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NCAT PLANS A TEST TRACK FOR EVALUATING HMA PERFORMANCE

The Alabama Department of Transportation and the National Center for Asphalt Technology (NCAT) are planning to construct and operate an oval test track (accelerated pavement loading facility) to evaluate the performance of various hot mix asphalt (HMA) test pavements. Auburn University has purchased 310 acres of land approximately 15 minutes from the university for the test track. Construction is expected to begin this summer and scheduled to be completed by late summer, 1999.

It is estimated that in the United States the annual expenditure on HMA is approximately \$15 billion dollars. If steps can be taken to extend

the life of an HMA pavement only one percent (30-60 days) expected savings of \$150 million per year in HMA costs alone would be possible. A typical state DOT expends \$100-200 million per year on HMA. Many other associated costs such as traffic control, striping, shoulders, etc., increase this cost even more. Each State DOT can easily save \$2 million or more per year simply by increasing the life of its HMA by one percent. Therefore, good effective research that leads to improved performance of HMA will more than pay for itself in a very short period of time.

Efforts have been made in the past
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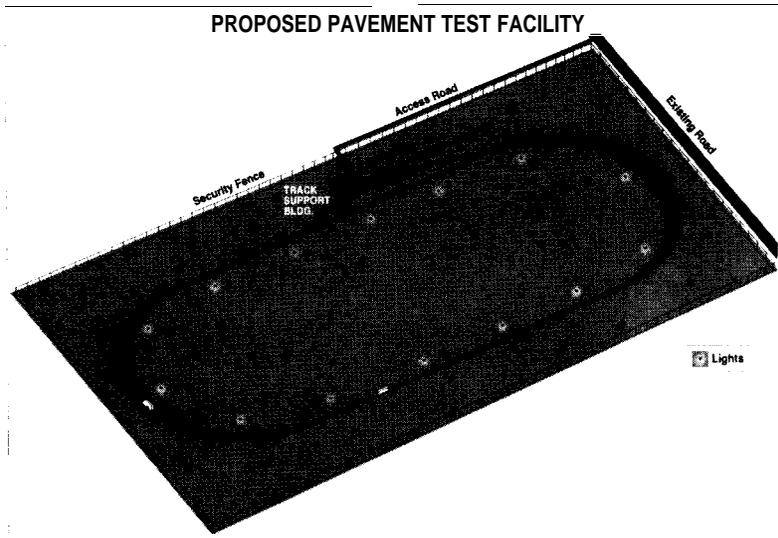
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Proposed layout of the oval test track facility



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few years to develop test methods and procedures for predicting performance based on HMA properties. A major effort has recently been completed as part of the Strategic Highway Research Program (SHRP). This program developed new binder tests and new mixture tests that are performance based. As a result of this program Superpave mix design and analysis procedures were developed. Efforts are needed to verify and calibrate these models to provide optimum results. Because of the wide variety of aggregate types, gradations, and asphalt binder sources it will take much work to verify them.

Work is presently under way by contract from FHWA to develop models to predict performance based on SHRP work. This effort involves the investigation of models developed under SHRP as well as new models. The models that are ultimately selected must be verified and correlated based on actual traffic. This will take years, and therefore will likely never be adequately accomplished using data from existing roadways. The best way to accomplish this work is with accelerated

testing so that the data can be accurately collected in a relatively short period of time (typically 1-3 years).

Additional work has been performed in recent years with laboratory rut testers. These devices apply repeated loadings to laboratory samples at elevated temperatures to evaluate rutting potential. They appear to have some benefit in predicting rutting, but verification of these methods is expensive and time consuming. Verification results are needed as soon as possible because many states have already begun to use some of these rut testers. At this point in time there is not a standard procedure for conducting such laboratory wheel tracking tests. Work is needed to develop a standard test procedure that provides test results that relate best to rutting.

The Federal Highway Administration (FHWA) is aware of this need for verifying methods to predict performance. As a result, the FHWA funded the construction and operation of a full scale test track near Reno, Nevada, to evaluate a number of mixtures under accelerated loading. Approximately 25 200-foot (60-m) long test sections are being evaluated. The primary objective is to evaluate the effect of construction variables (such as asphalt content, gradation, and as-constructed density) on HMA performance. Since the number of variables is so high, only one aggregate source and one asphalt cement source were used in the study. This indicates that much additional work is needed to verify that the various methods of predicting rutting are accurate for a wide range of aggregate and asphalt cement sources. Early results from these accelerated tests indicate that some mixtures are not performing as expected. This shows that additional work is necessary to better understand how various types of HMA mixtures will perform.

Many advances have been made during the past few years to better understand and predict pavement performance. Much work needs to be done in the next three to five years to verify and to calibrate these new approaches developed under SHRP and related studies. The only way to obtain the performance data needed in a reasonable amount of time is with accelerated loading. The oval test track concept offers the best solution to obtain the most data within a short amount of time. The test track can be used to fully evaluate 20-25 various pavement sections within two years. After the two years of traffic has been applied, the test track can be reconstructed and another 20-25 sections evaluated in another two-year period. One primary advantage of an oval test track is that the pavement is loaded with actual trucks very similar to roadways. Some additional advantages include: (1) better control of construction quality, (2) better control and measurement of traffic, (3) accelerated loading so that test time is reduced. (4)

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

Phone: (334) 844-NCAT (6228) Fax: (334) 844-6248

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E. Ray Brown, Director

Prithvi (Ken) Kandhal, Associate Director/Editor

James S. Ki Hi an III, Associate Editor, College of Engineering

*The managers of all regional
Superpave Centers met at
NCAT on March 30-31*



(TEST TRACK, Continued from page 2)

improved safety since traffic can be stopped when inspecting and sampling test sections on an oval track, and (5) better control of data collection. The primary advantages of the test track compared to other load simulators include: (1) several sections can be trafficked at one time, (2) better simulation of traffic, (3) more sections tested within a given period of time, and (4) lower cost per test section.

