



# ASPHALT TECHNOLOGY NEWS

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## NCAT TEST TRACK AND NEW BUILDING UNDER CONSTRUCTION

The construction of the pavement test track and new building for the National Center for Asphalt Technology (NCAT) is progressing well.

The pavement test track near the Auburn University campus will be utilized by transportation agencies nationwide to facilitate the practical application of research designed to extend the life of flexible pavements. Managed by NCAT, the test track will provide a rare opportunity for sponsors to answer specific questions related to flexible pavement performance in a full scale, accelerated manner where results do not require laboratory scale extrapolations or lifelong field observations.

Funding for construction of the 1.7-mile (2.7-km) oval facility, built on 309 acres of land purchased by Auburn University, was provided by the Alabama Department of Transportation (ALDOT). The first phase of construction, which covered initial site work through completion of the subgrade, has been completed. The second phase was awarded to APAC's Couch Division and involves completion of the pavement structure through the experimental mixes. Work on the permeable asphalt base and dense-graded base and binder courses has been completed. Test sections consisting of 50 mm binder course and 50 mm wearing course are under construction. A state-of-the-art,  
*(Continued on page 2)*



*Aerial view of the 1.7-mile, oval NCAT Test Track after HMA base course construction was completed.*

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**E. Ray Brown, Director**

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



*NCAT Test Track showing the HMA plant at bottom right, and testing laboratory and truck maintenance buildings at top center.*

Sponsors typically fund research on two sections in order to compare life cycle costs of common paving alternatives. In this manner, they can rationally manage the public's investment in flexible pavements by choosing mixes that cost less over the life of the structure. For example, it is unwise to spend less on construction if the cheaper construction alternative results in a substantially higher life cycle cost. In addition to comparing alternatives for sponsors, NCAT is responsible for guiding the overall effort in a direction that will address global issues for the HMA industry as a whole. For example, can fine graded mixes perform as well as coarse graded mixes if both are proportioned in a manner consistent with established design criteria?

The following are specific mix attributes whose performance will be compared on the test track:

Coarse-graded, fine graded, and through restricted zone gradation of Superpave mixes; neat versus modified asphalt binder at optimum content and optimum plus 0.5 percent; stone matrix asphalt (SMA) versus Superpave mix using granite aggregate; and 12.5 mm versus 9.5 mm Superpave designed mixes.

The following are the global primary objectives which will be useful to the HMA industry:

- Effect of aggregate type (gravel versus stone versus blend)
- Effect of aggregate gradation (different gradations and maximum nominal sizes)
- Effect of mix type (SMA and dense-graded designed with Superpave technology)
- Asphalt binder (neat versus modified, design versus 0.5 percent higher asphalt content)

The following tests will be conducted on mixtures used in all test sections:

- Static and dynamic creep (confined and unconfined)

*(Continued on page 3)*

*(Under Construction, Continued from page 1)*

4,700-sq. ft. (440-m<sup>2</sup>) on-site testing laboratory has already been completed and is in operation.

Experimental sections on the test track are cooperatively funded by external sponsors, most commonly state DOT's, with subsequent operation and research managed by NCAT. Forty-six test sections are being installed at the facility, each at a length of 200 feet (60 m). Materials and methods unique to section sponsors are imported during construction to maximize the applicability of results. After construction has been completed, a design lifetime of truck traffic (10 million standard axle loads) will subsequently be applied over a two-year period. Unlike conventional efforts on public roadways, research at the NCAT pavement test track will be conducted in a facility where axle loadings will be precisely monitored and environmental effects will be identical for every mix. An array of surface parameters (smoothness, rutting, cracking, etc.) will be monitored regularly as truck traffic accumulates to facilitate objective performance analyses. State DOTs typically have to wait five to 15 years to obtain less reliable results in full-scale field studies on public roadways.

*(Under Construction, Continued from page 2)*

- Loaded wheel testing on laboratory compacted specimens and cores
- Gyrotory shear analysis (Corps of Engineers and Superpave gyrotory compactor)
- Indirect tension with temperature sweep
- Shear testing (repeated shear constant height)
- Frequency sweep shear testing at three temperatures
- Fatigue testing on rectangular beams

The following post construction evaluation will be conducted:

- Hourly temperature, moisture, weather data
- Truck ESALs logged continuously via VIS
- Weekly surface distress measurements
- Monthly profiles, falling weight deflectometer, and surface friction
- Periodic coring to monitor densification

Some of the questions we expect to be answered based on the performance of various test sections are as follows:

- Can existing test equipment and procedures be used to predict field performance in terms of rutting?
- Does the Superpave restricted zone for gradation correlate with performance?
- Do fine and coarse graded mixes provide similar performance?
- How does SMA perform compared to dense-graded mixes?
- How does the use of modified asphalt binders affect performance?
- How does aggregate type affect performance?
- How does a small change in asphalt content affect performance?



*NCAT Test Track — HMA Paving train constructing the base course*



*NCAT's new building under construction*

Besides the Federal Highway Administration, the highway agencies from the following states are sponsoring test sections: Alabama, Florida, Georgia, Indiana, Mississippi, North Carolina, South Carolina, and Tennessee.

The NCAT test track is the result of an industry and government commitment to work together to improve the quality of flexible pavement performance, thus maximizing the taxpayer's investment in America's roadway transportation infrastructure. The new facility is expected to clarify the relationship between methods and performance such that design and construction policy in the future can be objectively guided by life cycle costs.

The construction of NCAT's new administration and laboratory building is also on schedule, and will be completed in July. The facility is located in the City of Auburn's Technology Park, approximately five miles from campus. The new building will house administrative, laboratory, and training operations of NCAT. The total building area is 40,230 sq. ft. (3,700 m<sup>2</sup>) which is a significant increase compared to the existing NCAT facilities. The new building will have approximately 11,200 sq. ft. (1,040 m<sup>2</sup>) for offices, 17,500 sq. ft. (1,625 m<sup>2</sup>) for laboratories, 6,150 sq. ft. (570 m<sup>2</sup>) for training facilities (including an auditorium), and 4,900 sq. ft. (455 m<sup>2</sup>) for aggregate receiving and storage.

It will be exceptional to have all NCAT facilities at the two locations (test track and new administration and laboratory building). The NAPA Research and Education Foundation and Auburn University worked together to develop a funding plan for the building. The total package including site preparation, landscaping, and turnkey delivery will cost approximately \$3.6 million.

