

# ASPHALT TECHNOLOGY NEWS

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## NCAT COMPLETES EVALUATION OF RELATIONSHIPS OF HMA IN-PLACE AIR VOIDS, LIFT THICKNESS, AND PERMEABILITY

The National Center for Asphalt Technology (NCAT) has completed National Cooperative Highway Research Program (NCHRP) Project 9-27, "Relationships of HMA In-Place Air Voids, Lift Thickness, and Permeability."

It is generally accepted that proper compaction of hot mix asphalt (HMA) pavements is vital for a stable and durable pavement. High air voids resulting from low in-place density allow water and air to penetrate into

the HMA pavement leading to an increased potential for water damage (stripping), oxidation, raveling, and cracking. Past research has shown dense-graded HMA pavements become excessively permeable at in-place air voids above 8 percent. However, recent studies have indicated that coarse-graded Superpave mixtures can be excessively permeable to water at in-place air voids less than 8 percent. Therefore, there is a need

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Placement of hot mix asphalt with different lift thicknesses for NCHRP Project 9-27

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## —NCAT Completes Evaluation

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to determine the minimum in-place density (maximum allowable air voids) needed for Superpave mixtures to achieve a relatively impermeable and durable HMA pavement.

Recent research conducted by the Florida Department of Transportation (FDOT) has indicated that HMA lift thicknesses can have an influence on density, and hence permeability. FDOT constructed several pavement test sections on Interstate 75 that included Superpave mixtures of different nominal maximum aggregate sizes (NMAS) and lift thicknesses. Results of this experiment suggest that increased lift thicknesses can lead to increased pavement density and, hence, lower permeability. The FDOT study suggested that a lift thickness ( $t$ ) to NMAS ratio ( $t/\text{NMAS}$ ) of 4.0 is preferred. In the past, a minimum  $t/\text{NMAS}$  of 3.0 has generally been used in the industry. Obviously, there was a need to evaluate this ratio based on NMAS, gradation, and mix type (Superpave and SMA) due to the potential problems of achieving the desired density in the field.

Another major concern that has come to the forefront since the adoption of Superpave is the proper method



*Cores obtained from test sections which used different lift thicknesses for 19 mm coarse-graded Superpave mix*

to measure the bulk specific gravity ( $G_{mb}$ ) of compacted HMA samples. Most Superpave mixtures that have been designed and placed on the roadway have been coarse graded. The currently accepted method for determining the  $G_{mb}$  is AASHTO T166. This method consists of first weighing a dry compacted sample in air and then obtaining the submerged and saturated surface dry masses. This procedure was usually adequate for the relatively fine-graded mixes used in the past. However, with the coarser gradations typically being used today, errors in  $G_{mb}$  measurements have been observed in some cases at typical in-place air void ranges.

The importance of the  $G_{mb}$  measurements lies in the fact that it is the basis for volumetric calculations utilized during both HMA mix design and construction. During Superpave mix designs, volumetric properties such as air voids, voids in mineral aggregate (VMA), and voids filled with asphalt (VFA) at the design number of gyrations are used to evaluate the acceptability of mixes. All of these volumetric properties are based upon  $G_{mb}$ .

In most states, acceptance of constructed pavement is based upon percent compaction. Pay factors, whether reductions or bonuses, are generally applied to percent compaction. Thus, the errors observed when utilizing AASHTO T 166 can significantly affect both the owner and the contractor.

The objectives of this major research project were (1) to determine the minimum ratio of lift thickness  $t$  and nominal maximum aggregate size ( $t/\text{NMAS}$ ) needed for desirable pavement density levels to be achievable, and thus impermeable pavements; (2) to evaluate the permeability characteristics of compacted samples at

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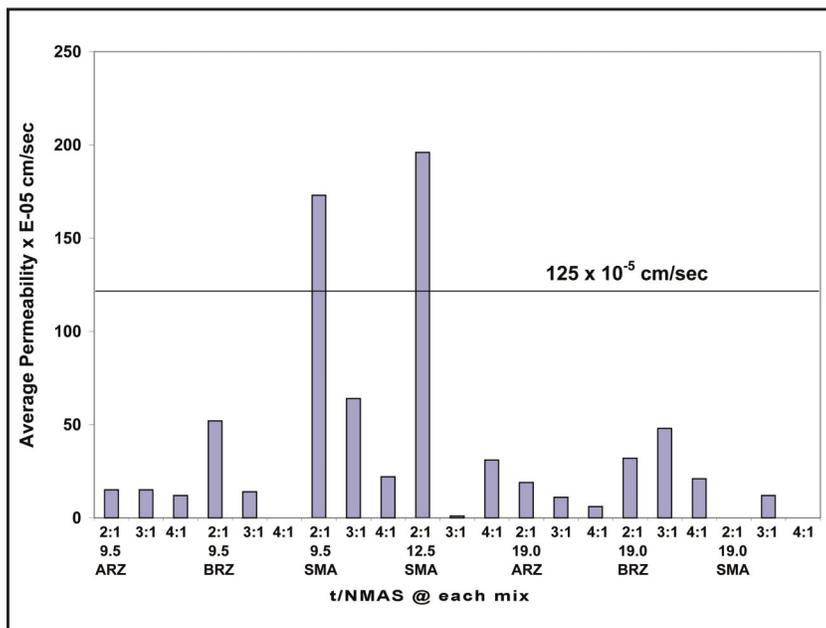
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different thicknesses; (3) to evaluate factors affecting the relationship between in-place air voids, permeability, and lift thickness; and (4) to recommend a proper method for determining the bulk specific gravity ( $G_{mb}$ ) of compacted HMA.