Many states have expressed interest in validation of some of the new tests being used to predict performance. Because of this interest more states have begun to look at various ways of accelerated loading. As a result of this interest in accelerated loading, the Alabama DOT will pay for all construction costs associated with the construction of the proposed oval test track and support facilities in Auburn. After the track is constructed it is anticipated that several state DOTs, in partnership, will fund the operation of the track through the purchase of test sections. Each state will be responsible for the cost associated with construction, trafficking, data collection, and analysis of its test sections. Each state DOT will be able to select local materials to be used in test sections.

An advisory group will be established to plan the experimental design for the test sections. It will be made up of representatives from all participating DOTs (which may include local universities). A test plan will be developed by this advisory group to obtain the maximum benefits possible from the test sections while allowing each state DOT to select the materials and design for their sections.

The test track consisting of 24 HMA test sections will be approximately 9,000 feet (2,750 m) long and will have two straight sections that are approximately 6,000 feet (1,830 m) in combined length. Each test section will be 200 feet (60 m) long and 12 feet (3.5 m) wide. The proposed layout of the test track is shown on page 1. The Alabama DOT will contract for the construction of the track including clearing, grading, processed subgrade, subbase, base course, and prime coat. All participating state DOTs will be responsible for the cost of test section construction and other operational costs for the track.

It is anticipated that a pooled fund effort will be used to support the track. The FHWA (Region 4) has agreed to serve as the coordinator for the pooled fund effort, while the Alabama DOT will serve as the host state.

A local contractor will be selected to construct the various test sections. All materials such as aggregates and asphalt binder will be provided to the contractor by each state DOT. Mixes will be sampled and tested by NCAT prior to and during the construction process. Testing for each test section will include but not be limited to: asphalt content, aggregate gradation, laboratory volumetric, in-place volumetric, laboratory wheel tracking, and Superpave mix analysis. In-place samples will also be taken periodically throughout the two-year cycle to evaluate densification (this will allow verification of Superpave N_{design}) and other properties.

The pavement will consist of two 12-foot (3.5 m) lanes and a 4-foot (1.2 m) shoulder on each side. One of the two lanes will be used to help stabilize plant production and evaluate roller patterns prior to

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The NCAT Board of Directors met in Auburn on April 6 to review NCAT activities

(TEST TRACK, Continued from page 3)

construction of the actual test section.

After all sections are constructed application of traffic will begin. Traffic will be applied at a rate of five million ESALS per year. It is anticipated four trucks will be used and configured so that each truck will apply approximately 10 ESALS per pass. The expected axle weight is 20,000 pounds (9 Mg). It is anticipated that each truck will have three trailers.

The trucks will be operated at 40-50 mph (60-85 km/hr) which appears to be the optimum speed for this track. Higher speeds would require more curve length or more super elevation and would likely cause more dynamic loading, especially adjacent to sections that begin to become rough.

As the track is loaded, performance data will be collected on a regular basis. Each week, data such as rutting, cracking, raveling, traffic, and air temperature will be collected for all sections and provided to each state participating in the study. On a regular basis (approximately monthly) data such as profilometer, falling weight deflectometer, and surface friction will be collected. This data will also be provided to each state DOT. On a semi-annual basis a meeting of all participants will be held at NCAT to inspect the pavement sections and to discuss performance.

Two years of traffic (10 million ESALS) will be applied to each test section. It is anticipated that some mixtures will fail prior to completing two years of traffic. If this happens the section will be repaired and traffic continued.

After 10 million ESALS have been applied, traffic will be stopped and the test results analyzed. Trenches will be cut in sections with significant rutting to identify

in which layers the rutting has occurred. It is then anticipated that new sections will be constructed and a new series of test begun.

The two types of failure that lend themselves to accelerated loading are rutting and fatigue. Therefore, these are the two primary failure modes that will be investigated. Other problems such as thermal cracking, etc. will be evaluated but they are not primary items to be investigated under accelerated loading.

Even though a state DOT may be specifically involved with one, two, three, or four test sections, results from all test sections will be available to each state.

Some specific benefits that state DOT's may receive from the test track results include: (1) validation and calibration of Superpave mixture analysis tests; (2) determination of the effect of asphalt PG grade on performance; (3) evaluation of benefits of using asphalt binder modifiers; (4) evaluation of aggregate consensus properties (fine aggregate angularity tests and gradation requirements); (5) verification of N_{design} for Superpave gyratory compactor for various traffic levels; (6) validation of wheel tracking tests for predicting performance; (7) determination of performance loss due to segregation; (8) effect of pavement roughness on truck maintenance and fuel consumption; (9) evaluation of methods to repair rutted pavements; and (10) evaluation of structural coefficients for stone matrix asphalt (SMA), open graded friction courses, and large stone mixes.

SUPERPAVE MIX COMPACTION IN THE FIELD—"THE TENDER ZONE"

The existence of a "tender zone" while compacting some Superpave mixes in the field has been reported. The "tender zone" is the HMA pavement temperature zone in the range of 250 to 170°F (this can vary) where compactive effort does not result in any additional density in the pavement. It has been suggested that the breakdown roller should be used very close to the paver so that at least 90 to 92 percent compaction is achieved before the HMA mat cools down into the "tender zone." Rolling can resume after the mix cools below the "tender zone" and continue until minimum density requirements are met. The big question is—what are the causes of the "tender zone" in some Superpave mixes? We would like to hear from the readers. The discussion will be published in the next issue of **Asphalt Technology News**. — *Editor*

ASPHALT FORUM RESPONSES

The following responses have been received to questions raised in the Fall 1997 Asphalt Forum.

