

# ASPHALT TECHNOLOGY NEWS

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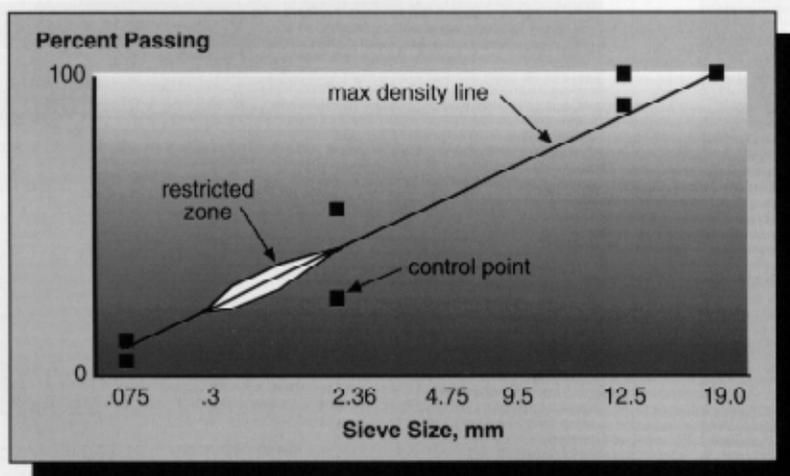
## NCAT EVALUATES RESTRICTED ZONE IN SUPERPAVE GRADATION

The National Center for Asphalt Technology (NCAT) has undertaken National Cooperative Highway Research Program (NCHRP) Project 9-14, "Investigation of Restricted Zone in the Superpave Aggregate Gradation Specification." The primary objective for this research is to determine under what conditions, if any, compliance with the restricted zone requirement is necessary when the asphalt paving mix meets all other Superpave requirements such as fine aggregate angularity (FAA) and volumetric mix criteria.

The Strategic Highway Research Program's (SHRP)

asphalt research was primarily aimed at the properties of asphalt binders and paving mixes and their effect on asphalt pavement performance. The study of aggregate properties (including gradation) was intentionally excluded from the asphalt research program. However, SHRP researchers had to recommend a set of aggregate properties and an aggregate gradation specification (without the benefit of experimentation) so that a comprehensive Superpave mix design system could be formulated.

SHRP formed an Aggregate Expert Task Group (ETG)  
*(Continued on page 2)*



*Restricted Zone in the Superpave mix gradation.*

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**National Center for Asphalt Technology, 211 Ramsay Hall, Auburn University, Alabama 36849-5354**

**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 Director/Editor**

**James S. Killian III, Associate Editor, College of Engineering**

*(Restricted Zone, Continued from page 1)*

consisting of 14 acknowledged experts in the area. In lieu of a formal aggregate research program, ETG used a modified Delphi approach to develop a set of *recommended* aggregate properties and criteria that are now included in the Superpave volumetric mix design method. The Delphi process was conducted with five rounds of questionnaires. The final recommended aggregate gradation criteria included control points between which the gradation must fall, and a restricted zone that lies along the maximum density line (MDL) between the intermediate size (either 4.75 or 2.36 mm depending on the nominal maximum size of the aggregate in the mix) and the 0.3 mm size.

Although the restricted zone was included in Superpave as a recommended guideline and not a required specification, some highway agencies are interpreting it as a requirement.

Many asphalt technologists believe that compliance with the restricted zone criteria may not be desirable, or even necessary in every case, to produce asphalt mixes with good performance.

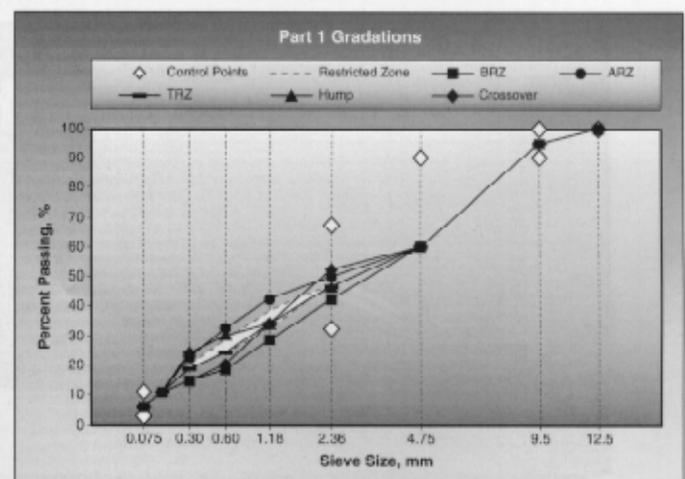
If highly angular aggregates are used in the mix it is likely that it will not exhibit any tenderness during construction and will be rut-resistant under traffic although its gradation may pass through the restricted zone. The Georgia Department of Transportation has successfully used such mixes for many years. Some asphalt technologists also question the need for the restricted zone when the mix has to meet volumetric properties such as minimum voids in the mineral aggregate (VMA) and specified air void contents at  $N_{initial}$ ,  $N_{design}$ , and  $N_{maximum}$  gyrations.

It is obvious that the effect of restricted zone on mix performance should be evaluated on the basis of a statistically planned and properly controlled experiments, which is the subject of this NCHRP Project on restricted zone.

Since the restricted zone is applied within the fine aggregate sieve sizes, the shape and texture of the fine aggregates are the most important factors affecting the performance of HMA mixtures. Therefore, the approach taken in identifying and selecting fine aggregates for use in the study was to select aggregates with varying values of fine aggregate angularity (FAA). Also included within the selection criteria were the mineralogical composition of the fine aggregates and type of crusher. Maximization of these three criteria will ensure using fine aggregates with a wide range of properties.

Factor-level combinations to be included in Part 1 of this project consist of two coarse aggregates, nine fine aggregates, five 9.5 mm nominal maximum aggregate size (NMAS) gradations, and one compactive effort. Different NMAS gradations and compactive efforts will be used in Parts 2 and 3 of this project. Of the five gradations proposed to be used in all parts, three

*(Continued on page 3)*



**Figure 1: Gradations**

*(Restricted Zone. Continued from page 2)*

will violate the restricted zone while two will fall outside the restricted zone (control). These five gradations are illustrated in Figure 1.

