

ASPHALT TECHNOLOGY NEWS

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NCAT UNDERTAKES THIRD CYCLE OF LOADING THE TEST TRACK

The National Center for Asphalt Technology (NCAT) initiated the third cycle of loading the test track on November 10, 2006. The test track research to date has consisted of three cycles. The first (Phase I) began in 2000 with the installation of forty-six test sections on the 1.7-mile oval track. The only variable among the sections was the properties of the hot mix asphalt (HMA) mixtures in the top four inches of the pavement. This cycle of tests was completed in 2002 after ten-million Equivalent Single 18,000-pound Axle Loads (ESALs) had

been applied to the sections. This traffic level is representative of 10 to 20 years of traffic on many rural Interstate highways.

The second cycle (Phase II) of tests began in 2003. Eight sections were removed full depth and reconstructed to provide different thickness of HMA. Some of the structural sections used modified asphalt binder and others used unmodified asphalt binder in adjacent sections. Fourteen sections were milled and inlaid with new
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The third cycle of loading the NCAT test track began in November 2006. Ten million ESALs will be applied to the track in two years.

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NCAT Undertakes Third Cycle

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mixes to be evaluated in the same fashion as the 2000 experiments. The remaining sections were left in place to evaluate the effect of two more years of traffic (another ten-million ESALs) and the effect of an additional two years of exposure on durability.

A summary of test track findings from the first and second cycles and their implementation by various states was given in the Spring 2006 issue of the Asphalt Technology News. Some of the highlights include:

- The amount of rutting in coarse-graded and fine-graded Superpave mixes was approximately the same
- On average, there was more than a 50 percent reduction in permanent deformation when the high temperature grade was bumped from PG 64 to PG 76, the latter being a polymer-modified asphalt binder
- Although only crushed stone is recommended in stone matrix asphalt (SMA), the SMA containing only crushed gravel aggregate gave satisfactory performance in terms of permanent deformation
- Although both SMA and Superpave test sections sponsored by Georgia exhibited very good rutting resistance (less than 2 mm), the Superpave section experienced some loss of fines

associated with weathering after the second cycle of loading (5 years and 20 million ESALs)

- An additional 0.5 percent asphalt binder can be added to Superpave designed HMA without causing any problem, especially when polymer-modified asphalt binders are used
- There was a significant increase in rutting for non-polymer mixes
- Test track performance results were successfully used by two sponsoring states (Indiana and Florida) to calibrate their in-house accelerated pavement test devices
- South Carolina determined from their test sections that HMA containing an aggregate with LA abrasion loss exceeding their specification requirements gave satisfactory performance during construction and in service
- Both Mississippi and Tennessee determined from their test sections that they could blend limestone aggregate with crushed gravel aggregate in the wearing course mix without compromising the skid resistance

The on-going research at the track, now in the third cycle (Phase III), continues to provide valuable information regarding pavement materials and mixtures, construction procedures, and structural pavement design.

Reconstruction of the third-cycle test sections was completed on October 19, 2006 by East Alabama Paving Company. During the 2006 construction, 47 aggregate/RAP stockpiles, five liquid asphalt binders,

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Construction of structural test sections in progress



Milling operation for construction of the 2006 test track

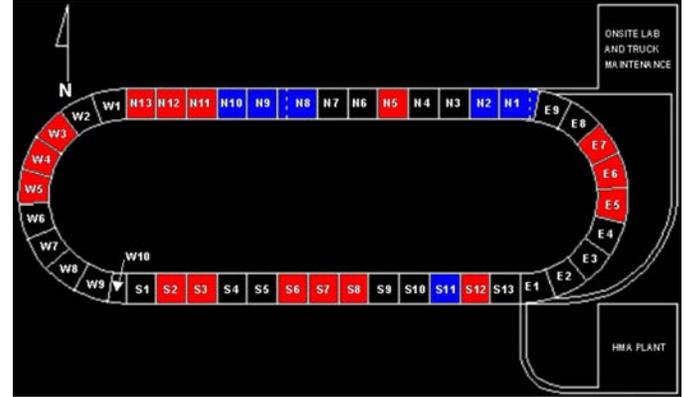


Figure 2. Layout of the 2006 test track

two base types, and two subgrade types were used. The average HMA density on the track was 94.2 percent of the theoretical maximum density. (See Figure 1.)

As shown in the layout plan, the third-cycle test sections can be categorized as follows: structural test sections (shown in blue), milled and inlaid test sections (shown in red), and test sections for additional trafficking (shown in black). (See Figure 2.)

Structural Test Sections

The second-cycle test track had eight structural test sections (N1 through N8). In the third cycle six new structural sections (N1, N2, N8, N9, N10, and S11) were reconstructed. The pavement layer types and their respective thickness are illustrated in the

cross-section of the eleven structural test sections. The instrumented structural sections are part of a larger, multi-state validation effort for mechanistic-empirical pavement design. The following are the main structural study areas for the third-cycle experiments:

- Mechanical-Empirical Pavement Design
 - Model validation
 - Model calibration
 - Material characterization
- Pavement Rehabilitation
 - Link pavement response (stress, strain) to structural deterioration (cracking, rutting)
- Perpetual Pavement Design
 - Determine strain threshold related to performance

As shown in the cross-section of the eleven structural test sections, the following variables will also be evaluated in addition to different thickness of pavement layers:

- Unmodified asphalt vs. polymer-modified asphalt: Most highway agencies assign the same structural coefficient to all dense-graded HMA regardless of asphalt binder type. Many laboratory studies have shown polymer-modified HMA is stronger and has longer fatigue life compared to conventional HMA. However, such comparison will be evaluated in this full-scale field experiment.