Some Arizona asphalt binder suppliers have reported difficulty meeting the minimum $G^/\sin \delta$ of the RTFO residue (AASHTO MP-1). They report that they must produce an inferior product to meet this portion of the specification. Have any other states experienced similar problems?*

There is considerable concern among contractors in Arizona about obtaining smoothness on Superpave mixes (Arizona DOT has incentives for smoothness). Has anyone else had similar problems? (Julie Nodes, Arizona DOT)

Kentucky (Allen Myers, Kentucky Department of Highways)

Kentucky has not experienced any problems with PG binders not meeting the $G^*/\sin \delta$ of the RTFO residue. Neither samples submitted by suppliers for certification nor samples taken on construction projects for quality-assurance testing have revealed any difficulties. Also, Kentucky's suppliers have not reported any problems in meeting this specification.

Regarding smoothness on Superpave projects, Kentucky has experienced only one project with both Superpave and smoothness specifications. On this job, some difficulty was encountered with the final pavement smoothness. The harsh nature of Superpave mixtures requires considerable compactive effort to achieve a desirable density; this extra effort may be detrimental to the smoothness of the mat. In Kentucky, we plan to concentrate on designing our Superpave mixtures such that density is achievable without a destructive amount of compaction.

Louisiana (Chris Abadie, Louisiana Transportation Research Center)

As reported in Specification Corner of the Fall 1997 issue, Louisiana's proposed specification reduces the $G^*/\sin \delta$ on RTFO material from 2.2 to 1.75 for modified binders. This proposal was written based on data which shows our PAC 40-HG asphalts and PAC30 asphalts supplied exhibit a lower ratio of (RTFO $G^*/\sin \delta$ /Original $G^*/\sin \delta$) than our AC-30s. We are looking at providing more aging action for the "thicker" binder in the RTFO jar by inserting a metal rod thereby exposing more surface area to the air.

Smoothness for our HMA pavements has not been much of a problem since the material transfer vehicle (MTV) requirement was implemented.

Illinois (Bruce Peebles, Illinois DOT)

Illinois DOT has not experienced a problem meeting the minimum $G^*/\sin \delta$ in the RTFO test.

Regarding smoothness our experience is with dense-graded Marshall mix designs using crushed coarse aggregates. We found proper mix temperatures, keeping the breakdown rollers close to the paver, and controlling segregation reduce the potential for rough pavements.

Georgia (Lamar Caylor, Georgia DOT)

The Georgia DOT (GDOT) has not had any problems with asphalt binder suppliers meeting the minimum $G^*/\sin \delta$ for the RTFO residue. GDOT does not understand how an inferior product is produced by meeting this specification requirement. Permanent deformation is governed by limiting $G^*/\sin \delta$ at the test temperatures to a value greater than 2.2 kPa. To minimize rutting, this minimum value must be met.

There have been no problems obtaining target smoothness on Superpave surface mixes (12.5 mm).

- 1. How many states use the phase angle to indirectly specify polymer content of PG binders? If used, what phase angle is specified?*
- 2. How do other states specify mixing and compaction temperatures for PG 70-XX and PG 76-XX binders? By temperature/viscosity charts? By manufacturer's recommendation? By state's definition?*
- 3. Are other states allowing gyratory compactors besides Pine and Troxler to be used? If so, what criteria are used to "qualify" these other compactors?*
- 4. What optimum air-void content are other states using for coarse-graded Superpave mixtures? Kentucky's large-stone base mixtures specify a target air-void content of 5.5-6.0 percent. What should we use for Superpave designs: the same targets or 4.0 percent?*
- 5. What design life are other states using for calculation of ESALs for a Superpave project? Twenty years across the board? Different values for resurfacing and rehabilitation projects versus new construction?*
- 6. Have any other states experienced a drastic decrease in air voids and VMA between the laboratory Superpave mix design and plant-produced-mixture specimens compacted with the gyratory compactor? (Allen Myers, Kentucky Department of Highways)*

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SUPERPAVE VOLUMETRIC MIX DESIGN WORKSHOPS

Superpave volumetric mix design workshops will be held at NCAT regularly. These workshops consist of two and a half days of intensive lecture, demonstration, and hands-on training on Superpave mix design procedures. Upon completion the participants will be able to conduct the Superpave mix designs in their laboratories.

Please call (334) 844- NC AT(6228) for brochure or information, or visit our web site at: <<http://www.eng.auburn.edu/center/ncat>>

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Ohio (Dave Powers, Ohio DOT)

1. We use phase angle as one of several criteria for polymer modified asphalt binders: 77 degrees maximum for SBR and 82 degrees maximum for SBS type polymers.
2. We require a temperature/viscosity chart for all binders, but we will go with the manufacturer's recommendations if reasonable. based on our experience.
3. Gyrotory compactors must pass the FHWA criteria when tested through a Superpave Center.
4. We do not have any experience with Superpave base course mixtures. However, we will use our traditional range of 4.5 to 5.0 percent for air voids.
5. Since the Superpave gyration chart was established based on 20-year design life, we would not deviate from it because the truck traffic is the key to minimize rutting. If other design life is used. the number of gyrations may have to be altered.

Georgia (Lamar Caylor, Georgia DOT)

The Georgia DOT (GDOT) uses a maximum phase angle of 75 degrees to indirectly place controls on polymer content of PG 76-22 binder.

GDOT specifies mixing and compaction temperature for PG 76-22 (polymer-modified grade) based on previous construction history and mix design experience. Currently, GDOT uses 350° F (177°C) and 325° F (163° C) as the mixing and compacting temperatures, respectively, for materials of this grade.

Although the data is limited, comparisons that have been made of Superpave mixtures using the Superpave gyrotory compactor reveal that both air voids and VMA compare reasonably well between the laboratory mix design and the plant produced mix.

Illinois (Bruce Peebles, Illinois DOT)

The Illinois DOT uses a force ductility test and an elastic recovery test to ensure adequate polymer content in modified asphalt binders.