All five gradations follow the same trend from the 12.5 mm sieve down to the 4.75 mm sieve. From the 4.75 mm sieve, the BRZ gradation passes below the restricted zone and above the lower control points. The ARZ gradation passes above the restricted zone and below the upper control points. These two gradations are designated the control gradations since they do not violate the Superpave restricted zone. The remaining three gradations do violate the restricted zone. From the 4.75 mm sieve, the TRZ gradation passes almost directly along the maximum density line through the restricted zone. The Hump gradation follows a similar gradation as the TRZ gradation down to the 1.18 mm sieve where it humps on the 0.6 and 0.3 mm sieves. The hump gradation represents gradations generally containing a large percentage of natural sands, and is likely to cause tender mixes. From the 4.75 mm sieve, the Crossover gradation begins above the restricted zone on the 2.36 mm sieve but then crosses through the restricted zone between the 0.6 and 0.3 mm sieves. The crossover gradation represents gradations which are not continuously graded between 2.36 mm and 0.60 mm sizes and generally exhibit low mix stability. All five of the gradations then meet at the 0.15 mm sieve and follow the same trend down to the 0.075 mm sieve. A common material passing 0.075 mm sieve or No. 200 sieve (P200) will be used in all HMA mixtures to eliminate P200 as a variable. Different P200 materials stiffen the asphalt binder and HMA mixtures to a different degree and, therefore, will affect the mix performance test results.

Mixture designs will first be conducted for the three gradations passing through the restricted zone. If any of these three mix designs meet all Superpave volumetric requirements, then mix designs will be conducted for the two control gradations (ARZ and BRZ). Mixtures meeting all volumetric requirements will be used for performance testing. This approach was selected because the Superpave volumetric requirements are believed to detect a potential problem mixture.

The performance of mixes meeting volumetric requirements will be evaluated on the basis of performance related mechanical tests. Since the primary purpose of the restricted zone is to avoid rut-prone mixes, the mixes in this study will be evaluated for their rutting potential. This will be

accomplished by two different types of tests: empirical and fundamental. For the empirical test, the Asphalt Pavement Analyzer (APA) will be used. The Superpave shear tester (SST) and the dynamic confined creep (DCC) test will be utilized as fundamental tests. These three tests are proposed to ensure a satisfactory conclusion of this study.

The Asphalt Pavement Analyzer (APA) II is an automated, new generation of Georgia Loaded Wheel Tester. The APA II features controllable wheel load and contact pressure, adjustable temperature inside the test chamber, and the capability to test the samples either while they are dry or submerged in water. The APA test will be conducted dry with 8,000 cycles, and rut depths will be measured continuously. The APA can test three pairs of gyratory compacted specimens of 75 mm height. Testing with the APA will be conducted at 64°C, which corresponds to a PC 64 asphalt binder to be used in this study.

The Superpave shear tester (SST) developed by SHRP is a closed-loop feedback, servo hydraulic system that consists of four major components: a testing apparatus; a test control unit; an environmental control chamber; and a hydraulic system. The ability of a pavement structure to resist permanent deformation and fatigue cracking is estimated through the use of the SST. The SST simulates, among other things, the comparatively high shear stresses that exist near the pavement surface at the edge of vehicle

*(Continued on page 4)*

## **WORKSHOPS ON HMA MIX DESIGN INCLUDING SUPERPAVE**

Workshops on hot mix asphalt mix designs including Superpave will be held at NCAT on January 24-27, 2000; February 14-17, 2000; and March 20-23, 2000. These workshops consist of two and a half days of intensive lecture, demonstration, and hands-on training on HMA mix design procedures. Upon completion the participants will be able to conduct the HMA mix designs in their laboratories.

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**Prithvi (Ken) Kandhal**  
Associate Director, NCAT  
211 Ramsay Hall  
Auburn University, AL 36849-5354

*(Restricted Zone, Continued from page 3)*

tires; stresses that lead to the lateral and vertical deformations associated with permanent deformation in surface layers.

Dynamic confined creep test (or repeated, constant stress permanent deformation test) is considered to be a fundamental experimental method to characterize the rutting potential of HMA, since fundamental creep principles can be applied to deformation of viscoelastic mixes. A Material Testing System (MTS) will be used to conduct this test. A deviator stress along with a confining stress is applied on a HMA sample for 1 hour, with 0.1 second load duration and 0.9 second rest period. After the one hour test the load is removed and the rebound measured for 15 minutes. The strain observed at the end of this period is reported as the permanent strain, which indicates the rutting potential of the mix. This test has been used successfully by NCAT in a national study of rutting. The test temperature will be 60°C. Test loadings will consist of 138 kPa (20 psi) confining pressure and 827 kPa (120 psi) normal pressure.

Test results from the three mechanical tests will be analyzed to obtain performance data of HMA mixtures containing different gradations and FAA values.

It is not expected that all three permanent deformation tests (one empirical and two fundamental) will provide exactly similar results. If that was the case, only one mix validation test would have been sufficient. However, all three tests may not be equally sensitive to changes in gradation and FAA values. Their relative sensitivity to changes in gradation and FAA values will be evident from the test data. The test which is most sensitive to these two important factors of this research project will be considered relevant and significant.

Statistical analysis of the test data should demonstrate very clearly under what conditions, if any, compliance with the restricted zone requirement is necessary when the HMA mix

meets all other Superpave requirements such as FAA and volumetric mix criteria for the project.

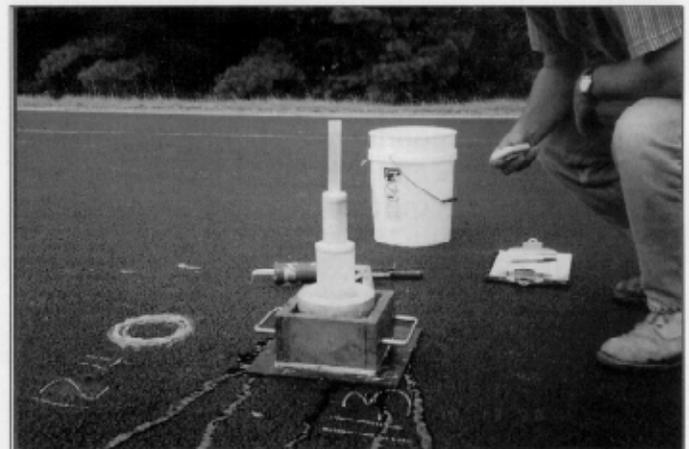
This project is scheduled to be completed by April 30, 2000.