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2006 Structural Study

Depth, in.	Florida N1	Florida N2	Alabama N3	Alabama N4	FHWA N5	FHWA N6	FHWA N7	Oklahoma N8	Oklahoma N9	Missouri N10	Alabama S11
1											
2											
3											
4	PG 76-22	PG 67-22					PG76-22 SMA	PG76-28SMA	PG76-28SMA	PG70-22SMA	PG76-22
5			PG 67-22	PG 76-22	PG 76-22	PG 67-22	PG67-22	PG76-28	PG76-28	PG70-22	
6								PG64-22	PG64-22		PG67-22
7											
8											
9											
10					Granite Base	Granite Base	Granite Base	PG64-22 RB	PG64-22	PG64-22	Granite Base
11											
12	Limerock Base	Limerock Base	Granite Base	Granite Base							
13									PG64-22	Type 5 MO Base	
14								Chert Base			
15											
16									Chert Base		
17											
18											
19											
20	Chert Subgrade							Clay Subgrade			
21											
22											
23											

Figure 1. Cross-section of eleven structural test sections showing different pavement courses.



Laying stress/strain measuring instruments before paving the test track

- Pavements over a subgrade with low stiffness vs. pavements over a subgrade with high stiffness
 - Stone Maitrix Asphalt (SMA) vs. Superpave in the wearing course
 - Rich HMA bottom course vs. standard bottom course: Two test sections (N8 and N9) have a rich HMA base course with high binder content. The rich base course has a potential of minimizing the propagation of fatigue cracks from the bottom upwards.

All the structural test sections are fully instrumented to measure stress, strain, and temperature. Multi-depth thermister probes have been installed in all 46 sections on the test track for measuring temperature.



RAP used in some test sections was processed to break down in different size fractions

Paired with data from an onsite, automated weather station, these data are used to precisely characterize the performance environment for each experimental section. Additionally, the sections that make up the structural experiment have high-speed instrumentation arrays consisting of strain gauges and pressure plates installed at select depths. Data generated by these devices are used to quantify the pavements' response to passing loads, which is useful in validating pavement analysis and design methodologies that are mechanically based.

Milled and Inlaid Test Sections

Sixteen second-cycle test sections were milled and inlaid with new binder and/or wearing course mixes to evaluate their resistance to rutting and/ or other performance parameters. The following mix attributes will be evaluated:

- Superpave mixes containing 0, 20, and 45 percent reclaimed asphalt pavement (RAP) material and different grades of PG binders
 - Superpave mixes designed with relatively lower number of design gyrations
 - Superpave mixes designed with low air voids resulting from high asphalt content as well as from using a denser gradation for comparison
 - Open-graded Friction Course (OGFC) mixes containing cubical and flat & elongated
- (continued on page 5)*



The HMA plant used for constructing the 2006 test track; various aggregate and RAP stockpiles can also be seen



HMA paving on the 2006 test track

aggregate particles for comparison

- OGFC mix containing 100 percent crushed gravel aggregate
- Dual porous friction courses (9.5 mm nominal maximum aggregate size at top and 12.5 mm nominal maximum aggregate size at bottom) placed with a European twin-layer paver
- Recycled HMA mix produced with warm mix asphalt technology



European double paver was used in simultaneous paving of two different courses of open-graded friction course



Roadside control panels for instruments embedded in pavement courses

Test Sections for Additional Trafficking

Some state DOTs have decided to keep their test sections in place for additional trafficking, because these test sections have not shown any significant distress as yet. The additional trafficking in the current third cycle may better discern performance differences among different mix types.

Test sections for the third cycle of loading have been sponsored by the US Federal Highway Administration, Alabama, Florida, Georgia, Indiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas. Trafficking of these test sections will continue until 10-million ESALs are applied in about two years (by October 2008). Based on the experience from the first and second research cycles, it is believed the results from the current third research cycle will also be highly practical and easily implementable, thus improving the quality and longevity of hot mix asphalt pavements.

Design, construction, and performance details for all 46 test sections can be seen at the NCAT test track web site: www.pavetrack.com.

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.

Nevada (Darin Tedford, Nevada DOT)

The Nevada DOT is still experimenting with the implementation of Superpave mix designs. We plan to construct three Superpave designed projects in 2007.

New York (Zoeb Zavery, New York State DOT)

The New York State DOT has implemented an internal angle requirement for Superpave gyratory compactors. The gyratory compactor and the specimen molds must meet the requirements of AASHTO T 312 – Standard Method of Test for Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor. The gyratory compactor will be set annually to meet the internal angle requirement of $1.16^\circ \pm 0.02^\circ$, and may be set and verified using any suitable device designed for that purpose.