The production and placement temperatures for modified PG asphalts are based on producer's recommendations. Others are specified by state definition.

Illinois DOT allows gyrotory compactors that have been evaluated and approved by a Superpave center according to AASHTO PP 35.

Illinois DOT uses fifteen-year design life for all HMA projects.

The addition of anti-stripping agents to PG asphalts binder changes their properties and sometimes results in the product not meeting the specified grade. Should PG grades be specified to meet the specification after addition of the anti-stripping agent, or should the PG asphalt binder be tested prior to addition of the anti-stripping agent? (Terry Hughes, New Brunswick DOT)

Kentucky (Allen Myers, Kentucky Department of Highways)

Kentucky has not experienced any failures of PG binders to meet specifications due to the addition of an anti-stripping agent. In one instance. the addition of a particular anti-stripping agent actually raised the upper temperature of the PG binder by two degrees. If the concern lies in the final product being placed on the roadway, then the final PG binder product (after the anti-stripping agent is added) should be tested. In cases where the agent is added at the HMA plant. the contractor could then be considered the manufacturer of the material and required to follow the guidelines as any other binder supplier.

Georgia (Lamar Caylor, Georgia DOT)

The Georgia DOT currently specifies the performance grade before the addition of anti-stripping agents. Samples of binders which contain anti-stripping agents have been tested, but no failures have been encountered.



ASPHALT FORUM

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

Florida (Gale Page, Florida DOT)

Florida's mat density requirement for 94 percent Gmm (maximum 6 percent air voids) for coarse-graded Superpave mixes may be tough to achieve but is attainable if right compaction equipment is used at the right time in the right sequence for the particular mix and environmental conditions.

Georgia (Lamar Caylor, Georgia DOT)

Have others experienced difficulty in sealing cores from coarse Superpave mixtures (25 mm) in order to determine density? What methods have been used successfully?

Illinois (Bruce Peebles, Illinois DOT)

1. What procedure do other states use to determine percent moisture in HMA mixtures? Is this procedure used as part of mix production process control?
2. What procedure do other states use to approve a particular anti-strip additive for use in HMA mixtures?

Louisiana (Chris Abadie, Louisiana Transportation Research Center)

Do any states currently specify stone matrix asphalt (SMA) mix design and plant control utilizing the gyratory compactor?

Do any states require compaction to N_{max} and then back calculate air voids at N_{design} for plant control on Superpave mixes? If so, have you adjusted N_{design} based on a history with the materials?

Maine (Dale Peabody, Maine DOT)

We understand that the Federal Highway Administration and Florida DOT are recommending that the minimum lift thickness for Superpave should be four times the nominal maximum aggregate size. This change would have an economic impact on our hot mix asphalt program which currently uses lift thickness 2 to 2 1/2 times the maximum aggregate size. Are other states impacted by this recommendation? What are the minimum anticipated lift thicknesses for Superpave mixes in other states? Do others plan to use Superpave mixes on overlay projects as well as full construction/rehabilitation projects?

Missouri (Jim Campbell, Missouri DOT)

Four Superpave projects will be constructed during the 1998 construction season. The projects are all PCCP overlays. Approximately 140,000 tons of mix will be laid on these four jobs. The jobs completed to date are performing well.

Nebraska (Laird Weishahn, Nebraska Dept. of Roads)

Nebraska Department of Highways has decided to use the fine aggregate angularity (FAA) test procedure for the fine aggregate and specify minimum FAA values for some of our present dense-graded mixes, which are normally very fine mixes above the maximum density line. We are specifying values of 43 and 44 for a couple of mixes on our major state highways which have traffic volumes in the second and third categories as defined by Superpave. Although the Superpave mix for the same projects will require a FAA value of 40, we believe a higher FAA value is required for mixes much finer than the Superpave mixes. Have other states applied the FAA requirement to non-Superpave mixes and what are the results of this effort?

South Carolina (Milt Fletcher, South Carolina DOT)

Which states are implementing a QC/QA program in Superpave mixtures? If a state is implementing a QC/QA Superpave program, what type of Superpave QC/QA specification is being developed (percent within limits, absolute average deviation, etc.)?

Vermont (Timothy Pockette, Vermont Agency of Transportation)

Of the seven Superpave projects let in 1997, four were completed, one was started, and two were carried over to 1998. There were no problems encountered in Vermont. Construction went well and compaction was achieved with both daytime and nighttime paving.

Virginia (Bill Maupin, Virginia DOT)

The Virginia DOT experienced two major failures of overlay on milled asphalt pavement that were believed to be attributed to one or a combination of several causes. The overlay started to fail and show
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(*ASPHALT FORUM*, Continued from page 7)

distress less than six months after placement. Distress included white stain, pumping of fines (not base material) to surface and localized disintegration. Possible causes were permeable surface, failure to properly clean milled surface, poor tack, and thin scabs of old pavement left on milled surface. Has anyone experienced similar problems? How do you clean wet fines from milled surface? How do you get proper amount of tack without creating safety problems with tracking? How do you handle scab problem?

(We investigated a similar distressed pavement in Oklahoma a few years ago. The new overlay started to exhibit white stains and localized disintegration within a few months after construction. The problem was not the milled surface but the underlying layer which was already stripped and should also have been milled off. White stains were resulting from the white fines of the stripped aggregate being brought up to the surface by water. I recommend you examine the existing HMA course for stripping. - Editor)

Cores of coarse mixes sometimes seem to indicate a false high density. High absorption during the specific gravity determination is rarely experienced so that alternate methods such as paraffin or parafilm coating of specimen is "necessary." Do others have this problem?