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

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## MINNESOTA STUDIES THERMAL CRACKING OF ASPHALT PAVEMENTS

**Shongtao Dai and Roger Olsen**  
Minnesota Department of Transportation

Asphalt pavement cracking due to cold temperatures or temperature cycles is a serious and extensive problem in Minnesota. Pavement cracking resulting from cold temperature is referred as low temperature cracking, while cracking due to temperature cycling is referred as thermal fatigue cracking. Cracks allow water to enter into the base underneath the asphalt pavement, which may cause pumping of the base material. The pumping eventually results in a depression at the crack. Also, deicing solution such as salt can enter into the cracks during winter months and cause localized thawing of the base and a depression at the crack. Furthermore, water entering the crack may freeze, which may form an ice lens. The ice lens can produce upward lipping at the crack edge. All of these reduce ride quality and pavement life. Minnesota has spent a large amount of funding repairing roads which have failed due to thermal cracks. In 1999, the Minnesota Department of Transportation (MnDOT) spent about \$450,000 solely on repairing roadway cracks. In addition, millions of dollars have also been spent on overlay or reconstruction of roads which failed due to extensive thermal cracks.

In order to study thermal cracking mechanisms of asphalt pavements, an effort is being initiated by the Office of Materials and Road Research at MnDOT. Three research projects related to field experiments, laboratory tests, and numerical simulation have been developed to study this subject.

The first project is a field study. In 1999, MnDOT constructed three sections on the MnRoad research facility. The three sections have different PG grades, including PG 58-28, PG 58-34, and PG 58-40. Also, crack detection tape and strain gauges are embedded in the pavements to monitor pavement response. The crack detection tape can detect when pavement cracks, which will provide field information on cracking temperatures of different mixtures.

The second project is laboratory prediction of cracking temperatures. This project is being conducted at Mathy Technology & Engineering Service, Inc. The mixtures mentioned above will be tested under indirect tensile testing configuration to determine cracking temperature following SHRP procedures. Also, the bending beam rheometer and the direct tension tester will be used to test extracted asphalt binders to determine critical cracking temperatures of the binders. The predicted cracking temperatures of binders and mixtures will be compared with measured cracking temperatures of the three MnRoad sections.

The third project consists of numerical modeling of thermal cracking of asphalt pavements. The project is being performed by the University of Minnesota. It is well known that thermal cracking of asphalt pavement is related not only to asphalt mix properties but also to pavement structure. For example, base/subgrade material has influence on thermal crack pattern and frequency. However, most existing models, such as the Superpave low temperature cracking model, do not consider the influence of base/subgrade. To pursue an accurate prediction of thermal cracking temperature, crack initiation and spacing, the project will develop a numerical model which can consider base/subgrade, rate of cooling, and temperature cycling effects on thermal cracking formation. The prediction will be compared with field measurements.

From these studies, MnDOT hopes to obtain performance criteria to be used in mixture and pavement designs to minimize the occurrence of low temperature cracking. This may provide long-lasting HMA pavements and in turn save millions of dollars in the future.

## SEARCH FOR A SIMPLE PERFORMANCE TEST FOR HOT MIX ASPHALT

A vast majority of states are implementing Superpave volumetric mix design. However, specifying agencies and HMA contractors need a mechanistically based performance test for Superpave mixes, similar to the Hveem and Marshall tests for traditionally designed mixes. One of the primary objectives of the National Cooperative Highway Research Program (NCHRP) Project 9-19, "Superpave Support and Performance Models Management," is to develop simple performance tests for rutting and if possible, fracture, for incorporation in the Superpave volumetric mix design method. Researchers working on this project are expected to announce their recommendations this spring. Test protocols will then be developed and field trials conducted to validate the recommended test prior to full-scale implementation by the HMA industry.

NCHRP PROJECTS RELATED TO DEVELOPMENT OF PERFORMANCE/STRENGTH TESTS FOR HMA				
Project	Title	Researcher(s)	Cost	Completion Date
9-16	Relationship Between Superpave Gyrotory Compaction Properties and Permanent Deformation of Pavements in Service	Michael Anderson, Asphalt Institute	\$250,000	May 2001
9-17	Accelerated Laboratory Rutting Tests: Asphalt Pavement Analyzer	Prithvi Kandhal, National Center for Asphalt Technology	\$350,000	August 2001
9-18	Field Shear Test for Hot Mix Asphalt	Donald Christensen, Pennsylvania State University	\$200,000	February 2001
9-19	Superpave Support and Performance Models Management	Matthew Witczak, Arizona State University	\$1,700,000	November 2001

*(Search, Continued from page 4)*

As shown in the table on this page, three other NCHRP projects also involve development of a rutting or strength test.

Project 9-17, "Accelerated Laboratory Rutting Tests: Asphalt Pavement Analyzer," will evaluate the Asphalt Pavement Analyzer (APA) to determine its suitability as a general method of predicting rutting potential and for use in field quality control and quality assurance (QC/QA) operations. Researchers are testing HMA mixtures used on MnRoad (Minnesota), WesTrack (Nevada), and Accelerated Loading Facility (FHWA) in a full factorial experiment, where the APA test variables are specimen type (cylinder versus beam), air void content (4 versus 7 percent), hose diameter (25 versus 38 mm), and two test temperatures. The objective is to determine which set of test conditions is best at predicting the rut depths observed in the field.

NCHRP Project 9-16, "Relationship Between

Superpave Gyrotory Compaction Properties and Permanent Deformation of Pavements in Service," will investigate the relationship between mix properties measurable during Superpave gyrotory compaction, and subsequent rutting of in-service pavements. A second objective of this project is to recommend any practical modifications to existing Superpave gyrotory compactors, test methods, or both, to measure identified properties.

NCHRP Project 9-18, "Field Shear Test for Hot Mix Asphalt," will enhance and refine the prototype field shear test (FST) device developed in NCHRP Project 9-7, and validate its use as a mix design and QC/QA tool for predicting rutting potential of HMA mixtures.

With these four NCHRP projects being executed concurrently, it is hoped that suitable performance or strength tests will be developed in the near future. Such tests can then be used as a part of the Superpave mix design system and for QC/QA of HMA mixtures.