All four objectives of this research project are interrelated. Permeability has been shown to be related to pavement density. Increased lift thickness has been shown to allow desirable density levels to be more easily achieved. Permeable mixes tend to increase the potential for errors in  $G_{mb}$  measurements when using AASHTO T166.

The evaluation of the relationship between thickness, density, and permeability was conducted both in the laboratory and the field. Various HMA lift thicknesses were placed in a Superpave gyratory compactor and density determined. The variables included: 3 aggregates, 4 gradations, 3 nominal maximum aggregate sizes (NMAS) for Superpave mixes, and 3 NMAS for SMA mixes. After the mix designs were performed for these mixes they were compacted in the Superpave gyratory (100 gyrations) to  $t/NMAS$  ratios of 2.0, 3.0, and 4.0. The effect of  $t/NMAS$  on density was then determined. The plan was to select the  $t/NMAS$  that gave optimum density. However, the results did not provide a clear answer.

It was then decided to use a vibratory compactor. It was believed that the vibratory compactor would better simulate field compaction and would provide more reasonable answers. However, the test results from the vibratory compactor were also unable to provide a clear answer.



Effect of  $t/NMAS$  on permeability of compacted HMA at 7% air voids

Therefore, the effect of  $t/NMAS$  on compaction was evaluated in a field study where the lift thicknesses were varied and compacted under similar conditions. The NCAT test track was being rebuilt during this evaluation. All of the mixes to be placed at the track had to be evaluated in a test section prior to actual placement on the track. Seven mixes from the track were constructed on a paved surface adjacent to the track to look at the effect of lift thickness on density. A general description of these seven mixtures is provided in the table. The seven mixes were compacted at lift thicknesses varying from 2 to 5  $t/NMAS$ . For some of these seven mixes one side was compacted with vibratory roller and the other side was compacted with vibratory and rubber tire roller. The test data was evaluated and provided reasonable results for establishing minimum  $t/NMAS$ .

#### Mix Information for Field Density Study

Section	NMAS	Gradation	Asphalt Type	Aggregate Type
1	9.5 mm	Fine-Graded Superpave	Unmodified	Granite and Limestone
2	9.5 mm	Coarse-Graded Superpave	Unmodified	Limestone
3	9.5 mm	SMA	Modified	Granite
4	12.5 mm	SMA	Modified	Limestone
5	19.0 mm	Fine-Graded Superpave	Unmodified	Granite and Limestone
6	19.0 mm	Coarse-Graded Superpave	Unmodified	Granite

Another part of this field study examined the effect of lift thickness on permeability. Permeability tests were conducted in-place with a field permeameter and in the laboratory with a laboratory permeameter using core specimens from the seven test sections.

Based upon the results of this study, the following conclusions have been drawn.

- The ratio of lift thickness  $t$  and the nominal maximum aggregate size ( $t/NMAS$ ) is clearly related to the density that can be obtained under normal rolling conditions. For improved compactibility, it is recommended that the  $t/NMAS$  be at least 3 for fine-graded mixes and at least 4 for coarse-graded mixes. Ratios less than these suggested numbers can be used but it will likely require more compactive effort to obtain the desired density. Care must be exercised when the thickness gets too large to ensure that adequate density is obtained.

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## PUTTING RESEARCH INTO PRACTICE

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

### 1. WORKABILITY OF HOT MIX ASPHALT (Guddimettla, Cooley, and Brown)

One of the important issues in the HMA industry is the compactibility of mixes. This concern has arisen from the increased use of coarse-graded mixes and/or the increased use of polymer-modified binders, which are difficult to compact because of low workability. If the workability of a mix can be quantified, it will also indicate the compactibility of the mix.

The primary objective of this study was to develop a device to measure the workability of hot mix asphalt mixes. Workability was used in this study to describe the ease with which a HMA could be constructed. Based on the test results and analyses conducted in this study, the following conclusions were drawn:

- The prototype workability device developed in this study was successful in differentiating various mix characteristics. The workability of mixes was measured by pushing a paddle through hot HMA placed in a bucket and measuring the torque required to maintain a specific rate of revolution. Measurements can be made at different temperatures as the mix in the bucket cools down.

- The workability of HMA was affected by aggregate particle shape and angularity. Mixes prepared with a cubical, angular granite were less workable (required more torque at a given temperature) than mixes prepared with a semi-angular, crushed gravel.

- The workability of HMA was affected by the nominal maximum aggregate size (NMAS) of the mix. As the NMAS increased for a given aggregate type, gradation shape, and binder type, the workability decreased.

- Binder type significantly affected the workability of mixes. As expected, mixes containing a PG 76-22 binder were significantly less workable than mixes containing a less stiff, unmodified PG 64-22 binder for

a given temperature.

- As expected, the temperature of the mix significantly affected the workability of HMA. There was a relationship between workability and temperature that showed increased workability at higher temperatures.

### 2. EVALUATION OF NEW TEST PROCEDURES FOR DETERMINING THE BULK SPECIFIC GRAVITY OF FINE AGGREGATE USING AUTOMATED METHODS (Prowell and Baker)

Determining the bulk specific gravity of fine aggregate is very important when designing HMA mixtures and for other uses. The bulk specific gravity is used in calculating the voids in the mineral aggregate (VMA) of an HMA mixture. The current method of determining the dry bulk specific gravity (Gsb) of fine aggregates using AASHTO T 84 or ASTM C 128, uses a cone and tamp to determine the saturated surface-dry (SSD) condition of a fine aggregate. This method does not work well when determining the SSD condition of angular or rough fine aggregates because they do not readily slump. Therefore, a more accurate and more repeatable method of determining Gsb is needed to provide lower variability between operators and to address problems associated with angular materials. In order to solve this problem, a method that is more automated and less user dependent is needed to determine both Gsb and absorption of fine aggregates.