## NCAT EVALUATES AND SELECTS A FIELD PERMEABILITY DEVICE

Within the hot mix asphalt (HMA) community, it is a generally accepted notion that the proper compaction of HMA pavements is vital for a stable and durable pavement. For dense-graded mixtures, numerous studies have shown that the initial in-place air void content should not be below approximately 3 percent or above 8 percent. Based on past experience, low air voids are believed to lead to rutting and shoving problems while air void contents in excess of 8 percent are believed to allow water to penetrate into a pavement. However, a study recently completed by the Florida Department of Transportation (FDOT) has indicated that Superpave mixtures designed on the coarse side of the restricted zone can be permeable to water at air void contents below 8 percent. As a part of this FDOT study, a laboratory permeability device utilizing a falling head concept was developed for the testing of cores.

As a result of work performed by the FDOT, a laboratory permeability device is now available to evaluate the permeability of HMA pavements. However, this test is essentially a destructive one since cores must be cut from the roadway. If a field permeability device could be found that can provide accurate and repeatable results, it would negate the need for cutting cores. A device of this nature would also allow for corrections in

*(Continued on page 5)*



*NCAT field permeability device is in use on a new Superpave mix pavement.*

**(Permeability. Continued from page 4)**

pavement construction to be made in the field if permeability values are too high. Therefore, during 1998 the National Center for Asphalt Technology (NCAT) conducted a study through the Southeastern Superpave Center to evaluate several different field permeameters and to select and standardize a field permeability device.

To accomplish the objective of the study, three ongoing construction projects were visited. At each of the projects, field permeability tests were conducted on newly compacted HMA pavements using four different field permeameters. All four of the devices used a falling head approach to measure permeability. Also at each of the projects, cores were obtained from which laboratory permeability was determined using the FDOT procedure. In order to select and standardize one of the four field permeameters, the data from each project was analyzed to determine which permeameter correlated best with the accepted laboratory permeameter, which one was the most repeatable, and which was the easiest to use.

Results from this study showed that data from two of the four field devices were not statistically different than the laboratory data. Next, the repeatability of the two devices was compared to the repeatability of the laboratory device. Again, this analysis (comparisons of coefficients of variation) indicated that the two field devices had similar repeatability as the laboratory device. The third criteria for the selection of a field device was ease of use. Since two of the four field devices were not significantly different from the laboratory permeameter and had similar repeatability, the selection process came down to which device was easier to use. Based on this criteria, one of the devices was selected. The selected device is shown in the photograph.

The selected device was unique from the other three permeameters evaluated because it uses a three-tier standpipe. As shown in the photograph, each tier consists of a standpipe with a different diameter. The standpipe with the smallest diameter is at the top and the largest diameter standpipe is at the bottom. This configuration was designed in an effort to make the permeameter sensitive to the flow of water into a pavement. For pavements that are relatively impermeable, the water will fall within the top tier standpipe very slowly. For pavements of "medium" permeability, the water should flow through the small diameter standpipe quickly but slow down when it reaches the larger diameter middle tier standpipe. Likewise, for a very

permeable pavement the water should flow through the top and middle standpipes very quickly but slow down in the larger diameter standpipe bottom tier standpipe.

An additional feature of the device is that a flexible rubber mat is placed between the permeameter and the pavement surface. In order to seal the field permeameter to the pavement surface, a silicone-rubber caulk is placed between the device and rubber mat and between the rubber mat and pavement surface. A weight is used to hold the device on the pavement surface. This weight is used to resist the uplift force when water is introduced into the permeameter. The rubber mat was incorporated because, being flexible, it pushes the caulk down into the surface voids of the pavement when the weight is lowered onto the field permeameter resulting in a better seal between the permeameter and pavement surface.

Because of the success of this research study, a second phase was authorized by the member states of the Southeastern Superpave Center. This second phase will entail taking the selected permeameter into the field and evaluating the in-place air void content at which pavements become excessively permeable. A secondary objective will be to evaluate what factors influence the permeability of Superpave designed mixtures.

Allen Cooley, Research Engineer - NCAT

## ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS CELEBRATES ITS 75TH ANNIVERSARY

The Association of Asphalt Paving Technologists (AAPT) which is **the most** prestigious asphalt **organization** in the **world**, celebrated its **75th anniversary** during the **annual** meeting held in Chicago March 5-10. **AAPT** is dedicated to **advance** the asphalt paving technology. The 3day annual technical meeting of AAPT is held in March every year, which includes asphalt related technical sessions, symposium, workshops, and government engineers' forum. Its journal "Asphalt Paving Technology" is a widely referenced and Prestigious source of literature in the asphalt field. Members **of AAPT** get the **free** bound journal of over **800 pages** (cost **\$75**) every year against the nominal annual dues of **\$90**. **If you wish to become a member please contact:**

**AAPT**  
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Phone: (651) 293-9188  
Fax: (651) 293-9193

## ASPHALT FORUM RESPONSES

*The following responses have been received to questions raised in the Fall 1998 Asphalt Forum.*

*We have not placed any Superpave mix that passed through the restricted zone. We would like to know if any agency has experience with a fine-graded (gradation passing above restricted zone) 12.5-mm Superpave mix. (Murari Pradhan, Utah DOT)*

**Oklahoma (Wilson Brewer Jr., Oklahoma DOT)**

We could not get a mix design to work with fine gradation. It has always been set below the restricted zone.

**Connecticut (Keith Lane, Connecticut DOT)**

Connecticut placed in 1997 over 12,400 tons of a fine-graded Superpave mix on Route 2 in Colchester as part of a long term pavement performance (LTPP) study. It will be monitored over the next several years.

**Maine (Dale Peabody, Maine DOT)**

We have had good experience with fine-graded Superpave mixes, particularly the 9.5 mm mix when used for a variable depth shim or hand work.