NCAT (Prithvi “Ken” Kandhal, Associate Director Emeritus NCAT)

Please refer to the cover story on NCAT Test Track in this issue of the **Asphalt Technology News**. Several important findings have resulted from the first and second cycles of experiments conducted from 2000 to 2005 on the test track, which has been subjected to 20 million ESALs of traffic. We would like to have your comments on the following findings:

1. The amount of rutting in coarse-graded and fine-graded Superpave mixes was approximately the same.
2. Although only crushed stone is recommended in stone matrix asphalt (SMA), the SMA containing only crushed gravel aggregate gave satisfactory performance in terms of permanent deformation.
3. It is possible to blend some limestone aggregate with crushed gravel aggregate in the wearing course mix without compromising the skid resistance.

NCAT's Asphalt Technology Course (January 29 - February 2, 2007)



Back, L-R: Brian Prowell (Instructor), Jason Moore (Instructor), Cindy Rutkoski, Tom Pieters, Erik Forster, Thomas Feldman, Tom Carter, Kenneth Murphy. **Middle, L-R:** Don Watson (Instructor), Charles Smith Jr., Doug Sites, Richard Ragoza, Alan Trzyna, Jason Davis, Andre Smit (Instructor), Bryan Kalbfleisch, Kip Book. **Front, L-R:** Andrea Kvasnak (Instructor), John Cheever, Jeff Shelley, Phillip Hocher, Donald Sutherland, Jarrett Welch, Raph Mason, Randy West (Instructor)

ASPHALT FORUM RESPONSES

The following responses have been received to questions raised in the Fall 2006 **Asphalt Forum**.

1) *Have any states experienced inconsistent mixture characteristics, namely erratic volumetric properties, in SMA containing fly ash as the mineral filler component? What type of asphalt mixing plant (e.g., counter-flow drum, parallel-flow drum, double-barrel drum, batch, etc.) was involved, and how was the fly ash introduced? How were the quality and consistency of the fly ash verified?* (Allen Myers, Kentucky Transportation Cabinet)

Mississippi (James Williams III, Mississippi DOT)

Mississippi has constructed only one SMA pavement and did not experience any problems during production. The SMA was produced in a drum plant with the fly ash vane fed from a bin.

Nebraska (Laird Weishahn, Nebraska DOT)

Nebraska used fly ash as an additive to our Type MQ mixtures in the 1980s. These were quartzite mixes very similar to the SMAs that came along in the 1990s. The addition of fly ash allowed us to use less binder in the mixture. Then, we began checking mix volumetrics and found we were also getting erratic volumetric properties. We concluded it was caused by the variations in fly ash gradations. The fly ash producers were asked to provide us with gradations of their fly ash and we were all surprised by the fact the gradation was never uniform. This resulted in the erratic volumetric properties. It is quite possible that

very fine fly ash (say less than 25 microns) would act as an extender of binder and the coarser fly ash (say more than 25 microns) would act as dust. The fly ash industry could not provide a uniformly graded material so we stopped the use of fly ash in our Type MQ mixture.

Ohio (Dave Powers, Ohio DOT)

We do not have any experience with the use of fly ash in SMA in Ohio.

2) *Please read the cover story in the Fall 2006 issue of the Asphalt Technology News (you can also access this newsletter on the NCAT website, www.ncat.us) concerning the completion of NCHRP Project 9-9 (1), "Verification of Gyration Levels in the Ndesign Table" by NCAT. Based on this major national study, a revised table of Ndesign gyrations used in the Superpave mix design system has been recommended. Recommendations have also been made to eliminate both Ninitial and Nmaximum requirements. Please share your comments on these proposed major revisions to the Superpave mix design system.* (Prithvi "Ken" Kandhal, Associate Director Emeritus, National Center for Asphalt Technology)

Colorado (Roy Guevara, Colorado DOT)

The Colorado DOT (CDOT) has not used Ninitial or Nmaximum requirements for over five years and has not experienced any negative consequences.

CDOT recognizes that the Superpave mix design system produces mixes that are not able to achieve 4 percent air voids after several years' densification under traffic. In an attempt to get pavements to 4 percent air voids after several years of exposure to traffic, CDOT adjusts the void target when the contractors turn in their mix designs. When possible, the voids target is lowered as much as 1 percent to try to get more binder into the mixes. This stopgap measure has worked well and will continue to be used until the Superpave mix design system adjusts the design number of gyrations, compaction temperatures, angle of gyration, or compactive force applied to produce mixes that better replicate road performance.

