (d) Security seals for all samples to be delivered for QA and referee testing.

The specification on segregation for visually defective mix in contracts for all HMA has been revised to include: (a) A penalty of \$15/m² for medium segregated patches and a bonus of \$1.50/t/lane-km for a continuous segregation-free pavement and (b) A new referee method based on "texture depth ratios" for different mix types.

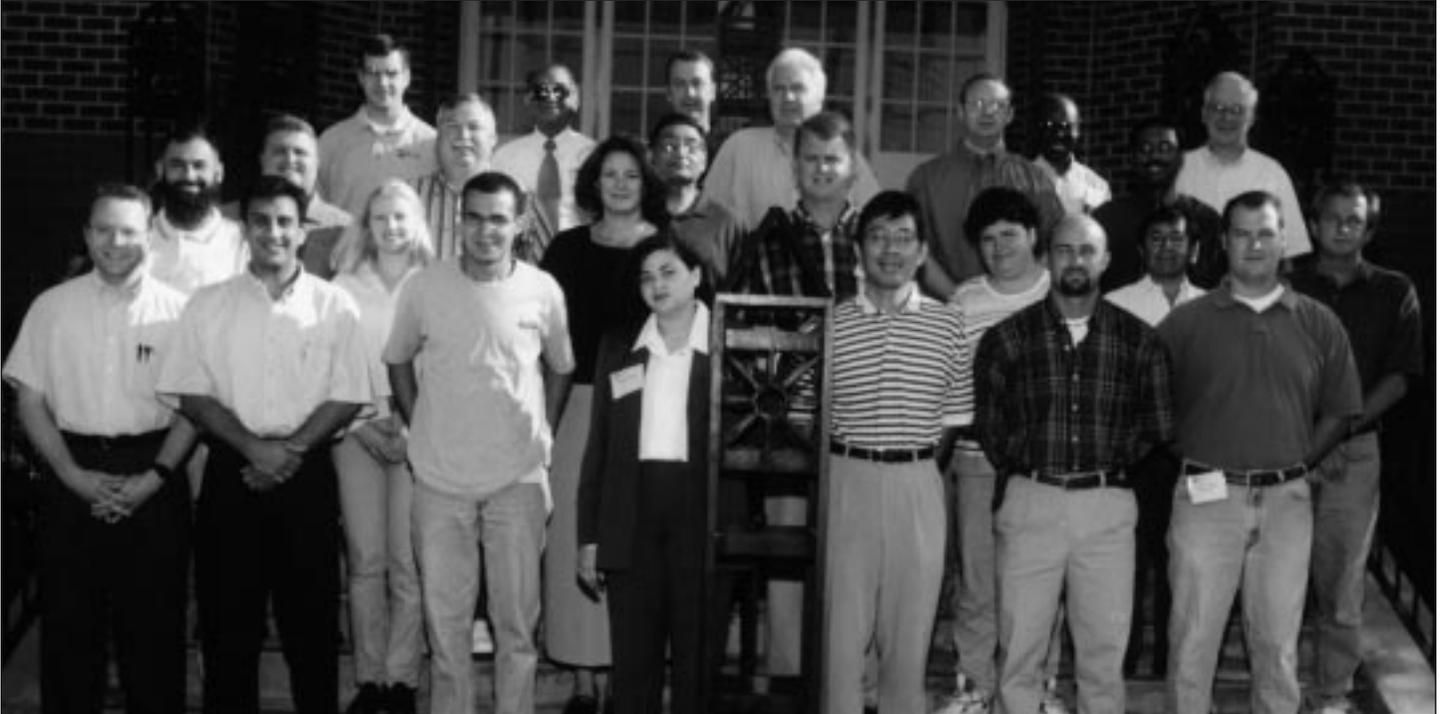
The new end-result specification for smoothness implemented on all surface courses has been revised to include: (a) Full penalties on all 2-lift contracts with the premium of penalty for a price reduced sublot increased to 20 percent; (b) Reduced penalties for all single lift contracts; (c) For night paving, a separate specification used with reduced penalties; (d) Allowance of some unrepaired scallops to be left in place; and (e) Approved profilograph operator requirements.

The use of NCAT Ignition Furnace was implemented this year for non-limestone mixes after extensive review and evaluation of the impacts of various factors such as accuracy of testing, aggregate types, end result specification payment factors, and different furnace types.

Australia - The Australian Asphalt Pavement Association (AAPA) issued its National Asphalt Specification, Edition 1, January 2000 as an aid to promoting national uniformity in asphalt specifications. Austroads, which represents the various State Road Authorities, is now looking at the possibility of adopting the AAPA National Asphalt Specification as the Austroads National Specification in support of their mission to promote nationally uniform practices. Although promising, it is likely that some adjustment would be required by both the user and industry for this to be achieved.

AAPA has recently issued the following two Implementation Guides: "Stone Mastic Asphalt- Design & Application Guide," and "Asphalt Plant Process Control Guide."

NCAT's Professor Training Course, June 2000



Front Row, (left to right): Michael Smith, Mohammad Khattak, Mostafa Elseifi, Marwa Hassan, Chang-Jen Lan, Damon Hollis, Paul Crigler

Second Row, (left to right): Aref Alderbas, Ewa Rodzik, Leigh Ann Archbold, Brian Wood, Kelly Seitter, Nicasio Lozano, Terry Anderson

Third Row, (left to right): *Chris NeSmith, Hal Johnston, Hadi Yamin, Khaled Sobhan

Fourth Row, (left to right): *Robert James, *Ken Kandhal, *Shane Buchanan, Steve Jaouen, Stefan Romanoschi, Pius Igharo, *Doug Hanson

*Instructors



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