**Colorado (Tim Aschenbrener, Colorado DOT)**

The restricted zone is listed in our specifications for guidance, but there is no requirement to stay out of it. Some mix designs go through the restricted zone, but there is not a large percentage. Most of the mixes go above the restricted and some go below the restricted zone. We specify both 19.0 mm and 12.5 mm mixes.

We have had most of our construction and performance problems with the mixes that go below the restricted zone (compaction problems because of tenderness, compaction problems because the mix is extremely stiff, and permeability problems). The fine mixes have generally not had these problems. The construction experience with fine mixes is very successful. They have been more successful than the coarse mixes. The performance of the fine mixes is just as successful, if not slightly better, than our coarse mixes. The coarse mixes have experienced some minimal amounts of raveling and potholing in areas that were permeable.

*Does any agency require percent within limits (PWL) for quality assurance of roadway density on Superpave mixtures? If so, what is the minimum specified? (Chris Abadie, Louisiana Transportation Research Center)*

**Missouri (Jim Campbell, Missouri DOT)**

Missouri DOT has PWL requirements in

Superpave QC/QA specifications. We require all lots with a pay factor of less than 50 or any sublot with material compacted to less than 90 percent of the theoretical maximum density to be removed. The percent compaction results have generally tended to be low on Superpave mixtures. This is being reviewed by the Missouri DOT and the HMA contractors.

**Colorado (Tim Aschenbrener, Colorado DOT)**

Roadway densities are taken with the nuclear gauge. The nuclear gauge results are correlated to cores. Our percent compaction is based on the theoretical maximum specific gravity. Statistically, if approximately 85 percent of the test results are within the limits of 92 percent and 96 percent relative compaction, then the contractor earns 100 percent payment. We also have incentives and disincentives for better and worse results of the percent within limits (PWL).

*The Superpave hinder tests show all polymers are about equal in performance. Are there any tests available to determine which polymers adequately resist rutting and fatigue cracking? (Randy Mountcastle, Alabama DOT)*

**Oklahoma (Wilson Brewer Jr., Oklahoma DOT)**

We use the elastic recovery test to determine if a PG graded asphalt binder has polymer in it. Polymers are generally added when the range between the high temperature and the low temperature in the specified PG grade is equal to or exceeds 90.

*Have other agencies experienced difficulty in comparing bulk specific gravity on Superpave mixtures compacted in different brands of gyratory compactors? How has verification of contractors' mix designs been handled? (Jim Campbell, Missouri DOT)*

**Kentucky (Allen Myers, Kentucky Department of Highways)**

We have not experienced a problem with varying bulk specific gravity values. Only two brands (and three models) gyratory compactors are currently in use in Kentucky. Regarding verification of the contractors' mix designs, Kentucky requires that the bulk specific gravity of the compacted mix, Rice specific gravity, air voids, and the VMA from the contractor's design fall within specified tolerances of the corresponding values from the agency's design.

## ASPHALT FORUM

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

### **Maine (Dale Peabody, Maine DOT)**

Are any states experiencing winter maintenance problems (freeze-thaw damage, difficulty removing ice, permeability concerns, etc.) with the 19 mm Superpave mixes that are allowed to remain over the winter? Is anyone having winter maintenance problems with the 12.5 mm mixes? Do states have policies to prevent the use of "coarse graded" Superpave mixes that will be left over the winter prior to placing the wearing surface in the spring?

### **Utah (Murari Pradhan, Utah DOT)**

We do not have premature rutting problems any more with the Superpave mix and PG binder. However, we are concerned with the fatigue problem that might result from coarse graded mixes and stiff binder. We have purchased an Asphalt Pavement Analyzer to determine the fatigue characteristics of our HMA mixes. We intend to conduct lots of tests on HMA mixtures this coming season to determine a threshold value

for coarse graded Superpave mix

We have converted to percent within limits (PWL) for all incentive/disincentive computations in our HMA specifications. We have separate specifications for construction and maintenance projects.

WC bought 11 portable gyratory compactors for the field laboratories for better control of the field production and acceptance testing. We have fully converted to PG grading. Most of the asphalt binders used last year were polymer-modified.

### **Australia (John Bethune, Australian Asphalt Pavement Association)**

In the review of the polymer modified bitumen (PMB) specifications, a considerable amount of industry test data is being collected and analyzed.

A number of different gyratory compactors are used in the Superpave design process. These will invariably have some differences in performance. How is this taken into account when you have a set number of gyrations?

## NCAT's MARCH 1999 ASPHALT TECHNOLOGY COURSE ATTENDEES AND INSTRUCTORS



**Front Row, L-R:** Charlie Walker, Danny Lan, Ken Van Daam, Stanley Crawford, Jeff Meyers, David Lyles, **Second Row:** Greg Tullier, Rick Winters, Harold Kallock, Nathan Bryant, Mayur Patel, Carl Skelton, **Third Row:** Roy Beard, Ben Head, Tim Williamson, Ricky Smith, Rodger Hopkins, Ron Hope, Mel Monk, **Fourth Row:** Barry Grizzard, Stanley Armstrong (plaid shirt), Ed Perry, Mike Doran, **Back Row:** Phillip Graves, John Knighton, Charles Cato, Ken Kandhal, Amar Raghavendra, Vishnu Diyaljee, Mike Huner

## SPECIFICATION CORNER

**Connecticut** - A QC/QA longitudinal joint density specification is being developed and will be incorporated into upcoming paving projects.

**Georgia** - Several refinements to Superpave specification have been made based primarily on recent research sponsored by the National Cooperative Highway Research Program (NCHRP) and technical working groups appointed by the FHWA.