Connecticut (Keith Lane, Connecticut DOT)

We are reviewing the findings of the NCHRP 9-9 report and each of its recommendations on a case-by-case basis. Although we do not disagree with some

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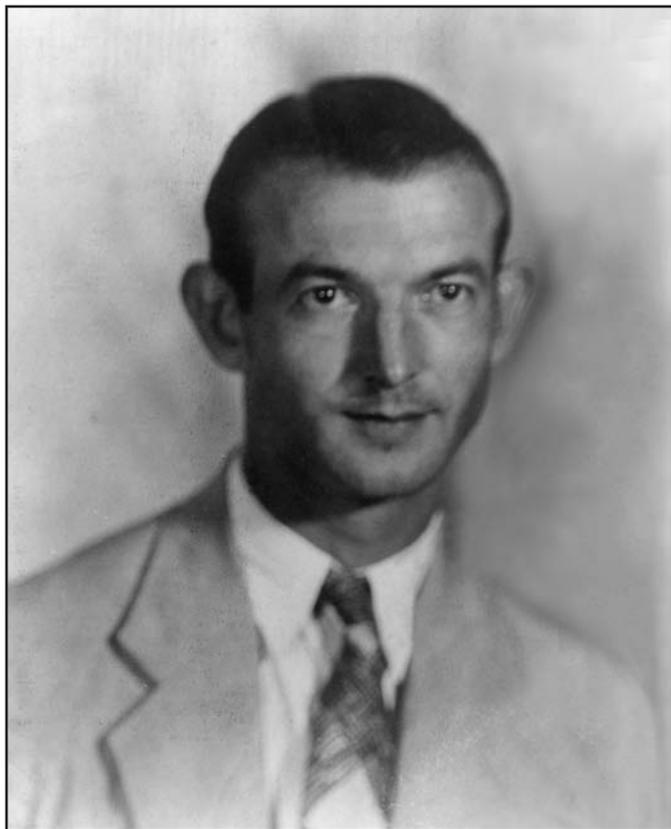
Professor Training Course in Asphalt Technology

Each year NCAT offers an 8-day course designed to prepare college and university civil engineering faculty to teach state-of-the-art undergraduate and elective courses in asphalt technology. This year's course will be offered on June 19-28. The course has been updated to include Superpave binder and mix technology, and stone matrix asphalt (SMA). Participants will receive a copy of NCAT's college textbook on asphalt technology and other resource materials. Some financial assistance in attending this course is possible. Please call NCAT at 334.844.NCAT for a brochure or information, or visit our web site at www.ncat.us.

SPECIFICATION CORNER

Colorado – The Colorado DOT will pilot a temperature-based segregation specification this summer. The specification was developed to help minimize nonuniform compaction of HMA due to cold areas in the mix laid by the paver. The specification allows nonrandom density testing if an area is 25° C or cooler than adjacent areas across the width of the mat. If four or more areas within a lot of 500 tons have density values of less than 92 percent of the theoretical maximum specific gravity, a 5 percent price disincentive will be applied to the 500-ton lot.

Indiana – The Indiana DOT had implemented percent within limits (PWL) specifications in 2006 on eight contracts and will expand the use of this specification to 12 contracts in 2008. This is a statistical specification based on test data obtained on in-place HMA samples.



This is a rare photograph of Bruce Gilbert Marshall of the then Mississippi Highway Department, who developed the earliest version of the Marshall Mix Design Method around 1939. Prior to Superpave, Marshall method was used in the US. It is still being used in most countries of the world for designing HMA. This photograph was supplied to NCAT recently by Bruce Marshall's nephew, Marty Deterding.

HMA is acceptable if its binder content, air voids, VMA, and mat density meet certain specifications. Loose HMA is obtained from plate samples behind the paver to determine binder content, air voids and VMA. Cores are used to determine mat density. The data from these eight contracts are being used to verify the specification limits to be used in determining the PWL. In addition, the contractor must collect additional samples at other random locations so comparisons can be made between the DOT and contractor test results.

An analysis of the test data from the eight contracts has indicated that the specification limits used for determining PWL of the mixtures tested were comparable to the limits used in the existing specifications. Only limited data could be obtained for 12.5 mm, 19.0 mm, and 25.0 mm nominal size mixtures. Contracts in 2008 will allow more of these mixtures to be analyzed.

Mississippi – The Mississippi DOT implemented an open graded friction course (OGFC) specification in January 2006. The OGFC will be used as a wearing course on high-traffic roadways and will contain native Mississippi gravel aggregates, fibers, and polymer-modified binders.

Nevada – The Nevada DOT has now adopted PG binder specification for use when specifying unmodified (neat) binders.

New York – The New York State DOT revised its Superpave mixture design criteria in 2006 to address durability concerns the state has experienced since the implementation of Superpave in 1996. The concerns were specifically related to top-down cracking, and premature reflective cracking and raveling that compromised the overall durability of HMA pavements resulting in loss of service life or additional maintenance. In order to improve the service life of HMA pavements, the following changes have been made for designing all standard mixes:

- Lower the design air voids to 3.5 percent
- Increase the minimum asphalt content by 0.2 percent
- Increase the minimum 2.36 mm sieve control point requirement by 3 percent (except for 9.5 mm mixes)

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PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of the Transportation Research Board held in Washington, DC in January 2007. We are reporting observations and conclusions from them, which may be of value to field engineers. These comments are obtained 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 paper are provided, with names of authors in parentheses, followed by a brief summary.

1. EVALUATING GEORGIA'S COMPACTION REQUIREMENTS FOR STONE MATRIX ASPHALT MIXTURES (West, Moore, Jared, and Wu)

Stone matrix asphalt (SMA) has been increasing in popularity in the United States. Twenty-eight states now utilize SMA, which has been reported to provide a 20- to 30- percent increase in pavement life over conventional asphalt pavements. In 1994, the Georgia Department of Transportation (GDOT) initiated a policy to use SMA on all interstates and other highways with average daily traffic (ADT) greater than 50,000 over a twenty-year design period.