## NCAT's MARCH 2000 ASPHALT TECHNOLOGY COURSE ATTENDEES AND INSTRUCTORS



*Front Row, L-R: Rick Primeaux, James Flikkema, Ananth Prasad, Lonny Traylor, Bill Schiebel, Mike Huner,  
Second Row, L-R: Reuben Roberts, Dave Zueck, Dan Jervis, Bryan Pearson, Huy Nguyen,  
Third Row, L-R: Iqbal Mahmud, Reza Akhavan, Marc Mares, Wayne Marshall, Geoffrey Peckham, David Fife, David Eller,  
Back Row, L-R: Ken Kandhal, Mike Schreiber, Reginald Murph, Bob Melani (baseball cap), Gene Thyen, John Quade, Kevin Foster*

## ASPHALT FORUM RESPONSES

*The following responses have been received to questions raised in the Fall 1999 Asphalt Forum.*

*The Michigan Department of Transportation intends to sample and test HMA mixture at the project site for acceptance. What experience do other states have with this procedure and will this process be used for all projects? (Mike Frankhouse, Michigan DOT)*

### **Pennsylvania (Timothy Ramirez, Pennsylvania DOT)**

The Pennsylvania Department of Transportation has sampled HMA mixtures for acceptance behind the paver since 1982. The project inspector randomly selects sample locations and witnesses the contractor collect the samples. Then, the Department transports the samples to its central laboratory for testing. This procedure has worked well when test results are within specification tolerances. However, when central laboratory test results are not within specification tolerances, the source of the problem becomes questionable, especially when the HMA producer's QC test results indicate that the mixture was produced within specification tolerances at the HMA plant. Ideally, disputes between central laboratory failing test results and HMA producer passing test results should be handled between the HMA producer and paving contractor. However, sometimes the central laboratory is dragged into these disputes. Currently, the department experiences a lot failure rate between three and six percent each year.

Another issue becomes the timeliness of the central laboratory acceptance test results. The central laboratory has a sample testing turnaround goal of four days, but this does not include days for transporting samples to the central laboratory. Typically, the department averages 12 days between the time the sample is collected and the central laboratory test result is reported. In addition, the testing turnaround goal may not be met during the peak of the HMA paving season.

During this year's construction season, the department intends to pilot three projects where acceptance samples will be sampled behind the paver and then transported back to the HMA producer's laboratory for acceptance testing. The HMA producer will run the acceptance testing and a department plant inspector will witness the testing. The department will occasionally select one of the samples to be sent to the department's central laboratory for quality assurance testing. The overall intent is to determine the acceptability of HMA producer acceptance testing and the effect on the timeliness of the test results.

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

The Missouri DOT has been in a pilot phase the past

four construction seasons with Superpave, quality control/quality assurance, and pay factors, which includes sampling and testing the hot mix asphalt from the roadway. The testing is performed in a field laboratory on the project. HMA production is just one aspect of the overall HMA project. Taking proper care in handling, hauling, and placement of the HMA are also vital aspects of the project and need to be accounted for in the overall testing procedures. The Department specifies for both quality control and quality assurance that loose mix samples for testing be obtained from the roadway behind the paver. We feel that this is the only true location where we can obtain an HMA sample and test it to make sure that we are getting an overall quality product that we have paid for. A 50-lb sample is obtained from behind the paver prior to breakdown rolling. The transverse and longitudinal location of the sample is randomly selected and then a full depth sample of the course being placed is taken. A typical loose mix sampling template of 18" x 18" x 2" for a Superpave 12.5mm mix is used to designate the area where the 50-lb sample is to be taken. Using a loose mix sampling template minimizes any possible sampling error caused by adjacent material falling into the extracted location, as well as providing a distinct area that can be repaired quickly and easily. This is a sampling process used on all Superpave mixtures.

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

Nebraska requires sampling from behind the laydown machine for acceptance. This procedure was started in the late 1960s. We believe it is the only place the sample should be taken. It does require a little extra effort by both the contractor and state personnel but it is our normal way of doing business. Sampling behind the paver encourages the contractor to handle, transport, and place HMA properly and strive for payment incentives.

### **Ohio (Dave Powers, Ohio DOT)**

The Ohio DOT has extensive experience with HMA sampling at the project site. Feel free to contact us at 614-275-1387.

*Review of a recent research report indicates that the restricted zone is probably not necessary for limestone and granite mixes. What are the other states doing with the restricted zone? (Randy Mountcastle, Alabama DOT)*

*(Continued on page 7)*

**Georgia (Lamar Caylor, Georgia DOT)**

In an April, 1999, revision, the Georgia DOT deleted the restricted zone from its specifications. Georgia requires that Superpave mixes meet requirements of no more than 5 mm rut when tested using the Asphalt Pavement Analyzer (APA). It is believed that the APA will provide sufficient assurance that a mix will remain resistant to rutting throughout its service life.

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

The Missouri DOT enforces the restricted zone parameters according to Superpave criteria. Missouri aggregates for the most part consist of soft limestones and dolomites. Therefore, the contractors design their Superpave mixes to go below the restricted zone. We have heard other states having success with Superpave mixes that go through the restricted zone; however, we do not accept any mixes that pass through the zone.

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

The Kentucky Department of Highways requires that the mixture gradation avoid the restricted zone during the laboratory design process. This requirement applies to the three highest gyrations levels ( $N_{\text{design}} = 75, 100,$  and 125) only. Kentucky is almost exclusively a limestone state.

**Ohio (Dave Powers, Ohio DOT)**

The Ohio DOT waives the restricted zone when designing mixes for high traffic applications.

*Maine is proposing the use of a 4.75 mm Superpave mix for use as a thin leveling course on overlay projects. Do any other agencies have experience with this? What VMA and VFA criteria would be appropriate for this type of mix?* (Dale Peabody, Maine DOT)

**Georgia (Lamar Caylor, Georgia DOT)**

Georgia does have a 4.75 mm mix but does not designate it as 4.75 mm Superpave since it does not meet the Superpave definition of nominal maximum aggregate size. This mix is used primarily for leveling on non-interstate projects. The criteria for this mix is that the air voids must be 4-7 percent, VFA must be 50-80 percent, and it must pass moisture susceptibility testing with a minimum percent retained of 80 percent.

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

We have also identified a need for a 4.75 mm Superpave mix for leveling and parking lot applications. Our immediate solution is allow mixtures designed at  $N_{\text{design}} = 50$  gyrations to pass through the restricted zone in order to achieve a finer, more desirable texture. For the long term, the Southeastern Superpave Center will hopefully undertake a research project this year to develop such a mix.

**Florida (Gale Page, Florida DOT)**

We will likely develop a 4.75 mm Superpave mix sometime this year.