Wyoming (George Huntington, Wyoming DOT)

Implementation of the NCAT ignition test for asphalt content raises problems particularly with aggregates that break down in the oven. How are other states calibrating the NCAT ovens for individual aggregates? (*ASTM provisional standard PS 90 of 1997 on "Asphalt Content of Hot Mix Asphalt by the Ignition Method" gives the procedure for calibrating the HMA mix containing the total aggregate. - Editor*)

Australia (John Bethune, Australian Asphalt Pavement Association)

Our Implementation Guide 3—Asphalt Plant Process Control Guide has created a good deal of interest as HMA industry moves to assess the concepts presented. Some workshops are likely to follow.

Israel (Shimon Nesichi, Public Works Department, Tel-Aviv)

Does any state have an approved absorbent for oil and gasoline leakage on HMA surfaces? We are looking specifically for solutions to problems which occur frequently as a result of traffic accidents and/or local spillage.

NCAT (Prithvi Kandhal, Editor)

Does any highway agency (besides Corps of Engineers and Federal Aviation Administration) specify a minimum density at the longitudinal joints of HMA pavement? If so, what is the minimum acceptable density level?

RESEARCH IN PROGRESS

We have discontinued the publication of this column in this newsletter because it now can be accessed on NCAT'S homepage. Click on "Research in Progress". It is updated frequently based on the information received from the Departments of Transportation.

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 two-week **intensive** course, which is held in February every year, 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/neat> for brochure or information.

SPECIFICATION CORNER

Alabama - About 30 Superpave projects will be constructed this year. A PG 67 grade asphalt binder specification similar to that of Georgia DOT will be used.

Arkansas - Effective January 1, 1998, Arkansas will use Superpave mixes exclusively.

Connecticut - A QC/QA specification for HMA density testing has been developed and will be incorporated into future construction projects.

Florida - Approximately 1.2 million tons of Superpave mixes were awarded in 1997. Florida is currently implementing larger size aggregate open graded friction course similar to Georgia D modified mixture.

Georgia - The Georgia DOT (GDOT) will fully implement Superpave by July 1, 1998. By that date, contractors will be responsible for designing all mixes used on the GDOT projects and the GDOT will verify the contractor's mix design for approval. The GDOT is currently processing contractor technician certification for Superpave design, in conjunction with the NCAT. In order to be certified by GDOT, the contractor lab technicians responsible for mix design must complete NCAT'S Superpave Certification Course with satisfactory results. The mix design laboratory is also required to be certified.

Hawaii - A performance based specification for smoothness is being developed. A profilograph will be used to measure the profile index.

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

Kentucky - The Kentucky DOT has produced a new specifications manual for 1998. This manual is written in the active voice/imperative mood style. All regularly used notes and provisions have been incorporated into the manual. The Superpave specification has been revised in order to comply with the target air void content of 4.0 percent. New guidelines for specifying polish-resistant aggregates in Superpave mixtures have also been developed.

Louisiana - Quality control procedures accepting direct certification of asphalt binder suppliers are being developed utilizing AASHTO PP26 as a guide. The

sample is taken at the point of last modification. (The use of anti-strip additives is not considered a modification.) Quality assurance test samples will continue to be taken at the contractor's plant.

Maine - Superpave has been fully implemented by the Maine DOT starting January 1 this year.

Missouri - The tolerances for VMA of field production from laboratory job mix have been expanded from ± 1.0 to ± 1.2 percent.

Nebraska - Seven Superpave projects have been scheduled for construction in 1998. The total amount of Superpave mix is approximately 220,000 tons, with designs in the second, third, and fourth traffic categories. PG Binders used will be PG 58-28, PG 64-22, and PG 70-22. All projects are overlays with thickness ranging from 50 to 130 mm.

Nevada - The following changes have been made to HMA specifications:

(1) For projects having gradation acceptance determined on samples obtained from behind the paver, the specification for percent passing the No. 200 (75 micron) sieve is increased by 1 percent on the maximum end. (2) Immediate control of the asphalt content for HMA will be accomplished by testing the completed mixture by the ignition method. (3) Payment for HMA is changed from dry weight of aggregate basis to wet ton as a method specification. (4) The use of alternative burner fuels will no longer be allowed. This is primarily due to concerns involving environmental issues and permits. (5) Prior to lime marination of HMA aggregates the maximum plasticity index (PI) allowed in any stockpile is 10. If the PI is over 10 it must be corrected by some means other than marination or blending to reduce PI. If the PI is 10 or less then marination is acceptable.

The following changes have been made concerning all future major paving projects:

(1) Samples for gradation acceptance will be taken from behind the paver. (2) Sieve analysis will be performed on aggregates obtained by the ignition method. (3) No adjustment will be made to the gradation results for the addition of mineral filler.

New Jersey - Only PG graded asphalt binders will be used starting this year. Six pilot projects will be constructed this year to implement Superpave mix design.

(Continued on page 10)

NCAT Applications Steering Committee met in Auburn April 2



(SPECIFICATION CORNER ,
Continued from page 9)

New Mexico - Two full Superpave projects were constructed last year. Thirty-one full Superpave projects are planned for this year. PG binder specification will also be implemented this year.

Oklahoma - The use of PG asphalt binders was commenced last year. One Superpave project was constructed last year, and eight to ten projects are planned for this year.

Oregon - Smoothness specifications based on profilograph will be implemented for interstate paving projects this year.

South Carolina - The standard performance grade binder specified in all HMA mixes is a PG64-22. Specifying a polymer modified PG76-22 in the 12.5mm Superpave

mix on interstate routes is being considered.

Vermont - Superpave binder specification following the AASHTO MP- 1 has been fully implemented. Seven projects were constructed in 1997 incorporating both Superpave volumetric and binder specifications. Three changes were made to AASHTO MP-2 as follows:

1. Production tolerances for aggregate gradation were not allowed to enter the restricted zone or exceed control points because it is recommended to stay away from these areas where tender mixes may be experienced. This caused the hot mix producers, who are responsible for mix designs, to design away from the restricted zone and control points. Only one mix design had to be changed to stay away from the restricted zone.