The objective of this study was to evaluate two automated methods for determining the Gsb of fine aggregates. Both methods were evaluated against the standard method described in AASHTO T 84. A round robin was conducted according to ASTM C 802 for each methodology. The round robin data were used to compare the Gsb, Gsa (apparent specific gravity), and absorption expected from a cross section of laboratories and materials. The round robin data were also used to develop a precision statement for each automated method.

The following two automated devices were evaluated:

- SSDetect. This device uses an infrared light source and detector to determine when the fine aggregate has reached the SSD condition.

- Corelok Device. This device uses a combination of a calibrated pycnometer and a vacuum-sealing device to determine Gsb and absorption.

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*NCAT Applications Steering Committee met at NCAT last December*

Six different aggregates were selected for the round robin testing. A wide variety of aggregates were chosen in an attempt to cover a wide range of material properties. A limestone, a medium and high dust diabase, a slag, a rounded sand, and a crushed gravel were selected for the study.

The following conclusions were drawn from this study:

- The CoreLok and SSDetect methods of determining fine aggregate specific gravity offer significant time savings over AASHTO T 84. Neither method requires the 16-hour soak period included in AASHTO T 84. This means that belt sweep samples of aggregates could be taken in a HMA plant to verify bulk specific gravities during construction for volumetric calculations in a timely manner.

- Both the Corelok and SSDetect methods generally produce Gsb results that are similar to AASHTO T 84. Where statistical differences occurred for Gsb between the new methods and AASHTO T 84, the differences were smaller for the SSDetect method. It is believed that AASHTO T 84 may not produce accurate results for angular materials with high dust contents. More frequent statistical differences exist between AASHTO T 84 and both the Corelok and SSDetect Gsa (apparent specific gravity) and water absorption results. However, Gsa and water absorption are not used in volumetric calculations for hot mix asphalt.

- The SSDetect offers improved precision as compared to AASHTO T 84. The precision of the Corelok method is not as good as AASHTO T 84. It is possible that the precision of the Corelok method will improve as technicians become more familiar with the procedure.

NCAT is planning to conduct a similar evaluation for the Gilson automated SSD device.

### **3. LABORATORY PERFORMANCE TESTING OF OGFC MIXTURES (Watson, Cooley, Moore, and Williams)**

A tentative mix design system was recently recommended by the National Center for Asphalt Technology (NCAT) for new generation open-graded friction course (OGFC) mixes. The new-generation OGFC mix has a coarser gradation than typically used in the past and includes fiber stabilizer and/or polymer modified asphalt binder to resist draindown. Polymer modified asphalt binder is also used to improve mixture durability and resist raveling.

Mix is compacted using 50 gyrations of a Superpave gyratory compactor and air void contents are determined by dimensional analysis. The Cantabro abrasion test is then conducted on unaged and aged (7 days at 60°C in a forced draft oven) samples. The Cantabro abrasion test is used in several European countries. A single Marshall compacted specimen is placed in a Los Angeles abrasion machine without the steel balls and is allowed to tumble in the drum for 300 revolutions. The resulting loss in mass from abrasion is then measured. An asphalt content that meets the following criteria is selected as optimum asphalt content.

1. Air Voids. A minimum of 18 percent based on dimensional volume is acceptable, although higher values are more desirable. The higher the air voids are, the more permeable the OGFC.

2. Abrasion Loss on Unaged Specimens. The  
*(continued on page 6)*

abrasion loss from the Cantabro test should not exceed 20 percent.

3. Abrasion Loss on Aged Specimens. The abrasion loss from the Cantabro test should not exceed 30 percent.

4. Draindown. Draindown should not exceed 0.3 percent by total mixture mass.

The objective of this study was to evaluate the laboratory performance of OGFC mixtures based on previous recommendations and, if necessary, refine the tentative OGFC mix design procedure developed by NCAT based on

results of the laboratory performance tests. The laboratory tests include a comparison of Cantabro test results for 50-blow Marshall and SGC compacted specimens; evaluation of a modified version of AASHTO T283 for moisture conditioning, which involved up to five freeze-thaw cycles and a comparison of the effect of fibers and polymer modified asphalt in reducing draindown.

Three aggregate types: granite, siliceous crushed gravel, and traprock were used for this study. Three Superpave performance graded asphalt binders were utilized: PG 67-22, PG 76-22 (SBS modified) and PG 76-34 (rubber modified).

The following conclusions were drawn from this study:

- The addition of fiber stabilizers significantly reduced the potential for draindown.
- Sample size did not significantly affect the Cantabro test results when comparisons were made between the 100 mm (4 in) diameter Marshall specimens and the 150 mm (6 in) diameter SGC samples.
- Unconditioned SGC samples should have Cantabro stone loss of no more than 20 percent. Since there is no significant difference between unaged and aged sample results, the aging procedure is not necessary.
- Results from this study show no significant difference in tensile strength when 1, 3, or 5 freeze-thaw cycles are used in the moisture conditioning procedure. Therefore, only one freeze-thaw cycle is needed.