*A recent study by our department has shown that one-hour aging of the HMA mix at the plant during production will more accurately represent the conditions occurring at the roadway, especially for mixes containing absorptive aggregates. Has any other state examined this issue?* (Gale Page, Florida DOT)

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

The Kentucky DOT employed a 90-minute aging period for plant-produced mixtures prior to the implementation of Superpave. Now, based on the guidelines of the Superpave process, that aging period has been eliminated. Fortunately, the majority of our aggregate is not absorptive enough to result in a major difference, but based on our previous experience, we agree that this aging period will affect the theoretical maximum specific gravity of the mixture.

*The benefits of using polymers with PG binders is well documented. Are other states relying on specifying PG binders only or are polymer modifications specified concurrently with PG binders to assure polymerization?* (Mike Frankhouse, Michigan DOT)

**Georgia (Lamar Caylor, Georgia DOT)**

Georgia is specifying PG binders only. However, Georgia has an additional requirement for the polymer-modified binder PG 76-22. It is specified that the phase angle (delta) measured by dynamic shear rheometer for PG 76-22 shall not be greater than 75 degrees to ensure a sufficient amount of polymer in the modified binder.

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

The Kentucky DOT uses PG 64-22, PG 70-22, and PG 76-22 asphalt binders. The PG 64-22 and PG 70-22 binders must satisfy the AASHTO MP1 requirements without further restrictions. The PG 76-22 must additionally satisfy a 75 percent elastic recovery requirement to ensure polymer modification.

*Has anyone recently noticed a change in HMA pavement characteristics after placement? We have experienced problems with HMA remaining soft for several days after paving.* (Keith R. Lane, Connecticut DOT)

**Oklahoma (Kenneth Hobson, Oklahoma DOT)**

We had one paving project which remained soft for several days. The mat has since hardened. One theory is that sand and clay particles blew onto the surface during HMA laydown. There was some variation in  $G^*/\sin\delta$  values of the binder used but it was within specifications for standard PG binders.

## 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.*

### **Florida (Gale Page, Florida DOT)**

Have other states experienced problems with AASHTO T 283 “Resistance of Compacted Bituminous Mixture to Moisture Induced Damage?” What percent water saturation is used for the test specimen? Is freeze and thaw conditioning used?

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

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

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

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

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

**(Editor:** We understand Minnesota DOT and Pennsylvania DOT are exploring the use of Micro Deval test to identify detrimental shale in aggregates. We will request their response to this question.)

### **Ohio (Dave Powers, Ohio DOT)**

We use lower than recommended  $N_{\text{design}}$  gyrations to achieve higher binder content and durability. No problems have been experienced to date. Do other states have similar experience?

The Ohio DOT Manual for Pavement Design and Rehabilitation was updated last year. It includes a section on “Treatment of High Stress Locations” which is being used by our districts.

### **Oklahoma (Kenneth Hobson, Oklahoma DOT)**

Oklahoma uses the Hveem method to perform asphalt

mix designs. Hveem stability tests were failing in our central laboratory while tests on the same material passed in other laboratories. It was determined that the Hveem molds had expanded near the top and were out of specification. New molds solved the problem.

### **Rhode Island (Francis Manning, Rhode Island DOT)**

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

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

### **Vermont (Timothy Pockette, Vermont Agency of Transportation)**

Aggregate angularity is important in the performance of HMA pavements. Superpave specification AASHTO MP-2 addresses this by requiring angularity tests on coarse aggregate in accordance with ASTM D 5821, and angularity tests on fine aggregate in accordance with AASHTO T-301, Method A. However, ASTM D 5821 tests the aggregate retained on the 4.75 mm sieve and AASHTO T-301 tests the aggregate passing the 2.36 mm sieve. If these two tests are followed, then the angularity of the material passing the 4.75 mm sieve and retained on the 2.36 mm sieve is never tested.

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

The National Asphalt Research Coordination (NARC) Group is very active since it was jointly formed in 1991 by Austroads (State Road Authorities) and the Australian Asphalt Pavement Association (AAPA). An important function of NARC is the implementation of research outcomes into test procedures and specifications, and national harmonization of standards and specifications. Items of interest contained in the February NARC Newsletter include agreement on HMA gradations and filler specifications, finalization of HMA test methods, framework specification for asphalt recycling, provisional specifications for multigrade binders, and the Austroads guide to the selection of pavement surfacing.

## SPECIFICATION CORNER

**Alabama** - Stone matrix asphalt will be used on all future interstate paving projects and pavements subjected to heavy, slow truck loading. Both polymer modified binder and fiber are specified in open-graded asphalt friction courses and SMA. Permeable asphalt treated base (PATB) with edge drains is used on new construction of flexible pavements to provide an effective drainage system.

**Connecticut** - A composite pay factor special provision is being developed for future HMA paving projects. Plant testing, density, and rideability will be included.

**Florida** - Plant-produced HMA is now required to be subjected to one-hour aging before conducting the Rice specific gravity and compacting in the Superpave gyratory compactor. The new gyration table in the 1999 AASHTO Provisional Standard PP-28 will be implemented beginning in July 2000.

**Kentucky** - The Kentucky DOT will let its first pavement warranty project this year. This project involves an HMA/cement concrete alternate bid and a five-year, extendable warranty. The length of the warranty may be extended at the bidder's option up to ten years; a bid credit is allotted for each year bid above the five-year minimum. Kentucky's Year 2000 specifications encourage informal partnering on all projects for which formal partnering is not designated in the contract. After incremental implementation over the past three years, all HMA projects let in Kentucky this year must conform to the Superpave binder and mixture specifications. The Kentucky DOT now requires a materials transfer vehicle for the placement of all mainline HMA mixture on interstates and parkways.

**Missouri** - The thin and elongated specification for coarse aggregate has been changed to read that no more than 10 percent of the blended aggregate particles retained on the No. 4 sieve will have a maximum to minimum ratio of 5 to 1. Previously a maximum to minimum ratio of 3 to 1 was specified with no more than 20 percent of the blended aggregate particles retained on the No. 4 sieve. Liquid anti-strip additives may now be used in Superpave mixes pending department approval. Stone matrix asphalt has been included in Superpave specifications. According to the revised Superpave specifications the contractor will not be allowed to start full production until half of the operating tolerances for the volumetric requirements of the contract have been obtained in a test strip as well as meeting other specified requirements. QC/QA and

Percent Within Limits (PWL) for pay factors will be fully implemented in this year's construction season for all Superpave projects.