In Georgia, the current specifications allow SMA mixtures to be designed either by using 50 blows of a Marshall hammer or using 50 gyrations in a Superpave

Gyratory Compactor (SGC). Various studies in the past have recommended gyratory compaction levels from 70 to 100 gyrations for SMA mix design. Although a few states have attempted to use gyratory compactors for SMA mix design, most agencies and/or contractors in the US continue to use a 50-blow Marshall compaction for the design of SMA mixes.

SMA mix designs using the Marshall method of specimen compaction have performed very well in Georgia for over a decade. With this history of success, the goal of this research was to change the type of compactor without changing SMA mixtures. Therefore, the purpose of this project was to evaluate the compaction requirements for SMA containing Georgia aggregates using a Superpave gyratory compactor. The project consisted of four tasks. Task 1 was to select materials that were commonly used for SMA in Georgia. Task 2 was to conduct SMA mix designs with the materials using four compactive efforts: 50-blow Marshall compaction, and 50, 75, and 100 gyrations with a Superpave gyratory compactor. Task 3 was to perform tests on the SMA mix designs from Task 2 to evaluate the effects of laboratory compactive effort on aggregate breakdown and rutting potential. Finally, task 4 was to verify the laboratory test results with sampling and testing of SMA mixtures actually produced and placed in Georgia.

The materials commonly used for SMA mixtures in Georgia were used in the study. Five granite aggregate

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John Bobo (right), administrator of the U.S. Department of Transportation's Research and Innovative Technology Administration, visited NCAT in February. Buzz Powell, NCAT test track manager, is explaining to him the significance of various test sections under evaluation.

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sources were used in the laboratory phase. These aggregates cover a wide range of Los Angeles (LA) Abrasion values and flat/elongated percentages within the Georgia specifications for SMA aggregates. The GDOT maximum limit for LA Abrasion is 45 percent, and the maximum limit for flat and elongated particles at the 3:1 ratio is 20 percent. Due to these limitations, only seven quarries are currently able to produce SMA stone in Georgia. The LA Abrasion value of the five aggregates ranged from 16 to 44 percent, whereas the flat and elongated particles ranged from 12.6 to 19.3 percent.

Cellulose fiber, added at 0.3 percent by weight of mixture, was used to minimize drain down. One percent hydrated lime was added to all mixes, as required by GDOT specifications. A PG 76-22 asphalt binder was used. The selected materials were combined to produce gradations similar to GDOT approved SMA mix designs. Optimum asphalt contents were determined for each blend gradation to yield 3.5 percent air voids using a 50-blow Marshall compaction and 50, 75, and 100 gyrations with the SGC.

Mix designs completed with the SGC were prepared at the respective optimum binder contents corresponding to each Ndesign level to test for rutting potential with the Asphalt Pavement Analyzer (APA).

Aggregate breakdown during laboratory compaction was also evaluated. For this analysis, aggregate breakdown was calculated as the change in percent passing on the 4.75 mm sieve and on the 0.075 mm sieve. The 4.75 mm sieve is the breakpoint sieve for 12.5 mm SMA mixtures and defines a break in the aggregate gradation between the fine and coarse aggregate. Breakdown of the gradation in an SMA can

reduce the stone-on-stone contact needed for good mix stability and alter the aggregate skeleton such that the VMA of the mixture collapses.

The following is a summary of test results:

- The number of gyrations required to obtain a density equivalent to 50 blows of the Marshall hammer ranged from 16 to 79 for the five SMA mixtures evaluated. This range of equivalent gyrations was found to be strongly influenced by the aggregate's resistance to degradation. The data shows that 35 gyrations with the SGC, on average, provided the same density as 50 blows from a Marshall hammer.
- SMA mix designs with the gyratory compactor yielded lower optimum asphalt contents than the same mix compacted with the Marshall hammer. At 50 gyrations, the optimum asphalt contents ranged from 5.6 to 7.2 percent. The minimum asphalt content currently allowed by GDOT specifications is 5.8 percent. As the number of design gyrations increased from 50 to 75, and 75 to 100, the optimum asphalt contents dropped by 0.5 percent on average.
- The SMA mix designs completed using the SGC had good rutting resistance in the APA test. The rutting potential of the mixtures did not appear to be sensitive to changes in asphalt content over the range evaluated.
- Fifty gyrations with the SGC caused slightly less aggregate breakdown compared to 50 blows with the Marshall hammer.

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NCAT hosted the delegates from the World of Asphalt 2007 on March 23. The delegates toured the NCAT laboratory and the test track.

NCHRP Projects Related to Hot Mix Asphalt

The Fall 2006 issue of the Asphalt Technology News included a list of NCHRP projects related to hot mix asphalt. We inadvertently omitted NCHRP Project, “Beta Testing and Validation of Performance Related Specifications (PRS) for HMA”, which is being conducted by Fugro Consultants, Inc., Austin, Texas. This project, with a contract price of \$ 1 million, was started in October, 2000 and will be completed in December, 2007. The objective of the project is to develop, test and implement a software package for a performance-based specification for hot mix asphalt.