#### 4. DETERMINING AIR VOIDS CONTENT OF COMPACTED SMA MIXTURES (Xie and Watson)



*Attendees of the meeting of the Task Group on Perpetual Pavement. Sitting (L to R): Dave Newcomb, Jim Musselman, Dave Timm, and Dean Weitzel. Standing (L to R): Brian Prowell, Prithvi Kandhal, Ray Brown, Joe Mahoney, and Harold Von Quintus.*

Stone Matrix Asphalt (SMA) has been used successfully in the United States since its first introduction in 1991. SMA uses a larger proportion of coarse aggregate compared to conventional dense graded mixtures. The resulting coarse texture of an SMA mixture may result in more internal air voids connected to surface voids (texture) than conventional mixtures although the volume of air voids is the same. Consequently, it becomes difficult to define the volumetric properties of compacted SMA mixtures. It is believed that volumetric properties of compacted SMA, especially the air voids content, are the most important parameters for determining the long-term performance of SMA pavement. Air void content in compacted SMA mixture is calculated from the bulk specific gravity and the maximum theoretical specific gravity of the mixture.

The standard method currently used to measure the SMA bulk specific gravity is AASHTO T 166, *Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens*, commonly known as the saturated surface dry (SSD) method. Another alternative method recently used is the CoreLok method.

The objective of this study was to compare the CoreLok and SSD methods for determining the bulk specific gravity of compacted SMA mixtures, and consequently the mix design volumetric properties especially air voids content.

Five aggregates with a range of LA abrasion loss from 17 to 36 percent were selected for the study. Three nominal maximum aggregate size (NMAS) mixtures were selected: 19 mm, 12.5 mm, and 9.5 mm. All the

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samples were compacted by a Superpave gyratory compactor (SGC) at 100 gyrations.

The CoreLok method uses a vacuum-sealing device. Under vacuum a plastic bag tightly conforms to the sides of the sample and prevents water from infiltrating into the sample. The volume of the specimen encapsulated by the bag is considered as the bulk volume of the sample.

The following conclusions were drawn from this study:

- There is a significant difference between air voids content measured by the SSD method and the uncorrected CoreLok method. The difference in air voids between these two methods had a range from 0.4 to 4.6 percent with a maximum air voids content of 7.1 percent by the SSD method. The uncorrected CoreLok method provided an average of 1.3 percent higher air void content than the SSD method.

- The difference between these two methods depends on air voids level and the NMAAS. As the air voids level increases, the difference between the two methods increases as well. With an increase in the NMAAS, the difference between the two methods increases also.

- The CoreLok method was found to have a system error that overestimated the air voids content at zero to very low air void levels. The correction factor for the machine used in this study was determined to be 0.5 percent. The correction factor for each machine used in the CoreLok method should be determined by testing a solid metal sample that is approximately the same size and shape as the asphalt specimen to be tested.

- The difference between corrected CoreLok and SSD results was found to be within one percent air voids for all 9.5 mm NMAAS mix samples. The difference between the two methods was more than one percent

air voids for 19 mm NMAAS samples with air voids greater than 3.7 percent, and for 12.5 mm NMAAS samples with air voids greater than 5.6 percent.

## —NCAT Completes Evaluation

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- The relationship between permeability and t/NMAAS is illustrated in the figure on page 3. The results were mixed concerning the permeability of coarse-graded (below the restricted zone or BRZ) and fine-graded (above the restricted zone or ARZ) mixtures. In some cases there appeared to be no difference and in others the coarse-graded mixtures appeared to have higher permeability. Most work that has been done indicates that coarse-graded mixes become permeable at a lower void level than fine-graded mixes.

Permeability testing needs to be conducted on local materials to develop an understanding of the effect of air voids, NMAAS, and grading on permeability. If permeability appears to be a problem consideration should be given to making permeability a part of the specification requirements.

- Four test methods were evaluated to determine the bulk specific gravity of HMA: the dimensional method, the gamma ray method, the water displacement method (AASHTO T166), and the vacuum-sealing method.

When laboratory prepared samples having low levels of water absorption were evaluated, the dimensional method resulted in the highest air void contents followed by the gamma ray method. The vacuum-sealing and water displacement methods resulted in similar air void contents when the water absorption level was low.

At low levels of water absorption, the water displacement method is an accurate measure for bulk specific gravity. The error develops when removing the sample from water to determine the saturated, surface-dry weight. The allowable absorption level to use the displacement test method is now 2 percent in AASHTO T166 but this can create accuracy problems according to this study. This number should probably be reduced to 1 percent or even lower for better accuracy. However, it is recommended that the absorption limit for the water displacement test method be set at 1 percent due to practical considerations.

For mix design samples and other laboratory samples that are compacted to relatively low voids, the displacement method will provide reasonably accurate answers. However, for field samples where the void levels will typically be 6 percent or higher, the vacuum-sealing method may often need to be used.

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## 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.*

### Colorado (Bill Schiebel, Colorado DOT)

Colorado is interested in any agency experience or any field performance data comparing projects built with polymer modified binders and projects built with acid or chemically modified binders. Are any other agencies taking action to limit the use of chemically modified binders in Superpave mixtures?

### South Carolina (Milton Fletcher, South Carolina DOT)

How are other states dealing with the issue of acid modified binders? Are restrictions being placed on all binder testing to minimize their use, such as an elastic recovery specification, or are the restrictions such that no acid modification is allowed at all?

### NCAT (Prithvi "Ken" Kandhal, Associate Director Emeritus)

Since 1992, the National Center for Asphalt Technology (NCAT) has conducted extensive research on different techniques of constructing longitudinal joints. The objective was to recommend techniques which give durable longitudinal joints. NCAT Research

### PROFESSOR TRAINING COURSE IN ASPHALT TECHNOLOGY

NCAT has written and published an up-to-date college textbook on asphalt technology. NCAT has also developed a training program for college and university civil engineering faculty that will allow them to offer state-of-the-art undergraduate and elective courses in asphalt technology. This 8-day intensive course is conducted at NCAT in June every year. It will be held on June 15-24 this year. The course has been updated to include Superpave binder and mix technology, and stone matrix asphalt (SMA). Some financial assistance in attending this course is possible. Please call NCAT at (334) 844-NCAT for brochure or information or visit our web site at <http://www.ncat.us>.