**Nebraska** - The Fine Aggregate Angularity (FAA) values specified in the Superpave specifications have been a subject of discussion in Nebraska. It is believed that rather than the values of 40 and 45, there should be a step by step increase in the FAA value as design traffic levels increase, i.e. 40, 41, 42, 43, 44, 45. Although the specification has not been changed, the department could make adjustments to the FAA value if something specific about the nature of the project traffic warranted it. An FAA of 43 was specified on some projects in which local traffic impacts were greater than "routine ESAL counts and projections" may predict.

**Ohio** - The Ohio DOT has updated the contractor verification acceptance program to cover all HMA mixes. Although QC/QA has been used for over 15 years, this updated program provides greater contractor/DOT interaction on projects and greater contractor accountability. A significant effort was made in 1999 in developing an ambitious warranty program which includes three, five, and seven year-warranties for HMA pavements. Performance of polymer-modified PG 70-22 was very successful in general applications. The Ohio DOT is moving away from behind the paver QC samples to the plant due to personnel issues.

**Oklahoma** - The specifications for PG binders have been revised as follows:

- PG 64-28 and PG 70-22 grades were eliminated; PG 64-22 and PG 70-28, respectively, will be used in lieu of the eliminated grades. PG 76-28 grade has been added.
- A maximum limit was set for  $G^*/\sin\delta$  due to high variability observed on a project. The ranges for original and RTFO residue are 1.00-2.50 kPa and 2.20-5.50 kPa, respectively.
- Elastic recovery test (ASTM D 6084) was added for RTFO residue with the criteria of 65 percent minimum for PG 70-28 and 75 percent minimum for PG 76-28. This was done to ensure high elastomeric properties and eliminate air-blown binders.
- The flash point was raised from 450°F to 550°F (230°C to 288°C) to eliminate highly volatile fluxes.
- Spot test with standard naphtha solvent was added to reduce "burnt" binder usage.

About 3.5 million tons of HMA were placed in 1999 in Oklahoma. About 10 percent of the total tonnage was let as Superpave projects.

*(Continued on page10)*

## RIBBON CUTTING FOR NCAT TEST TRACK AND RESEARCH CENTER

The ribbon cutting ceremony and open house for NCAT Test Track and NCAT Research Center building has been scheduled for Monday, October 23, 2000. Please contact Ms. Carol Tapley at (334) 844-NCAT for details.

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**Rhode Island** - A Superpave mix was designed by the Rhode Island DOT and placed on one project as part of preparations for the implementation of Superpave in the state.

**South Carolina** - The South Carolina DOT has implemented the use of the percent within limits (PWL) specification on all HMA projects starting with the February 2000 letting. The DOT is continuing to research the implementation of a new specification using the Asphalt Pavement Analyzer (APA) for all Interstate mixtures. This implementation will consist of a maximum rut depth for the mixture to be approved.

**Texas** - The effectiveness of nuclear density profiles as used by the Kansas DOT will be evaluated to detect segregation in HMA. Performance of stone filled HMA is being evaluated on heavy duty pavements. This is essentially a Superpave mix with high PG grade binder built to exact tolerances.

**Vermont** - The following specification changes have been made:

- The level of compaction on Superpave projects has been changed to  $95 \pm 2$  percent. Also, the compaction values will now be based on a statistical analysis.
- The new gradation table in the 1999 AASHTO Provisional Standard PP-28 has been adopted and will be implemented this year.
- Year 2001 QC/QA projects will have current stockpile gradation controls removed and the contractor will assume full responsibility for the quality of stockpiles.

**Wyoming** - Smoothness specification will be implemented for asphalt pavements this year. Paving problems have become too frequent and public scrutiny has reached new heights due to the high costs of paving. Two particularly visible problems occurred in the past few years which served as catalysts for this specification. Improvements in roughness measuring with lasers also have provided confidence that this process can be handled easily and accurately. The

Wyoming DOT purchased an ICC profiler which was used during last year's paving season to develop reasonable pay adjustment curves. Must-grinds and pay adjustments will be specified in this year's projects. Contractors will eventually be responsible for testing.

**New Brunswick, Canada** - Superpave is being implemented gradually, six projects are planned utilizing Superpave mix design. Performance graded (PG) binders will be utilized on all projects this year. The implementation of end result specification is being continued. The New Brunswick DOT is offering an incentive of \$2/ton if a material transfer vehicle is used on a paving project.

**Ontario, Canada** - End-result specification combining asphalt content, gradation, compaction, and air voids based on percent within limits (PWL) has been completed. The specification was included in all 1999 contracts. Complete price adjustments have been phased in. Each lot has ten 500-ton sublots. Bonuses are paid for greater than 95 percent within limits. Price reduction is applied for marginal materials.

Consensus recompaction temperatures will be enforced this year for hot mix acceptance testing. Compaction and recompaction temperatures for recycled mixes have been revised based on preliminary results of a study of recycled mixes.

A tack coat specification with payment factor has been implemented. New longitudinal joint specifications are being implemented in more trial contracts this year.

## 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.



## 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 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. EVALUATION OF OGFC MIXTURES CONTAINING CELLULOSE FIBERS (Cooley, Brown, and Watson)**

Open-graded friction courses (OGFCs) are special-purpose mixes used to improve surface frictional resistance, minimize hydroplaning, reduce splash and spray, improve night visibility, and lower pavement noise levels. OGFC is a hot mix asphalt (HMA) that is designed to include a high percentage of internal air voids through which water can be removed from a pavement surface. In order to achieve the high percentage of internal air voids, OGFCs typically utilize uniform grading for aggregates and a low filler (material passing 0.075 mm) content (2 to 5 percent). The combination of a uniformly graded aggregate and low filler content can lead to the asphalt binder draining from the mixture by gravity during transportation and laydown operations. This phenomenon is typically called draindown. To combat the draining of asphalt binder from the mixture, fibers are sometimes added to stabilize the binder during mixing and placement. An additional benefit of using fibers is that they have been shown to allow increased asphalt binder contents and thus increased film thicknesses, thereby increasing mix durability.

A recent survey of states that use OGFC indicated that 19 percent use some form of fiber. Most of these states specify mineral fibers because of a concern that organic fibers (cellulose) may absorb water leading to premature moisture susceptibility problems in the field. However, no research has been conducted to evaluate this potential problem with current cellulose fibers.