2. The dust asphalt proportion was left at 0.60-1.20 for mix designs but was changed to 0.50-1.20 for production testing. This change was made to allow for dry sieve analysis during production. No major effects were noted.

3. The PG Grade selection in Vermont is based on a map designed using reliability levels for both high and low temperatures. This was done to limit the number of different PG grades. Also, the PG grade is bumped at five million ESALS rather than 10 million ESALS because of the low number of ESALS in Vermont. These changes resulted in using five different PG grades: 70-28, 64-28, 64-22, 58-34, and 58-28.

Virginia - The Virginia DOT (VDOT) is continuing its third year of training efforts for Superpave. The VDOT,

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

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the Virginia Transportation Research Council, and the Virginia Asphalt Association cooperatively sponsor two certification classes: Superpave Volumetric Mix Design, and Superpave Asphalt Aggregate. Both schools require hands-on training and include an examination. The latter course is targeted towards quality control technicians in the aggregate industry. Approximately 150 technicians have been certified for Superpave volumetric mix designs. The VDOT recognizes hands-on courses taught by other institutions (such as NCAT) with satisfactory completion of an examination.

Washington - Four to eight Superpave projects are contracted per year to pave the way for full implementation.

Wisconsin - The State Departments of Transportation of Wisconsin, Minnesota, and Iowa have joined together to administer the "Tri-State Certification Method of Acceptance for Asphalt Cements." With this method, the three states administer the acceptance program in the same manner and have reciprocity of certification. This reduces testing requirements for the states and suppliers. Participation in the Tri State Round Robin is a requirement. The program is based on the program run by Wisconsin for the past seven years. A number of other states have expressed interest in joining the group.

Wyoming - Quality control/quality assurance (QC/QA) will be implemented on about 50 percent of HMA this year. QC/QA will be implemented on two recycled HMA jobs this year to gain experience. Detailed HMA mix design procedures have been developed for use by the private laboratories conducting mix designs.

Australia - An AUSTRROADS specification for polymer modified binders has been issued. The document is the result of a consultative approach involving representatives from a broad cross section of the pavement surfacings industry and government road authorities. This specification framework outlines the requirements for polymer modified binders including crumb (scrap) rubber for use in both sprayed sealing and HMA applications. It is an interim framework specification which is subject to review on a regular basis as further information and experience with the performance of different polymer modified materials is obtained.

The joint AUSTRROADS/AAPA/ARRB Transport Research publication "Selection and Design of Asphalt Mixes—Australian Provisional Guide" was successfully launched in late 1997. There has been a positive

response to the guide, with more than 300 copies issued to date. The preparation of a Stone Mastic Asphalt Design Guide has commenced.

New Brunswick, Canada - Standard specifications for asphalt concrete have been completely rewritten for 1998. New specifications are more end result oriented compared to the old method specification. It is planned to construct one Superpave project this year.

Ontario, Canada - A new end-result specification combining asphalt cement, gradation, compaction and air voids based on percent within limits is being included in all new contracts. A new end-result specification for smoothness on all multiple lift hot mix asphalt contracts is also being implemented. A new specification for PG-graded asphalt binder will be used on all new contracts. Four basic PG-grades will be used within the Province of Ontario. Changes in basic grade depend upon the traffic conditions and extent of-recycling.



PROFESSOR TRAINING COURSE IN ASPHALT TECHNOLOGY

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

PUTTING RESEARCH INTO PRACTICE

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

1. CRITICAL REVIEW OF VMA REQUIREMENTS IN SUPERPAVE (Kandhal, Foo and Mallick)

One of the problems encountered by highway agencies implementing Superpave volumetric mix design is the difficulty in meeting the minimum voids in mineral aggregate (VMA) requirement. The low VMA of the mixtures can often be attributed to the increased compactive effort by the Superpave gyratory compactor and the increased use of coarser asphalt mixes (gradations below restricted zone).

A vast majority of conventional asphalt mixes in the U.S. have gradations above the maximum density line. Many highway agencies have made their asphalt mixes coarser than those conventionally used in order to meet the Superpave VMA requirements. Superpave also recommends the use of aggregate gradations below the maximum density line especially for high volume roads. Even then, it is not always possible to meet the VMA requirement.

A literature review has indicated that the rationale behind the minimum VMA requirement for conventional asphalt mixes was to incorporate a minimum desirable asphalt content of 4.5 percent into the mix to ensure its durability. Studies have shown that asphalt mix durability is directly related to asphalt film thickness. Therefore, the minimum VMA should be based on the minimum desirable asphalt film thickness rather than an arbitrarily chosen minimum asphalt content because the latter will be different for mixes with different gradations. Mixes with a coarse gradation (and, therefore, low surface area) have difficulty meeting the minimum VMA requirement based on minimum asphalt content in spite of thick asphalt films. A critical review of the minimum VMA requirement was, therefore, conducted in this paper. The work included Superpave volumetric mix designs of six different HMA mixes. The following conclusions were drawn and recommendations made.

The minimum VMA requirement currently adopted

by Superpave to ensure mix durability is inadequate. It is not equitable to mixes with different gradations. The requirement penalizes mixes with coarse gradations (those below the Superpave restricted zone) which may have low VMA but have increased asphalt film thickness. Various studies have shown that the asphalt mix durability is directly related to film thickness.

It is recommended that minimum average asphalt film thickness be used to ensure mix durability instead of minimum VMA. A minimum average film thickness of eight microns is recommended at this time. The film thickness can be calculated from the asphalt content and surface area of the aggregate as shown in an example in this paper.

The current method of calculating aggregate surface area uses surface area factors as given in the Asphalt Institute Manual Series 2. The background research data for these surface area factors could not be found in the literature. Further research is needed to verify these surface area factors. However, the current surface area factors can be used at this time to calculate the "average" asphalt film thickness because (a) the optimum film thickness (such as eight microns) recommended in the literature is based on these factors, and (b) they are considered adequate for comparison purposes.