Some of the most notable changes are:

- Changed  $N_{max}$  to match the gyratory level recommended by the National Center for Asphalt Technology with the exception that traffic levels are based on average daily traffic rather than equivalent single axle loads.
- Eliminated  $N_{max}$ . The use of rut testing with the Asphalt Pavement Analyzer should accomplish the same thing as  $N_{max}$  was intended for-to assure pavements are not susceptible to rutting after several years of use.
- Deleted the restricted zone. Georgia has designed conventional mixes for years that violated the restricted zone requirements, and yet, those mixes were some of the most rut resistant mixes available. Rut tests with the Asphalt Pavement Analyzer indicate that Superpave mixtures with Georgia aggregates are generally not susceptible to rutting even though gradations may go through the restricted zone.
- Design 25 mm Superpave mixes at one gyratory level lower than specified in the plans for surface courses. This will provide a more flexible and durable base course for subsequent layers.
- Allowed use of the 12.5 mm Superpave mix for trench widening where it will be left exposed to traffic, and when indentation rumble strips are to be used.
- Revised gradations so that all mixes will be designed below the initial point of the restricted zone except for 9.5 mm Superpave mixes designed for low traffic volume projects in which the gradations would be required to go above the initial point of the restricted zone. The control points on the coarse sieve sizes were tightened to provide finer graded mixes, based on research at WesTrack and research by FHWA and others that shows that the finer graded mixtures perform better than extremely coarse graded Superpave mixtures.

These changes have been made to improve the durability and constructability of Superpave mixtures and are based on the most current research and other information available.

**Indiana** - Indiana DOT Bituminous Specifications have been completely rewritten to incorporate Superpave. Beginning this construction season, all HMA projects will make use of the new specifications.

**Kentucky** - Standard specifications are being revised for a new publication to be effective January 1, 2000. In the asphalt area, most of the "method specifications" will be deleted and most conventional mixtures will be replaced by Superpave mixtures. A "warranted asphalt pavement" specification is being developed for application on selected projects.

**Maine**-All paving contracts now use Superpave mixtures since Superpave was implemented fully on January 1, 1998.

Pilot projects are planned this year to implement ride quality specifications and ride quality performance measures. The ride will be determined by using IRI (International Roughness Index) gathered by a rolling dipstick.

An experimental project using permeable base material was constructed along Rte. 137 in Fairfield. Test sections of asphalt treated material, and untreated material, approximately 100 mm in depth were placed below the hot mix asphalt base and surface course. The department will monitor these sections for a minimum of five years to evaluate performance.

Construction was begun on a pilot project for HMA pavement warranty specification in 1998. A section of Rte. 1 in Houlton, Maine, is under reconstruction. The pavement will be completed under a warranty specification. The five-year warranty includes pavement distress monitoring and requires remedial work, should distresses exceed defect limits. The pilot project is part of the transportation quality initiative which should allow more contractor flexibility while maintaining or improving project quality.

**Michigan** - The Michigan DOT will discontinue measuring PG properties for asphalt binder recovered from mixtures for acceptance. The FHWA Expert Task Group recommendations for the use of RAP in recycled mixtures will be used for all construction projects. In addition, all projects that include E10, E30 or E50 mixtures will have five-year warranties for mixture materials and workmanship.

**Missouri** - Superpave, in conjunction with quality control/quality assurance (QC/QA) will be in its third year of pilot projects this year. This will allow more contractors and department personnel to gain experience. Twenty jobs are anticipated to be let this year. QC/QA will be fully implemented on all Superpave mix designs next year.

**Nebraska** - Contractors are required to have a Superpave gyratory compactor and an ignition oven on all Superpave projects this year. They must maintain control charts of

*(Continued on page 9)*

*(Specification, Continued from page 8)*

(1) hinder content by ignition oven, (2) laboratory air voids at  $N_{design}$  and (3) VMA. They must also report: (1) laboratory density, (2) ignition or cold feed combined gradations, (3) Rice gravity, (4) laboratory air voids at  $N_{initial}$ ,  $N_{design}$ , and  $N_{max}$ , (5) fine aggregate angularity (FAA) and coarse aggregate angularity (CAA) on both cold feed and after ignition.

A 2 percent pay incentive for both a single test air void and the moving average of four will be applied between 3.5 percent to 4.5 percent. These tests will be for each 750 tons produced. Mix will be rejected for single test <1.5 percent or >7.0 percent and for moving average of four tests <2.5 percent or >6.0 percent.

Oklahoma - Changes to Oklahoma DOT Superpave specifications have been made based on AASHTO recommendations. The following changes have been made to mix design and mix composition:

- Compact laboratory specimen to  $N_{design}$  gyrations to determine the density at  $N_{design}$ . The density at  $N_{initial}$  should be back calculated from this specimen. A separate specimen should be compacted to  $N_{max}$  gyrations to determine the density at  $N_{max}$ .
- The ratio of percentage of material passing the 0.075 mm sieve to the effective asphalt content should be from 0.X (changed from 0.6) to 1.6 (changed from 1.2).

South Carolina - HMA QC/QA specifications based on "percent within limits" specification will be implemented in the January 2000 letting.

A polymer modified PG 76-22 is being specified on all interstate Superpave 12.5 mm surface courses to reduce the possibility of fatigue cracking.

A revised standard asphalt supplemental specification permits a maximum of 15 percent crushed glass in HMA base and binder course mixtures.

Texas - In-place density pay factors have been added to the Superpave specification. This change has helped in improving in-place densities.

A PG-plus specification for binders was adopted in 1998, which specifies the type of polymer for high PG grades.

Utah - The following changes have been incorporated in the 1999 IIMA specifications:

- Superpave design gyratory compaction effort has been changed from seven to four traffic levels as recommended by the FHWA Expert Task Group (ETG). The number of gyrations and percentages of Gmm for  $N_{initial}$ ,  $N_{design}$ , and  $N_{max}$  have also been changed according to ETG recommendations.

- Voids in the mineral aggregate (VMA) at  $N_{design}$  gyrations for the field mix have been changed as follows:

Mix	From	To
25.0 mm	13%	12.0 - 14.0%
19.0 mm	14%	13.0 - 15.0%
12.5 mm	15%	14.0 - 16.0%

- Calibration factor is required for each HMA design for field and region ignition ovens.

New Brunswick, Canada - Superpave mix design will be used on three contracts this year. Superpave PG binders will be used on approximately 25 percent of the contracts this year with a goal of 100 percent next year.

Use of a material transfer vehicle (MTV) to reduce segregation and improve smoothness will be a requirement on some contracts this year with other contracts offering a "incentive per ton if a MTV is used.