The objective of this study was to evaluate the use of cellulose fibers within OGFC mixtures. This was accomplished by comparing cellulose and mineral fibers both in the field and laboratory. The field portion of this study entailed a visual distress survey performed on six experimental OGFC sections located on I-75 in Georgia. These test sections included OGFC sections with both cellulose and mineral fibers as well as other additives. At the time of survey, these test sections had

been in service for six years.

Since the major concern with cellulose fibers in OGFC is the potential to absorb water, the primary distress type evaluated in the laboratory was moisture susceptibility. Testing included determining the amount of water absorbed by lab-compacted OGFC samples, tensile strength ratios using different numbers of freeze-thaw cycles, the "boil" test, and rut testing with the Asphalt Pavement Analyzer in a submerged state.

Four mix designs were conducted, and included one aggregate source, one asphalt binder, and four types of fiber. The gradation for these mixtures was identical and met a Georgia DOT (GDOT) 12.5 mm OGFC gradation. A granite aggregate was selected for the study. The source was suggested by GDOT because of its potential for stripping. Of the four fiber types used, three were cellulose while the fourth was a slag wool mineral fiber. The three forms of cellulose included a loose fiber, a 66/34 pelletized fiber (66 percent cellulose fiber and 34 percent asphalt), and a 80/20 pelletized fiber. The cellulose fibers were added to the OGFC mixtures at a dosage rate of 0.3 percent based upon total mixture mass, while the mineral fiber was introduced at a dosage rate of 0.4 percent of total mixture mass. For all of the

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### **A SHORT COURSE IN ASPHALT TECHNOLOGY**

This training course has been developed by NCAT for practicing engineers who are involved with hot mix asphalt (HMA). The purpose of this one-week intensive course, which will be held on February 5-9, 2001 and March 5-9, 2001, is to provide a general understanding of all phases of HMA technology. Upon completion, the participant will be able to make knowledgeable decisions related to HMA pavements and communicate effectively with asphalt specialists when the need arises. NCAT will accept applications from practicing engineers from both private and public sectors in the United States and abroad. This includes personnel from the FHWA, state DOTs, FAA, Corps of Engineers, Air Force, Navy, county engineers, city engineers, consulting engineers, and contractors. Please call (334) 844-6241 or visit our web site at <<http://www.eng.auburn.edu/center/ncat>> (Click on "Education" at the top of the page, then click on "Upcoming Training Courses") for brochure or information.

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mixtures a PG 76-22 asphalt binder was used. This binder contained a styrene butadiene styrene (SBS) polymer.

Four types of laboratory tests were conducted. First, a test was used to quantify the amount of water absorbed into OGFC mixtures containing the four fiber types. This test was conducted by allowing compacted OGFC mixtures to soak in a 60°C (140°F) water bath for 72 hours. After soaking, the specimens were allowed to dry at room temperature. Mass measurements were obtained at 1, 2, 4, 21, 24, 48, and 72 hours to determine mass loss. Any mass loss should be water flowing or evaporating from the specimens. This test methodology was selected to evaluate how long water would be retained by OGFC samples containing the various fiber types.

The second laboratory test conducted was GDOT-66, “Method of Test for Evaluating the Moisture Susceptibility of Bituminous Mixtures by Diametral Tensile Splitting.” This procedure is similar to the modified Lottman procedure. Testing was conducted to evaluate the sensitivity to moisture-induced damage for mixtures containing the various fibers. The four mixtures were evaluated after 1, 3, and 6 freeze-thaw cycles.

The third laboratory test also evaluated the sensitivity of the different mixtures to moisture-induced damage. This testing was conducted in accordance with GDOT-56, “Test Method for Heat Stable Anti-Strip Additive.” For this test, loose OGFC mixture was placed into boiling water for 10 minutes (hence, the test has been called the “boil” test). A visual inspection was then performed to determine the approximate percentage of aggregate particles in which the asphalt binder was totally or partially removed.

The final laboratory test was conducted with the Asphalt Pavement Analyzer (APA). Three beam samples of OGFC were fabricated using the loose cellulose and mineral fibers. These beams were fabricated and tested in accordance with GDOT-115, “Method of Test for Determining Rutting Susceptibility Using the Loaded Wheel Tester,” while submerged in water at 60°C.

The following conclusions were drawn from the evaluation of the field test sections:

- All test sections appeared to have some minimal coarse aggregate pop-out and raveling
- The amount of rutting was insignificant in all test sections
- The primary cracking on all test sections was reflective from underlying PCC pavement

The following conclusions were drawn from the laboratory evaluation:

- Results of the water absorption testing indicated that

all four mixes had approximately the same rate of water loss

- Tensile strength ratio (TSR) testing and the boil test also indicated that the cellulose fibers are comparable to the mineral fiber with respect to resisting moisture damage; TSR tests after three freeze-thaw cycles were satisfactory (above 70 percent retained strength) for all four mixes

- Results of the submerged APA rut tests also indicated that the cellulose fiber mix was comparable to the mineral fiber mix

The data from this study is very interesting because the field data and laboratory data appear to provide the same indications that cellulose fibers performed comparably to mineral fiber.

## 2. UNCOMPACTED VOIDS AND PARTICLE INDEX TESTS FOR EVALUATING COARSE AGGREGATE (Hossain, Parker, and Kandhal)

The Superpave mix design system recommends fractured face count (ASMT D 5821) and flat and elongated particle count (ASTM D 4791) for controlling coarse aggregate angularity and particle shape. Most states use these or some modified version of these tests, but both tests are subjective, labor intensive and time consuming. ASTM D 3398, “Index of Aggregate Particle Shape and Texture,” provides a quantitative measure of combined relative particle shape and texture characteristics of aggregate. This test is labor intensive and time consuming, but more objective. The uncompacted voids test for coarse aggregate (AASHTO provisional standard TP56), developed by Ahlrich and

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recommended by NCHRP 4-19, is also more objective, and less labor intensive and time consuming.

Both particle index test and uncompacted voids test for coarse aggregate have been used primarily in research, but both have promise for controlling coarse aggregate quality.

This study was undertaken with the following objectives:

- Investigate the uncompacted voids and particle index tests for assessing shape, angularity, and surface texture of coarse aggregate
- Investigate the use of standard graded samples for both particle index and uncompacted voids tests, and
- Compare uncompacted voids and particle index

The crushed gravel and crushed stone aggregates included in this study were from sources used extensively in HMA in Alabama. Gradations were typical of dense graded HMA blends. Three chert gravels, one quartz gravel, one crushed limestone, and one crushed granite coarse aggregate was used. Several sizes of product produced at each gravel source were included to produce some variation in level of crushing. Coarse aggregate represented the material retained on the 4.75 mm (No. 4) sieve.