- For the field SMA mixtures, 34 gyrations with the SGC, on average, provided the same compacted density as 50 blows with the Marshall hammer. This verified the results of the analysis from the laboratory mix designs.
- All of the field SMA mixtures performed well in the Asphalt Pavement Analyzer.

The results from this study indicate that the relationship between gyrations in the SGC and the 50-blow Marshall hammer is significantly influenced by the resistance of the aggregate to degradation. Because most of the approved SMA aggregates in Georgia have L.A. abrasion values between 35 and 45, a relatively low number of gyrations are required to match the compactive effort from the 50-blow Marshall hammer. Although the data indicates that 35 gyrations or less would provide the same optimum asphalt contents as historically achieved with the Marshall hammer for the Georgia aggregates, that low of a compactive effort is outside of the range suggested by other SMA Ndesign studies, and is below the lowest compactive effort currently used for Superpave mixtures. A 50-gyrations compactive effort is more conservative and is well supported from the standpoint of very good performance in the laboratory and at the NCAT test track.

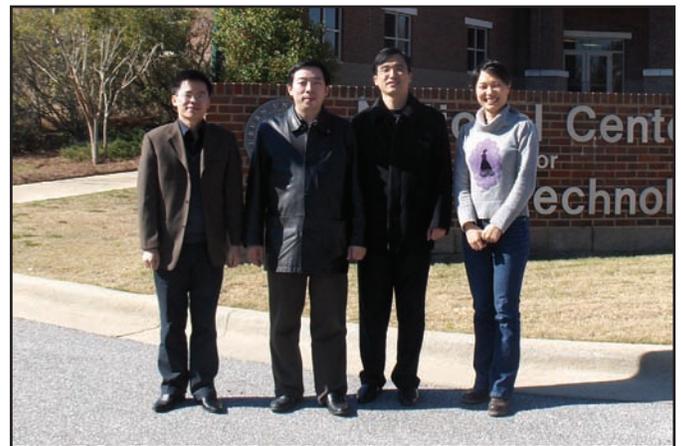
Therefore, based on Georgia’s successful use of aggregates with relatively high L.A. abrasion values in SMA, it has been recommended that the Ndesign for SMA mix designs be set at 50 gyrations using a Superpave Gyratory Compactor. This will reduce the asphalt contents of some SMA mixtures more than others. Aggregates with high L.A. abrasion loss results will have the greatest decrease in optimum

asphalt content compared to designs with the Marshall hammer. Accordingly, the optimum asphalt content may be increased to the minimum asphalt content specified by the GDOT for SMA to compensate for the minor loss of asphalt content when 50 gyrations are used in a mix design.

2. ACHIEVING FOUR PERCENT AIR VOIDS IN REAL PAVEMENTS WITH SUPERPAVE (Shuler, Harmelink, and Aschenbrener)

The Colorado DOT began implementing the Superpave mix design method in 1995. This included the originally SHRP recommended Ndesign gyration levels of 68 to 109 for low to very high traffic pavements. Design asphalt contents for these mixes

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A team of four highway research engineers from Shandong Province of the Peoples Republic of China visited NCAT in February. The team reviewed project data collected as part of the perpetual pavement project on the Bin-Bo Expressway in Binzhou. NCAT assisted in the construction and instrumentation of this project. The research engineers from left to right are: Wei Jincheng, Wang Lin, Zhang Jian, and Xin Xing.



Chinese engineers installing instruments with assistance from NCAT for the perpetual pavement project in Binzhou.

were lower than historically utilized for similar mixtures with comparable gradations and aggregate sources. Predictably, the pavements constructed using the initial SHRP design gyrations began to deteriorate prematurely due to moisture damage. A study was conducted in Colorado to determine whether these pavements were reaching the four percent design air voids level as anticipated. When the research found that air voids were reaching an asymptote well above this level, steps were taken to reduce the level of compactive effort during design and then observe the effect of this in the field. This paper summarizes these efforts to calibrate the Superpave design gyration levels to real pavements in Colorado so that an asymptotic level of four percent air voids occurs after approximately three years in service.

Two sets of air void data from two phases of this study have been presented in this paper. The first set (Phase I) is based on design gyrations originally recommended by SHRP and which led to higher in-situ air voids after three years than desired. The second set (Phase II) of air voids data is the result of lowering the design gyration levels.

Twenty-two projects were selected for evaluation in Phase I of this study. Projects were selected based on recommendations from an earlier research project, which suggested dividing the state into four high temperature regions and five traffic categories. The temperature regions are based on the highest 7-day average maximum temperatures. The traffic categories were obtained by subdividing the state into five 20-year, 18-kip equivalent single axle load levels. Each mixture met the Superpave mixture design criteria and was either a 1/2 inch or 3/4 inch nominal maximum

size dense-graded mixture. Although gradations of the mixtures were all different, and sources of aggregate used in the mixtures also varied, it was felt that a range of mixtures should be studied from around the state to determine the general ability of the design method to predict in-situ void levels after trafficking.