2. EVALUATION OF SUPERPAVE GYRATORY COMPACTION OF HOT MIX ASPHALT (Mallick, Buchanan, Brown, and Huner)

This study was undertaken in two parts with the following objectives.

Part I

The objective of Part I was to evaluate the effect of gradation and aggregate type on volumetric properties and gyratory properties of specimens compacted with the Superpave gyratory compactor.

Three all crushed granite mixes and three mixes containing crushed granite and 20 percent natural sand were prepared. The three mixes with each type of aggregate consisted of three gradations: (1) above restricted zone, (2) through restricted zone, and (3) below restricted zone. Mix designs were conducted with the Superpave gyratory compactor, and air void properties and Superpave design parameters (N_{initial} , N_{design} , N_{maximum}) were compared for the different mixes. More specifically, the following questions needed to be answered:

- (1) How are N_{initial} , N_{design} , and N_{maximum} values of mixes affected by the restricted zone?
- (2) How do the volumetric properties of all crushed and partially uncrushed mixes differ?

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Part II

The objective of Part II was to compare the correction factors for specimen bulk specific gravity obtained at different gyration levels during compaction of HMA, and to evaluate the change in correction factor, if any, with gyration levels.

According to the current Superpave specifications the bulk gravity of a sample is determined in two ways: from the compactor based on geometry of the specimen and from weighing in air and water. Both of these bulk gravities are determined at N_{maximum} , and then a correction factor is calculated to convert the bulk specific gravity determined by geometry of the specimen to the actual bulk specific gravity determined by weighing in air and water. The machine measured bulk specific gravity of specimens of all other gyrations are corrected based on this correction factor at N_{maximum} . The correction factor, C , is defined as $C = (G_{\text{mb, measured in air and water}}) / (G_{\text{mb, based on physical dimensions}})$ at N_{maximum} . The purpose of the correction factor is to eliminate the error of machine measured specimens caused by the assumption that each specimen is a smooth sided cylinder.

The above procedure assumes that the correction factor is constant at all gyrations, that is, the correction factor at N_{maximum} (or any gyration level) is the same as the correction factor at, say N_{design} . This assumption has been questioned by many researchers. A coarse-graded and a fine-graded mix were used in this part of the study.

The following conclusions have been drawn from this study:

- For a given aggregate, gradations below or above the restricted zone provided higher VMA than mixes through the restricted zone.
- Mixes with crushed aggregate provided higher VMA than mixes with partially crushed aggregate.
- Mixes with gradations below the restricted zone had the highest voids at N_{initial} , whereas the mixes with gradations above the restricted zone had the lowest voids at N_{initial} .
- For all crushed mixes, the mixes with gradations above the restricted zone had the highest voids at N_{maximum} , whereas the mixes with gradations below the restricted zone had the lowest voids at N_{maximum} .
- None of the mixes containing natural sand met all the requirements for volumetric and gyratory properties. The mixtures for all crushed material met all requirements when passing through the restricted zone and below restricted zone.
- Gradations through the restricted zone generally had the lowest optimum asphalt content and lowest VMA compared to gradations above and below the restricted zone.

- All crushed material through the restricted zone had better volumetric properties than the mix with 20 percent natural sand below the restricted zone in this study.

- The correction factor used to correct specific gravities of specimens compacted with the Superpave gyratory compactor is not a constant at different gyration levels for all mixtures. For the dense-graded and coarse-graded mixes studied, the correction factor was found to decrease and become close to constant at higher gyration levels. The coarse textured mixture had a larger difference between the back calculated and the actual air void levels.

- At lower gyrations, densities of specimens for the two mixes were found to be greater than the densities predicted by the gyration versus compaction plot obtained on the basis of correction factor of N_{maximum} . The difference between the actual and predicted densities were greater for the coarser gradation than for the finer gradation.

The following recommendation is made:

- To avoid erroneous air voids results, it is suggested that mixes be compacted to N_{design} for determination of design asphalt content. Air voids at N_{initial} can be checked on the basis of a correction factor obtained at N_{design} . After the mix design is completed, mixes can be compacted up to N_{maximum} to determine if N_{maximum} requirements are met.

3. GEORGIA DOT'S PROGRESS IN OPEN-GRADED FRICTION COURSE DEVELOPMENT (Watson, Johnson, and Jared)

This paper gives material composition of the Georgia DOT's open-graded friction course (OGFC), its film coating and draindown characteristics, production and construction considerations, and its performance.

Since OGFCs were conceived in the 1950's and 1960's, Georgia DOT (GDOT) has used these mixes as thin porous wearing layers, primarily on interstate highways. The early mixes used were very susceptible to premature failure due to weathering. In the early 1990's however, GDOT developed the 12.5 mm OGFC, which is now the standard GDOT mix. This mix, which has been used extensively statewide since 1993, is composed of aggregate, polymer-modified asphalt cement (PMAC), stabilizing fibers, and hydrated lime. It has been typically applied at a spread rate of 41 kg/m² (75 lb/yd²), which is equivalent to a lift thickness of 16 mm (5/8 inch). More recently, however, the spread rate has been increased to 50 kg/m² (90 lb/yd²).

OGFC mixes are typically gap-graded and thus contain high percentages of single-size coarse aggregate. OGFC typically has a high asphalt cement (AC) content, a thick AC film, a low percentage of

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material passing the 0.075 mm (No.200) sieve, high volumes of in-place air voids (10-20 percent), and an in-place thickness less than 25 mm. The inclusion of PMAC gave the mix greater film thickness, which safeguards against the weathering problems experienced by asphalt cements in earlier mixes. Mineral fiber has also been added to the 12.5 mm OGFC, typically 0.4 percent of the total mix. This ingredient stabilizes the binder during mixing and placement to protect against draindown, and it also enhances the material strength through the interlocking of fibers in the thick AC coating. Hydrated lime is added as an antistripping agent to OGFC and to all other mixes used on the Georgia state route system, including dense-graded mixes which underlie OGFC.