The procedure for uncompacted voids test for coarse aggregate is similar to the uncompacted voids test for fine aggregate, ASTM C 1252, but to accommodate large particles (19.0 mm to 4.75 mm), a 102 mm (4 inch) orifice funnel and a 152 mm (6 inch) diameter cylindrical mold are used. The drop distance is 114 mm (4.5 inch), the same as for fine aggregate. Two standard gradations were used, which matched the +4.75 mm portion of maximum density gradation with 19.0 and 12.5 mm maximum particle sizes. Uncompacted voids test was conducted on standard gradations and as-received gradations.

The particle index test was performed following the ASTM Standard D 3398. Particle index is measured as a function of inter particle voids. Aggregate is split into individual sieve sizes and tested. The voids in one-size aggregate are measured in the mold at two different compaction levels. An index is calculated by comparing the weighted difference between these two void contents with the voids of smooth aluminum spheres.

The following conclusions were drawn from this study:

- Gradation has a significant effect on both particle index and uncompacted voids tests. Tests on graded samples are not as time consuming, and produce results comparable with weighted average values computed with values from individual size fractions. For relative comparison and evaluation of aggregate sources, tests on standard graded samples may be used. Either of two proposed standard gradations for coarse aggregate may be used depending upon the availability of the size of

particles in a source.

- Uncompacted voids and particle index are highly correlated ( $R^2 > 0.86$ ) and, therefore, provide comparable measures of coarse aggregate particle shape, angularity, and surface texture.

### **3. DEVELOPMENT OF A NEW TEST METHOD FOR MEASURING BULK SPECIFIC GRAVITY OF FINE AGGREGATES (Kandhal, Mallick, and Huner)**

Bulk specific gravity of the fine aggregate is used in Superpave volumetric mix design calculations to determine the amount of asphalt binder absorbed by the aggregate and the percentage of the voids in the mineral aggregate (VMA). It is also used in the test for determining the fine aggregate angularity (FAA). The current test method of measuring the bulk specific gravity of fine aggregate (AASHTO T84 or ASTM C128) does not have satisfactory reproducibility. This method does not work satisfactorily for certain fine aggregates which are very angular and have rough surface texture. These materials do not slump readily when tested by the cone method specified in these standard tests to determine the saturated surface dry condition (SSD). This lack of precision in obtaining the bulk specific gravity of fine aggregate affects the Superpave volumetric mix design. The optimum asphalt content can be underestimated resulting in lean and brittle mixture (raveling and cracking) or can be overestimated resulting in rich and plastic mixture (flushing or rutting). There is an urgent need to develop an accurate and more reproducible test method for determining the bulk specific gravity of the fine aggregates.

This study was undertaken to develop automated equipment and a method of determining the saturated surface dry condition of the fine aggregate so that its bulk specific gravity can be measured with satisfactory precision and accuracy.

In the current test method, fine aggregates are spread on a pan and exposed to a gentle current of warm air until a free-flowing condition is reached. The aggregate is lightly tamped into a specified conical mold. If the cone stands when the mold is removed, the fine aggregate is assumed to have moisture on its surface, and it is dried further. When the cone just begins to slump after removal of the cone, it is assumed to be in a "saturated surface dry" state. In addition to variation caused by individual judgement, the fact that large particles tend to dry more quickly than small particles may lead to overdrying of the larger particles. These variations become significant in the case of aggregates having a rough and porous surface.

For natural, well-graded fine aggregates, the

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saturated surface-dry condition is usually reproducible. The end point is more erratic for crushed fine aggregates because the angularity of the particles does not permit a definite slump condition as do the rounded surfaces of natural sands. Besides, the higher percentage of material passing the 0.15 mm (No. 100) sieve also poses a problem in achieving the slump condition.

The National Center for Asphalt Technology (NCAT) has developed prototypes of equipment for establishing the saturated surface dry (SSD) condition of the fine aggregate in an objective manner. The NCAT SSD device consists of a rotating stainless steel drum with flights. Wet fine aggregate is fed into the drum and warm air is blown at one end of the drum to dry the aggregate uniformly in the rotating drum. Sensors for temperature are installed at either end of the drum for measuring the temperature of incoming and outgoing air and, therefore, determining the temperature gradient. One sensor for relative humidity is installed to measure the relative humidity of the outgoing air.

While the fine aggregate has surface moisture, both the temperature gradient and the relative humidity of the outgoing air remain relatively high. As soon as the SSD condition is reached, both the temperature gradient and the relative humidity decrease significantly. This is noted from the plot of time versus temperature gradient and relative humidity. The fine aggregate sample is taken out at that point and its weight and volume determined.

Seven fine aggregates were tested by the NCAT SSD device and the current standard test method. The results are very encouraging. The humidity of the outgoing air appears to establish the SSD condition more distinctly than the temperature gradient.

Equipment manufacturers were invited to build the commercial version of the NCAT's SSD device reported in this paper, which will be evaluated by NCAT. If the commercial version has the capacity of continuously monitoring the mass of the fine aggregate while it is drying in the drum, the sample does not have to be taken out of the drum for weighing when it reaches the SSD condition. The drying can then continue until the sample is completely dry to obtain its dry mass while in the drum. The difference between the SSD mass and the dry mass is the water absorption of the fine aggregate. The apparent specific gravity of the aggregate, which does not involve the SSD condition and is reasonably reproducible, can be measured in a separate test. The bulk specific gravity of the fine aggregate can be calculated by a formula using its percent water absorption, obtained in the NCAT SSD device, and its apparent specific gravity.

#### 4. EVALUATION OF NOTCHED WEDGE LONGITUDINAL JOINT CONSTRUCTION (Buchanan)

The proper construction of longitudinal joints is critical to the overall performance of a hot mix asphalt (HMA) pavement. Many times the in-place density at and across the longitudinal joint is substantially lower than the density of the remainder of the HMA surface. This low in-place density increases the potential for development of cracking and raveling to develop along the joint. Research has shown that the use of the notched wedge joint (NWJ) has the potential to increase the density at the longitudinal joint, which should result in a longer-lasting pavement. A notched wedge joint has a vertical notch depth of 12.5 mm (1/2 in.) to 25 mm (1 in.) depending on the mix type. The wedge (or taper) typically has a 1:12 slope (one vertical, 12 horizontal). The notched wedge joint is usually formed by attaching a steel plate to the front of screed.