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Reports 97-4 and 02-03 pertaining to this research can be downloaded free from our website, <http://www.ncat.us>. The main conclusions from this research project are as follows:

- The longitudinal joints with high densities right at the joint generally show better performance than those with relatively low densities. Highway agencies should specify minimum compaction levels to be achieved at the longitudinal joint to ensure good performance. It is recommended that the density right on the joint be not more than two percent lower than the density specified in the lanes away from the joint.
- Application of rubberized asphalt tack coat on the unconfined edge of the first paved lane resulted in a durable longitudinal joint.
- The Michigan notched wedge joint (12.5 mm vertical offset and 12:1 taper) has a good potential of obtaining a satisfactory longitudinal joint.

NCAT would like to ask the highway agencies what steps they have taken in recent years for obtaining a durable longitudinal joint. Please report the techniques and related specification criteria implemented. This will facilitate exchange of ideas on this important subject, which will be published in the next issue of the **Asphalt Technology News**.

## ASPHALT FORUM RESPONSES

*The following responses have been received to questions raised in the Fall 2003 Asphalt Forum.*

*What are the experiences of other states with the fine aggregate angularity (FAA) requirement in Superpave mixture design? We are interested in finding out if ASTM C1252 Method A has been preferred or if alternate methods/technologies have been used for evaluating the fine aggregates. Have some agencies discontinued the FAA evaluation? (Ed Johnson, Minnesota DOT)*

### **Colorado (Bill Schiebel, Colorado DOT)**

Colorado continues to require FAA minimum of 45. We use AASHTO T304 for determining the FAA value.

### **Indiana (Tommy Nantung, Indiana DOT)**

We require that the fine aggregate angularity value of the total blended aggregate material and recycled materials should meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure.

### **Kansas (Dick McReynolds, Kansas DOT)**

The Kansas DOT conducted research prior to Superpave to adopt the original angularity test method (ASTM C1252) for field use with Marshall mixes. The Kansas Test Method KT-50 "Uncompacted Void Content of Fine Aggregate" proved extremely successful because it allowed aggregate suppliers, contractors, and the Kansas DOT field staff to determine angularity in about 30 minutes. The test method uses a volumetric flask to determine the equivalent specific gravity required by the standard test method. When Superpave was implemented, further research was done to confirm that the test method would also work with mixed fine aggregates (including limestone). The test method is still in routine use.

### **Kentucky (Allen Myers, Kentucky Transportation Cabinet)**

Kentucky utilizes AASHTO T304 (Method A) for determining FAA values. We test our asphalt mixtures for FAA at the laboratory design stage only, and our FAA requirements are very similar to AASHTO MP2 with one minor exception: for projects with less than 0.3 million 20-year ESALs, we require a minimum FAA of 40 for mixtures located both  $\leq 100$  mm and  $> 100$  mm from the surface.

### **New Mexico (John Tenison, New Mexico DOT)**

AASHTO T304 (Method A) is used to determine FAA for hot-mix asphalt aggregates. We have not discontinued its required use and have no plans in the future to do so.

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

Maine uses AASHTO T304 (Method A) for testing the "uncompacted void content of fine aggregate" for Superpave mixtures. We do not use the ASTM C1252. To date, we have not experienced any problems with our aggregates meeting the minimum FAA values required for Superpave designed mixes.

### **Missouri (Mark Shelton, Missouri DOT)**

Missouri uses AASHTO T304 (Method A) for determining FAA and all of our crushed material generally have FAA values equal to or above 45 percent. A large percentage of our Superpave mixtures have the 45 percent minimum requirement, and therefore, few contractors have looked at blending rounded natural sands in order to develop a mixture that compacts more easily.

### **Nebraska (Laird Weishahn, Nebraska Department of Roads)**

Nebraska uses AASHTO T304 (Method A) and we have actually increased our FAA requirements for lower traffic level mixtures due to the abundance of natural sands and rounded river gravels in Nebraska. The river gravels mostly have to be crushed to meet the FAA requirement.

### **Nevada (Michael Dunn, Nevada DOT)**

We have very limited experience with evaluating fine aggregates using the Superpave system. Over the last two years we have only constructed four Superpave test sections and the fine aggregates were evaluated using AASHTO T304. In each case, the FAA barely met the minimum requirement.

### **New Hampshire (Alan Perkins, New Hampshire DOT)**

We use AASHTO T304.

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*Mississippi DOT (MDOT) and HMA industry personnel visited NCAT Test Track and laboratory facilities in April. The DOT personnel included: Wayne Brown (Chairman of the Mississippi Transportation Commission); Butch Brown (MDOT Executive Director); Harry James (MDOT Chief Engineer); Joy Portera (MDOT Assistant Chief Engineer, Operations); David Foster (MDOT Assistant Chief Engineer, Preconstruction); Melinda McGrath (MDOT Assistant Chief Engineer, Maintenance); Randy Battey (MDOT State Research Engineer); and Richard Sheffield (MDOT Assistant State Materials Engineer). The group is seen here examining the two Mississippi test sections on the NCAT Test Track.*

#### **New Jersey (Frank Stia, New Jersey DOT)**

The New Jersey DOT uses AASHTO T304 (Method A) which is similar to the ASTM method C1252.

#### **South Carolina (Milton Fletcher, South Carolina DOT)**

South Carolina has only used FAA as a tool to assist in the approval of Superpave mix designs. ASTM C1252 (Method C) has been utilized with good success, but we have noted that this procedure could eliminate known angular material.