Ontario, Canada - The following specification changes are being implemented:

- End-result specification combining asphalt content, gradation, compaction, and air voids based on percent within limits has been completed and is being included in all contracts.
- Complete phase-i" of price adjustment will take place in 1999. Bonuses will be paid for greater than 95 percent within limits. Price reduction will be applied for marginal material. Each lot has ten 500-ton sublots.
- A "cw specification for visually defective mix is being developed. An interim specification was included on two contracts within each region to be constructed this year. A penalty of \$15/m<sup>2</sup> will be implemented for medium segregated patches.
- The two new end-result specifications for smoothness from last year are now combined into one for all surface courses.
- New specification for PG-graded asphalt is being implemented on all new contracts. Three basic PG-grades will be used within the province of Ontario. Changes in basic grade depend upon traffic conditions and extent of recycling. Consensus recompaction temperatures are to be enforced this year for hot mix acceptance testing.
- New longitudinal joint specification will be implemented in more trial contracts this year.

Australia - Agreement has been reached on a draft multigrade asphalt binder specification for hot mix asphalt (HMA) and sprayed sealing applications. Further work is being done on the development of a polymer modified bitumen specification. The Australian Asphalt Pavement Association is currently producing a national asphalt specification which includes asphalt materials, HMA design requirements, process control in production and placement of HMA, and quality control/quality assurance.

## 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 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. EFFECT OF FLAT AND ELONGATED COARSE AGGREGATE ON CHARACTERISTICS OF GYRATORY COMPACTED SAMPLES (Vavrik, Fries, and Carpenter)

Excessive amounts of flat and elongated (F&E) particles are generally known to have a negative effect on the design, construction, and performance of hot mix asphalt (HMA) pavement. This study was conducted to examine the effect of varying amounts of F&E particles on the compaction (volumetrics) and breakdown characteristics of the HMA mixtures.

Two coarse aggregates, dolomite and crushed gravel, were used in the study. The coarse aggregate particles were separated into three categories as follows:

- Greater than 5: 1 F&E (termed 5: 1)
- Less than 5: 1 but greater than 3: 1 F&E (termed 3: 1)
- Less than 3: 1 F&E (termed cubical)

An Illinois DOT modified Superpave volumetric mix design for high type traffic was used for both coarse aggregate mixes. The gyrations to 4 percent air voids were in the range of 90 to 100. The percentage of F&E particles was varied to produce four mixes for each coarse aggregate type as follows:

Mixture	Cubical	3:1	5:1
Cubical	100	0	0
50-50-0	50	50	0
30-50-20	30	50	20
70-0-30	70	0	30

All mixes were compacted to 100 gyrations with a Superpave gyratory compactor. Both volumetrics and breakdown of aggregate (degradation) during the compaction process were analyzed.

The following conclusions were drawn from this study:

- Increased levels of F&E particles give increased air voids in gyratory compacted HMA samples.
- Increased levels of F&E particles give increased VMA and VFA in gyratory compacted HMA samples.
- The gyratory compaction slope is increased with increased levels of F&E particles.

- Increased amounts of F&E give more breakdown and fracture of aggregate particles during gyratory compaction.
- Using soft F&E aggregates (dolomite is considered relatively softer or easily fractured than gravel in this study) caused breakdown of the coarse aggregate to produce a coarse fine aggregate which increased the void structure of the mixture. The breakdown was primarily noted in the percentages passing the 4.75 mm and 2.36 mm sieves.
- Using hard F&E aggregates (gravel) caused breakdown of the coarse aggregate to produce a void in the coarse aggregate structure. The breakdown was primarily noted in the percentage passing the 4.75 mm sieve.

### 2. DEVELOPMENT OF A METHOD FOR EARLY PREDICTION OF THE ASPHALT CONTENT IN HMA BY IGNITION TEST (Mallick and Brown)

The ignition test, developed by the National Center for Asphalt Technology (NCAT), has proved to be a fast, solvent free, and automated method of determining the asphalt content of an HMA sample. The time required to perform this test is about 30 to 40 minutes, which is significantly less than the time required to perform a solvent extraction test procedure. However, having the ability to determine asphalt content in 10- 15 minutes would allow the plant technician to identify any problem in mix production much earlier, and thus save a significant amount of time and money. This paper presents the results of a study carried out to develop a method for estimating the asphalt content of an HMA sample within 10 to 15 minutes after testing begins.

Several time versus loss in weight plots obtained during the ignition test were studied. Examination of the plot reveals that there are live distinct phases in the loss of asphalt binder from the mix. The first phase lasts for about nine minutes, during which there is very little loss. Between nine and ten to twelve minutes there is a significant loss in weight, after which follows a period of relatively constant

*(Continued on page II)*

## 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 "Research in Progress." It is updated frequently based on the information received from the Departments of Transportation and other sources.

*(PRACTICE, continued from page 10)*

weight. In the next phase, there is another significant loss in weight, and finally, when all of the asphalt binder is removed at the end of the test, the weight of the mix becomes constant with time. These five distinct phases were observed in the time versus loss in weight plot for most mixes with asphalt content equal to or more than 6 percent. In case of some mixes, this plot showed three phases only. In the first nine to ten minutes there is a very low rate of asphalt loss, after which the measured asphalt loss increases significantly between 10-12 minutes and 15-18 minutes, and then afterwards gradually becomes constant with time.

Observation of these typical trends in the ignition data led to this study to determine if it is possible to predict the final measured weight loss at some point in time before the end of the test.

The test results from four laboratories which participated in the NCAT ignition test method round robin study were analyzed to develop a method of prediction. Prediction factors were determined and applied to predict the asphalt content of gravel, limestone, traprock, and granite mixes. The predicted asphalt contents were reasonably close to the measured asphalt contents.

The method developed in this study and given in detail in the paper primarily consists of determining the prediction factor on the basis of test results from two samples and then predicting the asphalt content of additional samples on the basis of the prediction factor and the asphalt content loss at 10-15 minutes of test. Use of this method is expected to provide a good estimate of the measured asphalt content in less than half the test time. This short cut method should be used for quality control only and should not be used for acceptance or rejection of the mixtures.