During construction, samples of the loose asphalt mixture were obtained from behind the laydown machine. These samples were compacted using the Superpave gyratory compactor as follows:

- 3 samples at the design gyration value
- 3 samples at one level below the design gyration value
- 3 samples at one level above the design gyration value

Fifteen cores were taken from each project immediately after construction – three cores, each taken at 50 foot intervals in the left wheel path of the design lane, were collected from five locations. Testing on the cores was done independently and the value of the air voids from each location was calculated.

The top lift of each core was removed and tested for construction air voids by using maximum theoretical specific gravity and bulk specific gravity tests of the materials in accordance with AASHTO T209 and T166, respectively. At the time of construction mat compaction was within the specification range of 92 to 96 percent of theoretical maximum density (4 to 8 percent air voids). The average density of these 22 evaluation sections was 94.7 percent with a standard deviation of 1.6 percent. Each year after construction, five cores were taken from the pavement. These cores were taken in the vicinity of the group of the fifteen cores originally taken immediately following construction. The air voids from the five cores were averaged and recorded as the in-situ air voids for each project.

In-situ air voids in these 22 evaluation sections after trafficking for three through six years were compared to the air voids obtained after Superpave gyratory compaction of the field mixed/lab compacted material from each project. It was observed from Phase I of this study of 22 projects that the in-situ air voids after traffic densification in service were significantly higher than was desired. This prompted the Colorado DOT to reduce design gyration levels. Pavements constructed in 2003 had design gyration levels reduced to 50, 75 and 100 depending on traffic and climate. Seventeen projects were then selected for Phase II of this study

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NCAT's Superpave Mix Design Course (March 26-29, 2007)



Back, L-R: Don Watson (Instructor), Gene Summers, Andre Smit (Instructor), Bob Ekstrom, Meor Othman, Bob Jankowski, Michael Schwann, Larry Sieber, Kris Williams. **Front, L-R:** Andrea Kvasnak (Instructor), Jerrick Scott, Perry Lepley, Jeffrey Keck, Nick Plante, Justin Taylor, Jamie Creech, Russell Moon, Graham Hurley (Instructor). Not Pictured: James Van Acker

for coring after two and three years to determine if in-situ air voids levels more closely approached the desired four percent level produced during mix design. A recent review of the pavements constructed in 2003 using the reduced gyration levels indicates that less surface raveling is present than would be expected in similar pavements constructed using the higher gyration levels of the past after a similar service period. The following conclusions have been drawn from this study:

- Pavements constructed using the original Superpave design compaction criteria have not reached design air voids after six years service in Colorado. On average, the initial pavements studied had 1.2 percent higher air voids after three years service than the desired air voids level of four percent.
- Based on these findings gyration levels were reduced to 50, 75 and 100 depending on traffic and temperature. Results of this reduction led to an average in-situ air voids level of three percent after three years for the pavements where 75 gyration designs were used instead of the previously recommended 86 and 96 gyration designs. Mixtures where 100 gyration designs were used have 4.67 percent average in-situ air voids after three years. This is consistent with earlier findings in Phase I.

- Pavements where 75 gyration mixtures were placed appear to be densifying faster and to lower void levels than desired. This may justify an upward adjustment to gyration levels if this trend continues. Pavements where 100 gyration mixtures were placed appear to have leveled off at 4.7 percent air voids after three years, indicating that a downward adjustment might be warranted if this trend continues.

[Editor's Note: NCHRP Project 9-9 (1), "Verification of Gyration Levels in the Ndesign Table" was completed by NCAT at about the same time this Colorado study was published. The NCAT study was reported as the cover story in the Fall 2006 issue of the Asphalt Technology News. Being a national study it involved 40 HMA paving projects in 16 states to represent different traffic and climatic conditions across the US.]

NCAT Has New Domain Name

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

— Asphalt Forum Responses

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of its conclusions, it would be very premature in Connecticut to proceed with any specification changes at this time.

Kansas (Cliff Hobson, Kansas DOT)

We are waiting for the final published report to review data before commenting.

Mississippi (James Williams III, Mississippi DOT)

The Mississippi DOT currently uses the following requirements: N_{initial} must be less than 90.0 percent of the maximum specific gravity and N_{maximum} must be less than 98.0 percent of the maximum specific gravity.

New York (Zoeb Zavery, New York State DOT)

The New York State DOT's revised gyration levels (see Specification Corner in this issue) are similar to those proposed by NCAT. We believe N_{maximum} should continue to be checked during design and mix verification at the plant to provide some assurance that the mix will not be prone to rutting.

Ohio (Dave Powers, Ohio DOT)

We like the direction the NCAT recommendations are going and we believe the states will benefit from it. In Ohio, we have evolved an N_{design} of 65 gyrations for all high-traffic roads. This in conjunction with polymer-modified PG binder and a 94 percent minimum, bonus density specification, have given us a more durable mix HMA that performs well. I like N_{initial} for low-traffic mixes containing natural sand. It is a good control. I like N_{maximum} only as an additional check to control mixes that tend to run low in air voids. It is not essential in design though and we could live without it.

Research in Progress

We have discontinued the publication of this column in this newsletter because it can now be accessed on NCAT's homepage at 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.