#### **West Virginia (Richard Genthner, West Virginia Division of Highways)**

As noted in the **Specification Corner**, we are lowering the requirement for FAA to 43 percent for blends comprised of 100 percent crushed aggregate. We have experienced some problems with a couple of limestone sources that would not always meet the 45 percent requirement. These were sources that had provided quality, rut-resistant mix designs for several

years, so we did not feel comfortable in limiting their use based solely on the FAA criteria.

#### **Ontario (Kai Tam, Ontario Ministry of Transportation)**

A minimum FAA value of 43 is acceptable.

### **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.ncat.us>). 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.

## HOT MIX ASPHALT TECHNOLOGY - 50 YEARS AGO

Asphalt technology papers published many years ago make an interesting and informative reading. Sometimes, it seems we are trying to reinvent the wheel.

The following are excerpts from the Proceedings of the Association of Asphalt Paving Technologists (AAPT), Volume 23, 1954. We hope you will find them interesting. The comments in parentheses are those of the editor (Prithvi “Ken” Kandhal).

### **F.B. Odasz and D.E Nafus, “Statistical Quality Control Applied to an Asphalt Mixing Plant”**

“At the present time, a great deal of sampling and testing is being done in asphalt paving work. Besides the Marshall tests, this work takes the form of tests for voids content, analysis of the mix for asphalt content, screen analyses, the Hubbard-Field test and others. How much more wisely these results could be used! How much better basis for action the same, or even a lesser, amount of work would provide if the data were used in the form of control charts than just a running record!”

“Statistical quality control chart is a simple and useful tool that will signal the user when something is wrong and provide him with a basis for action to rectify the situation and control the variability of the process. Prompt and directed action will reward him with an economic advantage by reducing waste motion and material, and by assuring consistent operation at high quality.”

*(This paper illustrates the use of control charts for quality control of HMA. Individual test results are*

*plotted on the charts which show the job-mix formula target value, lower control limit, and upper control limit. Whereas some states have used these charts for a number of years, others have just started to use them in their quality control/quality assurance program.)*

At this AAPT meeting held in Louisville, Kentucky, a symposium titled “Control of Plant and Paving Operations in Asphalt Concrete Surface Construction” was also held. Some interesting observations were made during this symposium.

**Roger Martin**, who chaired the symposium, made the following introductory remarks:

“We are assembled today to discuss these problems from the “how-to-do-it” standpoint, more effective control in plant manufacture, and more efficient laydown methods. After we have exchanged information along this line, possibly, some of the more brilliant members will turn their thoughts toward rational evaluation of plant manufacture and laydown techniques. Questions pop into your mind in rapid-fire order. What is the exact mechanism of internal moisture in aggregates, which seemingly defies all laws of nature by running out the back end of a truck containing hot mix at a temperature 75°F above the boiling point of water? What is the boiling point of water in the capillary spaces? Does its heat of vaporization differ appreciably from that of surface water? What is the relation between

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## PAMELA TURNER JOINS NCAT

Pamela Turner joined the NCAT staff, as a laboratory engineer, in March. Pamela received her Bachelor’s degree in Civil Engineering from the University of Kentucky in 1996. While attending UK, she worked as a co-op student at the Asphalt Institute laboratory. After completing her degree, she accepted a full-time position with the Asphalt Institute as a Materials Engineer, focusing primarily on asphalt binder testing. Pamela is experienced in all aspects of asphalt binder testing, including conventional test methods and the Superpave system. She has participated in many research projects, both at the national level and for private clients, and has supervised the everyday activities of one of the premier asphalt binder testing facilities in the country. Although her primary field of expertise is asphalt binder testing, Pamela is also familiar with the Superpave mix design system, Superpave performance tests, and many other asphalt related tests.



*Pam Turner*

the time required for this water to dissipate itself and the size of the rock and the nature of the rock? A roller will shear and “squash” a pavement at too high a temperature, but over a certain range of temperatures the aggregate will “lock” and satisfactory compaction takes place. If it is rolled after it is too cool, permanent cracks are created. What method can be found to establish, in advance, the optimum rolling temperature limits? These are only a few of the questions which need to be answered.”

**W.H. Campen:** “It is my opinion that the Chief Inspector at the plant ought to really know asphaltic mixes. He ought to know bituminous mixes, from the bottom up. He ought to know how to analyze them. He ought to know if they are right when he looks at them. As far as the contractor is concerned, he ought to have good enough men at the plant so that they can keep the mix the way it has been set up for them. The contractor shouldn’t expect the inspector to guarantee his mix. In other words, the inspector can see that the mix is set right and then the contractor has to more or less keep it that way.”

*(Those were the days when the highway department inspector more or less controlled the asphalt plants.)*

**Roger Martin:** “Every time I hear this argument about batch plants and continuous plants I feel that it is a “tempest in a teapot.” Everybody gets good results with both of them. I think the main factor is the men running the plant. That is more important than what kind of plant you have.”

*(This still applies to batch plants and drum plants.)*

**George Birney:** “I think one tool that should be highly recommended is a pick handle on the back of a screed of a paving machine for those individuals who are anxious to jiggle that screed up and down. Another thing I have noticed on the spreading machine is that the operator will keep his feeding pan that leads into the hopper wide open, causing an uneven flow of mix to the screed.”

**W.H. Campen:** “Last year I was called to a project where an asphaltic concrete mixture was being prepared in a continuous mixing machine. After the mixture was given a preliminary rolling, it was allowed to cool for about 20 minutes. When rolling was resumed, the mixture was so unstable as to shove and flow out from under the roller. An investigation revealed a very absorptive aggregate. As the mixture came out of the mixer, water vapor issued from it. We finally attributed

the lack of stability to condensed water vapor which became entangled in the mixture and prevented adhesion and cohesion.”