The notched wedge joint was compared to conventional longitudinal joint construction techniques on projects in five states (Colorado, Indiana, Alabama, Wisconsin, and Maryland). The evaluation consisted of comparing the in-place density obtained through pavement cores at five locations across the longitudinal joint of the pavement (at the centerline, 150 mm (6 in.), and 450 mm (18 in.) on either side of the centerline).

Based on the test results obtained from the five projects the following observations and conclusions were made regarding the notched wedge joint (NWJ) technique.

- The NWJ technique resulted in an increased centerline density as compared to conventional joint construction for four of the five projects, with the increase being statistically significant for two of the four projects.
- It appears that the main reason for the increased density is the added confinement which is provided by the wedge portion along the edge of the first paved lane. For the one project where the NWJ did not yield higher centerline densities, a thick lift thickness [100 mm (4 in.)] may have been partially responsible.
- The use of the NWJ resulted in a decrease in the in-place density at the 150 mm (6 inch) hot side location

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Joe Meade (left), materials engineer from the Minnesota DOT, visited the NCAT laboratory in March. Tim Vollor, NCAT laboratory manager, is on the right.

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for four of the five projects. This is most likely a result of the wedge portion not being compacted to a sufficient level, leaving low density material in place. When the hot side is placed, the material placed on top of the wedge may be able to be compacted to the desired level, but the underlying material in the wedge probably remains at a lower density. Whether or not this low density will cause a problem in the future is dependent upon the magnitude of the density achieved in the top portion of the wedge. If the density is sufficient to prevent permeability, performance problems are less likely in the future. The in-place densities at a distance of 450 mm (18 in.) from the centerline on the cold and hot side are generally not affected by longitudinal joint type.

- Generally, the use of the NWJ did not cause any extra delays during the paving operations. For the contractors who had used the NWJ before, its construction has become commonplace. Contractors who had not used the NWJ before experienced some minimal delays while the NWJ was first being constructed. However, after constructing the NWJ for a short time, the delays were generally eliminated.
- Although a study of the possible increase in safety provided by the NWJ was not included in the study, there were general comments by several of the contractors in the study regarding the safety of the NWJ. One of the primary reasons for this was the reduction in liability provided by using the NWJ as a result of the reduction in the amount of paved lane to unpaved lane drop off.
- Production can be increased due to the ability to pave the entire day without having to double back and match up the other lane prior to traffic being returned to the roadway.
- Future evaluations of the field projects are planned for the upcoming year. At that time the performance of the NWJ sections versus the conventional sections can be evaluated.

## **5. RATIONAL APPROACH OF SPECIFYING THE VOIDS IN MINERAL AGGREGATE (VMA) FOR DENSE-GRADED HOT MIX ASPHALT (Mallick, Buchanan, Kandhal, Bradbury, and McClay)**

The minimum voids in the mineral aggregate (VMA) requirements in Superpave are based on the nominal maximum aggregate size in the mix. These requirements are based on the original recommendations by McLeod for relatively fine-graded mixes (gradation above the maximum density line). However, in view of the wide range of gradations used today, especially in Superpave, questions arise whether the nominal maximum size alone is capable of differentiating aggregate gradations for a wide band of gradation, ranging from very fine to very coarse, and whether there is any other factor which is more closely related to coarseness or fineness of the gradation, and which defines VMA more rationally

compared to nominal maximum aggregate size. Coarse-graded Superpave mixes (gradation significantly below the maximum density line), if designed with McLeod's minimum VMA criteria, could result into mixes with very thick asphalt binder film, because these mixes have relatively lower surface area. Recent experience has shown that such coarse-graded mixes have low resistance to rutting.

This paper presents a theory, and some data obtained from theoretical analysis and field projects. The theoretical analysis was conducted to backcalculate the VMA required for mixes with different gradations for a specific asphalt film thickness. A film thickness of 8.65 micron was used, which was back calculated from McLeod's work for a 12.5 mm nominal maximum size aggregate mix. The data from mix designs of Superpave paving jobs constructed by the Maine Department of Transportation in 1998 was also analyzed to evaluate the effect of different factors on VMA, and determine a suitable factor for specification of VMA.

Based on the results of this study, it is concluded that substantial differences in VMA exist among different permissible gradations of mix with the same nominal maximum aggregate size. The average difference in VMA for a 5 percent increase in percent passing the 2.36 mm sieve was found to be 0.4 percent, considering 9.5 mm, 12.5 mm, 19.5 mm, 25.0 mm, and 37.5 mm nominal maximum aggregate size mixes. Hence, a more rational way of specifying the minimum design VMA will be to specify VMA on the basis of percent passing the 2.36 mm sieve rather than the nominal maximum size. This will ensure about equal asphalt binder film thickness in all mixes to obtain reasonable durability of the mixes.

Tables have been presented for minimum VMA criteria based on percent material passing the 2.36 mm sieve (P 2.36) and 4.0 percent air voids in the compacted mix. An example of calculated minimum values of VMA for a 9.5 mm nominal Superpave mix at each 5 percent P 2.36 incremental value is provided in the following table:

<u>P 2.36 Range</u>	<u>Minimum VMA</u>
67-62	16.6
62-57	16.2
57-52	15.7
52-47	15.4
47-42	15.0
42-37	14.6
37-32	14.2

The current minimum VMA required for a 9.5 mm Superpave mix is 15.0 percent regardless of the wide range of P 2.36 values from 32.0 (lower control point) to 67.0 (upper control point).

More research is needed to pursue and validate this new concept of specifying minimum VMA.

# NCAT's FEBRUARY 2000 ASPHALT TECHNOLOGY COURSE ATTENDEES AND INSTRUCTORS



*Front Row, L-R: Mark Strickland, Bob Belden, Jason Mapes, Patrick Amaris, Saki Richardson, Bob Nickelson*  
*Second Row, L-R: Paul L. Bossé, Signe Erickson, Jenaah McLeod-Hanson, John Elkins, Mike Robinson, Marty McNamara*  
*Third Row, L-R: Dave Nelson, Jason Ashley, Bobby Barlow, Steve Ragan, Bill Whitfield, Mike Natale, Richard Richardson*  
*Fourth Row, L-R: Jonathan Ashley, Terry Butler, Ken Kandhal, Shane Buchanan, Steve Smith, Allen Cooley*  
*Back Row, L-R: Dawn Ford, Buzz Powell, Carl F. Baker, Mike Huner*



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