### 3. NUCLEAR DENSITY READINGS AND CORE DENSITIES: A COMPARATIVE STUDY (Choubane, Upshaw, Sholar, Page, and Musselman)

During its field implementation of Superpave, the Florida Department of Transportation (FDOT) initially specified the use of nuclear density gauges in the backscatter mode for pavement density determination. Following the construction of the first major Superpave project, it was observed that the completed pavement was excessively permeable. A subsequent investigation indicated that the actual in-place air void contents based on roadway cores were significantly higher than those estimated based on the readings of the nuclear density gauge. This difference was attributed to the rough surface texture (macrotexture) of the coarse-graded Superpave pavement. At that point FDOT discontinued the use of nuclear gauges for acceptance on Superpave projects and changed the density specification to a core-based density procedure. This specification required that the pavement

be cored at a frequency of one core taken randomly per 300 m. FDOT also believed that a more thorough investigation of nuclear gauge density readings under field conditions was needed to further assess the potential use of the gauge as an alternative to cores for acceptance or quality control purposes. This study was undertaken to compare pavement densities obtained from nuclear gauges and cores.

Density data was gathered on an I-95 Superpave project using live nuclear density gauges. Cores were also obtained from this section. For comparison purposes, core densities were determined in accordance to (1) the Florida test method FM I-T 166 (Method A), (2) ASTM D 1188 using parafilm, and (3) by dimensional analysis (weight and dimensions of each core sample were directly measured). The Florida test method is similar to that of AASHTO T-166 procedure, with the exception of immersing test samples for a shorter time period (2±1 instead of 4±1 minutes).

All five thin lift nuclear density gauges consisting of four different models (two gauges were of the same model) were manufactured by the same company, and were operated in the back scatter mode. No sand was used to fill the pavement surface voids because according to the manufacturer the surface texture did not affect the gauge



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readings. Readings were obtained with each of the five gauge units at the exact locations where cores obtained.

The test data from five nuclear gauges and three core testing methods were analyzed statistically. The following conclusions were drawn:

- Regression analyses indicated good correlations among the three core density methods. The dimensional method resulted in statistically lower density values while the respective density results as determined using FM I-T 166 and ASTM D 1 188 were not significantly different based on Duncan's multiple-range test.
- The five nuclear density gauges did not **always** produce similar results and did not consistently correlate with the core densities.
- It is essential to **correct** the readings of all nuclear gauges, including the thin lift gauges, for the density of the underlying materials.
- The comparison of the test data obtained by two units of the same model nuclear gauge appears to indicate that **nuclear gauge density testing** may be highly **operator** dependent.
- It may not be appropriate, at the present time, to substitute the nuclear gauge in place of core density for acceptance purposes until **further studies** are conducted.

#### 4. COMPARISON OF LABORATORY WHEEL-TRACKING TEST RESULTS TO WESTRACK PERFORMANCE (Williams and Prowell)

Accelerated laboratory rutting prediction tests are needed for design as well as quality control/quality assurance (QC/QA) of HMA mixtures. Laboratory wheel tracking (LWT) devices could potentially be used to evaluate rutting potential for design and QC/QA applications. However, it is important to compare accelerated laboratory tests to full-scale pavement performance under controlled conditions. **WesTrack** (an oval test track in Nevada) provided a unique opportunity for this comparison.

Ten rehabilitated HMA test sections (placed in the summer of 1997) of the **WesTrack** were the focus of this study. Permanent deformation (rutting) measurements obtained after 582,000 10-KIP equivalent single axle loads (ESALs) were used. Only downward rutting (excluding the upward shoving resulting from shear flow) from the original pavement **profile** was considered. The LWT devices do **not measure the uplift (shove)** portion of the rutting but rather measure the downward rutting.

Samples for the LWT devices were removed from the **WesTrack** test sections longitudinally in the wheel paths prior to loading. Three LWT devices were used:



Aerial view of the NCAT oval test track showing grading work almost completed. This 1.8-mile test track is scheduled to be completed by the end of this year, when traffic application will begin.

*(PRACTICE, continued from page 12)*

- French Pavement Rutting Tester (FPRT)
- Hamburg Wheel-Tracking Device (HWTD)
- Asphalt Pavement Analyzer (APA)

The LWT devices were run according to the test criteria recommended by the manufacturers with the following two exceptions: (a) an increased hose pressure of 828 kPa and an increased load of 533 N was used in APA, and (b) a test temperature of 60°C was selected for the APA and FPRT (based on actual pavement temperatures recorded on WesTrack). It was felt that the combination of a steel wheel and 50°C would be severe enough for the HWTD.

The following conclusions were drawn and recommendations made from this study:

- The three laboratory wheel tracking devices correlated satisfactorily with the permanent deformation of the WesTrack test sections studied. The correlations were 89.9 percent for APA, 83.4 percent for FPRT, and 90.4 percent for HWTD.
- The devices, although not perfect in predicting and/or ranking test section performance, did exhibit increased variability with poorer performance in terms of rutting.
- Two very important test criteria need to be emphasized. The first criteria is proper selection of appropriate test temperature that reflects the in-service pavement temperature. The second criteria, not studied in this project, is the need to use a laboratory compaction which simulates compaction in the field. Studies are under way by the Federal Highway Administration to resolve the compaction issue.

##### 5. USE OF RECLAIMED ASPHALT PAVEMENT (RAP) IN SUPERPAVE HMA APPLICATIONS (Stroup-Gardiner and Wagner)

The implementation of the Superpave mix design method has encouraged the use of coarser HMA mixtures which require tight control of both the overall gradation and percent passing the 0.075 mm (No. 200) sieve. There is some concern that because reclaimed asphalt pavement (RAP) stockpiles may have widely variable gradations as well as high percentages of minus 0.075 mm material, its use in Superpave mixtures may be seriously limited.

This research project evaluated the possibility of splitting RAP stockpiles on 1.2 mm (No. 16) screen using the coarser RAP fraction in a typical 12.5 mm below the restricted zone Superpave gradation. The finer RAP fraction was used in an above the restricted zone 12.5 mm Superpave gradation. Two sources of RAP (Georgia and

Minnesota) were used so that a wide range of asphalt and aggregate properties would be represented.