*(This aggregate had a water absorption of 5 percent.)*

**D.D. Dagler:** “Years ago a plant would put out three or four hundred tons in a ten-hour day and the contractor had two rollers on the job. Now he puts out a thousand tons a day and he adds another roller and he thinks that is sufficient. You just don’t get it and you just don’t get the workmanship.”

**J.J. Forrer:** “I have had the opportunity of looking on both sides of the fence, on the highway department’s point of view and now on the contractor’s point of view. I’ve had to change my views somewhat since I have been working on the contractor’s side. I have found that if the highway engineer could more clearly specify the end results that he wants, the contractor can get that for him and probably at less cost to the taxpayers than putting a whole lot of these gadgets and things like that on asphalt plants. I’ve seen these gadgets used and must say that the plants today are vastly improved over the first one I saw operated in 1912 in Memphis.”

“The point that I am trying to get at is I am wondering if we shouldn’t begin to think about a change of procedure; that is leave it up to the contractor. Say to him, “I want this. It’s up to you to get it. If you want to make your mix in a concrete mixer, go ahead. I am looking to you for a result in the end.” That procedure may be a little bit extreme and I purposely painted it extreme but I think that a good contractor can get the excellent results the highway engineer

wants without too much additional refinements on the equipment. It makes no difference whether he gets that from continuous mix or batch mix, or whether he does it with a wheelbarrow or the newest equipment.”

*(Now, that is called “end result specification” these days, which is being adopted or considered by many state DOTs.)*

## NCAT HAS NEW DOMAIN NAME

NCAT has a new domain name, to make it easier to find our web page. <<http://www.ncat.us>> is the new address, but you can also reach our web page by going to our old address, <<http://www.eng.auburn.edu/center/ncat/>>.

## SPECIFICATION CORNER

**Alabama** - Effective in April this year, the Alabama DOT is adopting the locking point mix design concept – similar to that used by the Georgia DOT. The locking point is where the sample being gyrated loses less than 0.1 mm in height between successive gyrations. The specifications require the locking point to be between 60 gyrations and the design number of gyrations. If the mix locks up outside this range, either 60 or the design number of gyration are used instead of the locking point.

After the locking point for the aggregate structure is determined, the optimum asphalt content is refined using the locking point as the new design number of gyrations. This approach is being taken to increase the overall asphalt contents in Superpave mixtures.

**Colorado** - Last year, the Colorado DOT made changes to the method of establishing production targets on all HMA projects with the purpose of increasing the asphalt content in the mixes. The historic Superpave mix design remains the same, but production targets for asphalt content, VMA, and other parameters are established based on the mix design data after a shift down in voids of up to 1.0 percent. This method helps ensure that the voids in produced HMA are filled with asphalt binder rather than other material.

Full incentive/disincentive specifications that impact payment for all HMA placed on the project were adopted last year. These specifications include longitudinal joint density requirement, which was necessitated due to inadequate performance of joints in the state. A target density of 92 percent is required at the longitudinal joint with a tolerance of “ 4 percent. The new joint density specification increased the overall density and decreased the variability during last year. The performance of ten projects before and ten projects after the new specification was adopted, is being tracked.

The Colorado DOT has begun to develop a pavement segregation specification. Segregation has also long been a major concern both to the DOT and the industry in the state. A pilot specification will be used this year to gather density profile data using methods similar to those used in Texas and Washington.

The Colorado DOT has banned the use of acid and alkali modification of binders for all 2004 projects. Detection methods are currently being finalized, and include pH and X-ray methods. Comparison testing of binders containing acids and polymers is being conducted using the Hamburg wheel device.

A pilot project of testing aggregates using the Micro Deval test has also begun.

**Kansas** - Since January 2001, only major Superpave projects had provisions for bonus and payment deduction for air voids and density based on percent within limits (PWL). Starting in October 2003, PWL specifications for air voids were added to all Superpave projects. Based on a review of data from the completed projects, the acceptable range for air voids was changed from 2.75-5.25 percent to 3.0-5.0 percent.

**Kentucky** - It is planned to publish a new specifications manual in March this year that contains several changes to HMA requirements. The major revisions involve the HMA acceptance program. The present payment schedule will be divided into three schedules depending on the method of density acceptance. The payment schedule for VMA will be modified to permit a three percent bonus for values above the AASHTO MP2 specified minimums and full pay for values down to 0.5 percent below the MP2 minimums. The payment schedules for air voids and lane density will correspond to the applicable ESAL level. A linear payment schedule will be introduced for air voids such that each 0.1-percent change in air voids results in a one-percent change in pay. A payment schedule for joint density for surface mixtures has also been implemented. Finally, a procedure has been standardized for determining when HMA with substandard properties should be removed and replaced versus accepting that pavement in place with a reduced pay factor.

**Missouri** - Missouri's Standard Specifications have been reviewed and revised. The new specifications will be effective in July this year. The specifications were reviewed to incorporate performance-related criteria and quality control and quality assurance (QC/QA), where possible. Some of the revisions are: (a) addition of tensile-strength ratio (TSR) for plant-produced HMA; (b) elastic recovery requirement for asphalt binders based on the spread between the upper and lower temperature gradings; (c) an acid insoluble residue requirement for aggregates used in HMA surface mixtures for high traffic pavements; and (d) requirement to conduct dry back procedure when the Rice test is conducted on a mixture containing aggregate with more

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than 2 percent water absorption.

The new "Performance Specifications" can be viewed at <<http://www.modot.mo.gov/design/specbook/perfiles.htm>>.