Tennessee (Heather Hall, Tennessee DOT)

Although Tennessee has not adopted the Superpave method of mix design, we have incorporated the option of utilizing the Superpave gyratory compactor into our standard specifications. Our in-house research has shown that a compaction level of 65 gyrations produces desirable volumetric properties; while at the same time allowing for increased binder contents, which reduce the likelihood of premature fatigue cracking. This compaction level was further evaluated at the NCAT Test Track during its second cycle (Phase II) and produced favorable results. Tennessee currently has no requirement for either N_{initial} or N_{maximum} compaction levels.

Utah (Tim Biel, Utah DOT)

We have discussed the NCAT recommendations briefly and do not have any major objections or concerns at this point.

Ontario (Chris Raymond, Ontario Ministry of Transportation)

Ontario is following the NCAT research closely and is considering a research study to validate the findings with Ontario's Superpave mixes.

— Specification Corner

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- Reduce the number of gyrations (See Table 1.)

Number of Gyrations				
Estimated Traffic (Million 80 kN ESALs)	< 0.3	0.3 to < 3.0	3.0 to < 30.0	≥ 30.0
N _{initial}	6	7	8	9
N _{design}	50	65	75	100
N _{maximum}	75	95	115	160

Table 1. Gyration recommendations for standard mixes

These mix design revisions are the result of a joint work group comprised of New York Construction Materials Association (HMA producers) and department representatives. The work group reviewed the performance of several asphalt pavements in New York State compared to the mix design, changes made by other states, past research findings, and preliminary findings from ongoing national research. The group determined that these changes would systematically

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increase the asphalt binder contents and would also result in slightly finer HMA mixtures to provide more durable HMA pavements without significantly increasing the potential for rutting. Initial evaluations of pavements constructed in 2006 with HMA meeting the new requirements are encouraging.

Ohio – The Ohio DOT has made the following specification revisions:

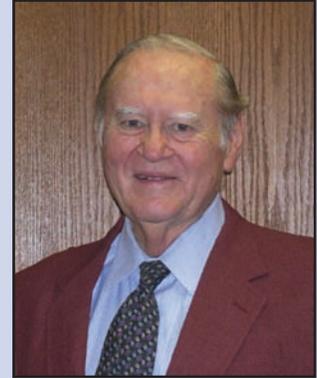
- The nighttime paving requirements (Ohio does a lot of night paving) have been upgraded to include smoothness, material transfer vehicle when applicable and better lighting requirements. This has been done to control the quality of HMA placement under low light conditions. Also included is a daylight DOT review of the HMA in the next morning.
- The micro-deval test has been introduced to deal with isolated problem aggregates. The test method is being considered as a possible replacement for the soundness test.
- A new density quality control has been introduced for checking the mat density of low-volume roads through the use of nuclear and PQI density gauges.
- Tack coat requirements have been revised to limit dilution of the emulsified asphalt and to ensure uniform application.
- The contractor test acceptance procedures have been revised to meet FHWA requirements.

Texas – The Texas DOT has adopted a new specification for a crack attenuating mix (CAM). This specification includes requirements for the Hamburg wheel-tracking device to evaluate moisture damage, rutting, and requirements to use the Overlay Tester Device developed by the Texas Transportation Institute to evaluate the cracking resistance of the mix. The CAM is used as an intermediate layer on top of jointed concrete pavements. Some districts use it across the state with a significant success in delaying reflection cracking.

Utah – The Utah DOT is currently working to revise the HMA specification so that the HMA acceptance is based on mix volumetrics rather than mix composition, such as asphalt content and gradation. The intent is to put the management and acceptance focus on the criteria that are considered the most important. The revised specification will be used as a special provision on several projects this year.

Ray Bass Alabama DOT Director

Ray Bass who served many years as the Alabama DOT Director (1971-1979 and 1983-1987) and Chief Engineer (1995-2005) died on March 22. He had served on the NCAT Board of Directors for a number of years. He was very supportive of all NCAT programs but in particular activities at the NCAT test track. Mr. Bass was also active in several AASHTO committees and served as chairman of the National Council of State Railroad Officials.



Dr. Freddy Roberts, Former Director of NCAT

Freddy Roberts, who served as the first director of NCAT, died March 16 in Ruston, La. Roberts was appointed director when NCAT was established at Auburn University in 1986. He served NCAT until 1990, when he joined the faculty at Louisiana Tech as a professor of civil engineering and T.L. James Eminent Scholar Chair.



Roberts earned his bachelor's and master's degrees from the University of Arkansas and his doctorate from the University of Texas. He was active in numerous engineering research committees at the state and national level, made significant contributions to hot mix technology and was co-author of the first ever textbook on this technology.

**NCAT's Asphalt Technology Course
February 26 - March 2, 2007**



Back, L-R: Don Waton (Instructor), Lec Overacker, Jared Fairchild, Ryan Zoeteway, James Van Acker, Rick Diaz **Middle, L-R:** Ken Cook, Chris Tobin, Mike Palmer, Les Weilacher, Randy West (Instructor), Andre Smit (Instructor). **Front, L-R:** Brett Peterso, Jon Amos, Jeff Wages, George Dumont, Chris Yarnell, Debbie Creswell, Katrina Parker, Brandon Newbold, Andrea Kvasnak (Instructor), Jim Wilkerson

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