While blinding of screens can occur during production when using this fine of a screen (1.2 mm), discussions with equipment manufacturers indicated this level of separation would be possible, given new developments in equipment technology.

Coarser RAP fractions showed a lower asphalt content and a lower amount of the material passing 0.075 mm (No. 200) sieve compared to the finer RAP fractions.

HMA mixtures containing different amounts of coarse and fine RAP fractions were compacted with a Superpave gyratory compactor for mix design.

The compacted HMA specimens were tested for resilient modulus, rutting (using the Asphalt Pavement Analyzer), and moisture susceptibility (using ASTM D4867).

Screening the RAP allowed up to 40 percent of the coarse RAP fraction to be used and still meet below-the-restricted zone Superpave gradation requirements. This was mainly due to the significant reduction in the finer aggregate fractions, especially the minus 0.075 mm material. The use of RAP in these mixtures resulted in a savings in the required neat asphalt of between 18 to 25 percent. A noticeable increase in mixture stiffness with as little as 15 percent RAP was seen. This change in mixture properties suggested that a softer grade of neat binder might be needed.

A maximum of 15 percent of the fine RAP fraction was used to produce an acceptable above-the-restricted zone Superpave gradation. The net savings in neat asphalt content was 25 percent. Little change was seen in tensile strengths due to the addition of this RAP fraction. However, there was a substantial increase in mixture stiffness at intermediate to warm temperatures. This increase was also seen as a 20 percent reduction in the APA rut depth when RAP was used.



Highway Engineers from People's Republic of China attended a training course in Stone Matrix Asphalt (SMA) Mix Design and Construction at the NCAT in March. The photograph shows the Chinese engineers with NCAT instructors.

## ASPHALT RELATED NCHRP PROJECTS

The following National Cooperative Highway Research Program (NCHRP) projects pertaining to hot mix asphalt (HMA) pavements are currently in progress or will be undertaken this year.

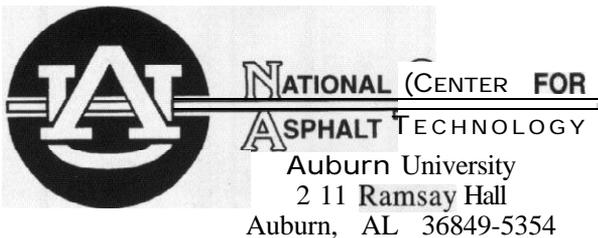
PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures (NCHRP I-371)	Hallin (ERES), Nichols, Consulting Engineers	400,000	December 2001	Develop and deliver with software the 2002 Guide for Design of New and Rehabilitated Pavement Structures based on mechanistic-empirical principles.
Superpave Protocols for Modified Asphalt Binders (NCHRP 9-10)	Bahia, Asphalt Institute	845,800	October 1999	Recommend modifications to the Superpave asphalt binder tests for modified asphalt binders.
Segregation in Hot-Mix Asphalt Pavements (NCHRP 9-11)	Stroup-Gardiner, NCAT	300,000	June 1999	Develop procedures for defining, locating, and measuring segregation and evaluate its effect on HMA pavement properties.
Incorporation of Reclaimed Asphalt Pavements in the Superpave System (NCHRP 9-12)	McDaniel, Purdue University	400,000	March 1999	Develop guidelines for incorporating RAP in the Superpave system.
Evaluation of Water Sensitivity Tests (NCHRP 9-13)	Epps, University of Nevada	150,000	March 1999	Evaluate AASHTO T-283 and recommend changes to make it compatible with the Superpave system.
Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification (NCHRP 9-14)	Kandhal, NCAT	400,000	April 2000	Determine through evaluation of the performance properties of HMA if the restricted zone requirement is redundant with fine aggregate angularity and volumetric mix criteria.

PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Quality Characteristics and Test Methods for Use in Performance-Related Specification of HMA Pavements (NCHRP 9-15)	Killingsworth, Fugro-Brent-Rauhut Engineering	450,000	December 2001	Identify construction-related and as-produced quality characteristics of HMA that affect long-term pavement performance. Select simple and practical tests that measure these quality characteristics and can be used in Performance Related Specifications.
Relationship Between Superpave Gyratory Properties and Permanent Deformation of Pavements in Service (NCHRP 9-16)	Contract pending	250,000	24 months	Evaluate Superpave gyratory compactor properties to predict rutting.
Accelerated Laboratory Rutting Tests: Asphalt Pavement Analyzer (NCHRP 9-17)	Contract pending	350,000	27 months	Evaluate APA test for predicting rutting potential of HMA.
Field Shear Test for Hot Mix Asphalt (NCHRP 9-1 81)	Contract pending	200,000	20 months	Enhance and refine the field shear test device for QC/QA of HMA production.
Superpave Support and Performance Models Management (NCHRP 9-19)	Contract pending	1,700,000	26 months	Develop and validate an advanced material characterization model for HMA.
Performance-Related Specifications for HMA Construction (NCHRP 9-20)	Epps, Nevada Automotive Test Center	1,500,000	January 2000	Develop performance related specifications for HMA construction and provide early field verification of the Superpave mix design method.
Validation of Performance-Related Tests of Aggregates for Use in Hot-Mix Asphalt Pavements (NCHRP 4-19 (02))	Contract pending	400,000	36 months	Evaluate by accelerated load tests and/or in-service pavement studies the validity of the aggregate tests identified in NCHRP 4-19.

# NCAT's FEBRUARY 1999 ASPHALT TECHNOLOGY COURSE ATTENDEES AND INSTRUCTORS



*Front Row, L-R: David Ross, Mack Mcgowin, Tim Melton, Thad Preslar, Christopher Sims, Durante Pryor, Daniel Dodd, Mickey Hebert  
Middle Row, L-R: Allen Cooley, Mike Law, Earl Coleman Jr., Drew Wilkie, William Flowers, Brad Benavides, Cliff Selkinghaus, Marvin Szoychen  
Back Row, L-R: Ken Kandhal, Henery Christian, André Jenkins, Zain Moloobhoy, Aaron Markham, David Lamm*



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