**Nebraska** - The HMA specification now has tolerance limits for VMA of the plant-produced mix. The minimum VMA is based on Superpave specifications. If two consecutive individual VMA values are below the minimum by more than 0.75 percent, the HMA payment will be reduced by 20 percent.

**Nevada** - The PG76-22NV asphalt binder has been used in the southern part of Nevada for the last two years. Preliminary results indicate that this binder is outperforming the conventional asphalt cements (AC-30 and AC-40) used in the past. Starting in 2004, the AC-20P binder will be replaced with PG64-28NV binder in the northern part of Nevada to have a uniform binder specification throughout the state.

**New Hampshire** - QA specifications will now be

applicable to thin asphalt overlays as well. Characteristics to be measured are: gradation, asphalt content, and in-place voids.

**New Mexico** - The Micro-Deval Apparatus (AASHTO TP 58) is being evaluated to establish maximum percent loss that will be allowed for HMA, concrete, and aggregate base course materials. This evaluation should result in a specification requirement for the 2005 construction season.

An IRI based smoothness specification has been adopted that will be used during the 2004 construction season. Initially, the 100 percent pay band will be set to 62.0 inches/mile but will be reduced by 2.0 inches/mile per year to 56.0 inches/mile by the 2007 construction season for all new and reconstruction projects. The 100 percent pay band for all pavement preservation and rehabilitation construction projects is 6.0 inches/mile higher than that for new and reconstruction projects.

**Oregon** - After the Superpave control points were introduced for HMA gradation, a trend toward finer

## NCAT's Asphalt Technology Course March 1-5, 2004



**Back, L-R:** Myles Tatum, Robert James (Instructor), Ron Elrod, Don Chappel, Clint Andrews, Doug Hanson (Instructor)  
**Front, L-R:** Don Watson (Instructor), Aaron Warren, James Dowland, Wen Hsiao, Ronald Martinez

gradations with more sand and excessive minus 200 sized material has been observed. This has resulted in the production of mixes, which are believed to have poor long-term durability and stripping resistance. To address this concern, dust to effective asphalt content ratio (0.8 to 1.6) has been added as a specification requirement during production. More restrictive dust to effective asphalt content ratio requirements are being considered when the percentage passing the No. 8 sieve exceeds 38 percent.

**Rhode Island** - An open-graded asphalt friction course (OGFC) mix is being developed based on the current NCAT pooled fund study. Work is continuing to develop a chemically modified, low viscosity crack sealer with fibers, that can be applied at a temperature of about 300EF.

**South Carolina** - South Carolina is in the process of revising and updating the Standard Specifications, which are scheduled to be published in January 2005. It is proposed to use the Superpave gyratory compactor for all mix designs in the state. This involves maintaining the present gradation limits on all mixes and switching to the gyratory compactor instead of the Marshall hammer.

Other key issues in the specification will include the allowance of reclaimed asphalt pavement (RAP) in high volume surface mixes that utilize the PG 64-22 binder and incorporating an asphalt plant certification procedure that will replace the AASHTO M 156 requirements of the current specification.

**West Virginia** - The fine aggregate angularity (FAA) requirement is being lowered from 45 to 43 percent for blends comprised of 100 percent crushed aggregate. Some problems were experienced with a couple of limestone sources that would not always meet the 45 percent requirement. These sources have provided quality, rut-resistant mix designs for several years.

#### **Ontario Ministry of Transportation**

1. It is planned to use Ontario's new special provision for SMA on all new contracts with more than 30 million ESALS (during 20 years' design life).

2. It is proposed to develop a new IRI-based smoothness specification utilizing lightweight profilers for trial contracts starting in the 2005 construction season.

3. An end-result specification for acceptance of surface course thickness using 50 mm cores and another using a nondestructive test method is currently being

used on trial contracts. Two test methods have also been finalized in conjunction with these specifications to measure layer thickness using nondestructive methods. Two trials have been completed successfully and up to eight additional ones are planned for this year.

4. An end-result specification for longitudinal joint compaction is being developed for use in 2004 HMA paving contracts.

5. A material (and a modified construction) specification for a Superpave 25 mm "rich bottom" mix has been developed. This will be used for pavements to be constructed this year, which will be based on the perpetual pavement design concept.

## **INTERNATIONAL SYMPOSIUM ON LONG-LASTING ASPHALT PAVEMENTS**

An international symposium on Design and Construction of Long-Lasting Asphalt Pavements will be held in Auburn, Alabama June 7-9, 2004. The International Society for Asphalt Pavements (ISAP) is the primary sponsor of this specialty conference. The National Center for Asphalt Technology (NCAT) will host the conference in Auburn, Alabama (100 miles southwest of Atlanta, Georgia). The conference is also co-sponsored by the Federal Highway Administration, the National Asphalt Pavement Association, and the Alabama DOT. The objective of this conference will be to address materials, mix design, and construction procedures to ensure long-lasting (perpetual) asphalt pavements. Topics will include: perpetual pavement design, materials and mix design, quality control/quality assurance, construction issues, contracting methods, and other related subjects. On-line registration is available through the NCAT website, <<http://www.ncat.us>>. For additional information concerning the conference, contact ISAP at <[isap@eng.auburn.edu](mailto:isap@eng.auburn.edu)> or call (334) 844-6228.

## NCAT's Asphalt Technology Course February 2-6, 2004



*Back, L-R: Jason Hale, Doug Hanson (Instructor), Brian Prowell (Instructor), Josh Harvill, Bill Fogarty, Paul Gluszak, Bill Pinkerton, Ralph Kinder  
Front, L-R: Chris NeSmith (Instructor), Don Watson (Instructor), Bob Pelland, Bill Taylor, Robert Smith, John Bourda, Nick Andrade*



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