Encouraged by results with porous European mix (PEM), GDOT began experimenting with a hybrid OGFC design. In the summer of 1992, OGFC specifications were changed to require a coarser gradation. The coarser gradation enhances permeability and resistance to rutting.

The GDOT has primarily used two polymers, styrene butadiene (SB) and styrene butadiene styrene (SBS), to modify asphalt cements used in OGFC mixes. Since the development and implementation of Superpave binder grading, empirical tests have been dropped, and Superpave PG76-22 binder is now used. A phase angle requirement of less than 75 degrees has been added to help ensure that polymer modification is used to meet the binder grade requirements. This value was obtained through Superpave binder tests on generic PMACS previously used by the GDOT.

The inclusion of mineral fiber resulted in several additional improvements to the mix. Fibers are generally used in OGFC to stabilize the asphalt cement (AC) film surrounding aggregate particles in order to reduce AC draindown during production and placement. Film thickness was increased through the addition of fibers by nearly 400 percent over conventional dense-graded mixes, and it was 30-40 percent thicker than for standard OGFC.

The conventional OGFC was placed at very low temperatures (110-120°C) because of excessive AC draindown during production and hauling. The modified OGFC can now be produced at much higher temperatures than conventional OGFC without draindown problems because of the addition of polymers and fibers. Typical mix temperatures now range from 160° to 170°C. The draindown susceptibility of GDOT modified OGFC mixes can be determined using a test developed by the National Center for Asphalt Technology (NCAT). The NCAT procedure specified that 0.3 percent is the maximum permissible draindown,

if the integrity of the mix is to be retained. Modified OGFC mixes which contain fibers and polymers have met this requirement. Unmodified OGFCs, however, have not.

Placement of modified OGFC is more difficult than placement of either conventional dense-graded mixes or conventional OGFC. The mix is extremely stiff and tends to "set up" quickly. Maintaining a continuous operation and keeping "everything hot" is critical in producing a smooth pavement. In previous years, the modified OGFC has been typically placed at a spread rate of 41 kg/m² (75 lbs/yd²), which is equivalent to a lift thickness of 16mm (5/8 in.). Since the mat thickness is only slightly larger than the maximum aggregate size, a slight grade change can lead to pulling and streaking of the mat. For this reason the recommended spread rate has been increased to 50 kg/m² (90 lb/yd²) within the past year. GDOT performs a permeability test using the falling head permeameter. This device is used to determine a permeability coefficient, represented in meters (feet) per day, for the mix being tested. This testing has shown that modified OGFC typically drains 73 m/day, far better than conventional OGFC (30 m/day). PEM, by comparison, drains approximately 100 m/day. Because the PEM has exceptional permeability, GDOT is considering its use for selected projects which have typical cross-slopes that would drain water across three or more lanes in the same direction.

The cost of modified OGFC is approximately 34 percent higher than that of conventional OGFC mixes. The additional cost is incurred from the extra components in the mix, as well as the equipment needed to properly introduce these components into the mix production. Increased production temperatures and slower production rates also contribute to increased production costs.

A typical service life of eight years was used for the standard OGFC. The modified OGFC is expected to last 10-12 years. Based on annualized costs, the modified OGFC would become a cost-effective alternative if it lasted just 19 months longer than the conventional mix. Modified OGFC is therefore an attractive, cost-effective alternative over conventional OGFC mixes.

4. EFFECT OF IGNITION TEST FOR ASPHALT CONTENT ON AGGREGATE PROPERTIES (Mallick, Brown and McCauley)

Although results from asphalt content determination by the NCAT ignition method have been very accurate, concerns have been expressed regarding the quality of aggregates recovered after the ignition test. The specific questions regarding the change in aggregate properties

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after ignition may be summarized as follows:

(1) Do the aggregates break down while burning the mix due to internal stresses?

(2) Are the physical properties of the aggregates altered due to ignition of the mix?

To answer these questions, NCAT initiated a study to evaluate change in properties of aggregates due to burning in the ignition oven. This paper reports the findings from this study.

Four different types of aggregates (granite, limerock, gravel, and traprock) were selected for this study. These aggregates were selected to have a wide range of physical properties. The properties chosen for evaluation included gradation, bulk specific gravity, absorption, NAA voids and fractured face count. The overall test plan consisted of determining the properties of aggregate before and after burn, and evaluating the change in the properties. Any breakdown of aggregate due to internal shear should be reflected in a corresponding change in gradation and fractured face content. Changes in specific gravity, absorption, and NAA voids properties would indicate changes in physical properties of the aggregates.

The amount of heat produced, and hence the effect of ignition on appropriate properties may be different for testing of aggregates (only) and ignition of asphalt-aggregate mixes. To find out which process has a greater effect on aggregate properties, 1,200 gram mixes were prepared with 6 percent (by weight) PG 64-22 asphalt binder. These mixes were then subjected to the ignition test. The aggregates were recovered after the ignition test and subjected to test for bulk specific gravity, absorption, NAA voids and fractured face content. The results were compared to results obtained from virgin aggregates and to results obtained from aggregates after being subjected to ignition testing. The relative magnitudes of change of properties after testing aggregates (only) and burning mixes were compared to determine which process had greater effect on the aggregate properties.

The results of this study show that aggregate properties such as bulk specific gravity, absorption, NAA voids, fractured face content and gradation can be altered by the ignition test. However, whether the changes are significant or not, the amount of change seems to be dependent on the specific type of aggregate. For all of the changes observed, it appears that the ignition process of asphalt-aggregate mix has a greater effect on the properties of aggregates, than testing aggregates only. Hence, correction factor determined from ignition testing on aggregates might not be representative of the correction factor obtained during ignition test of HMA.

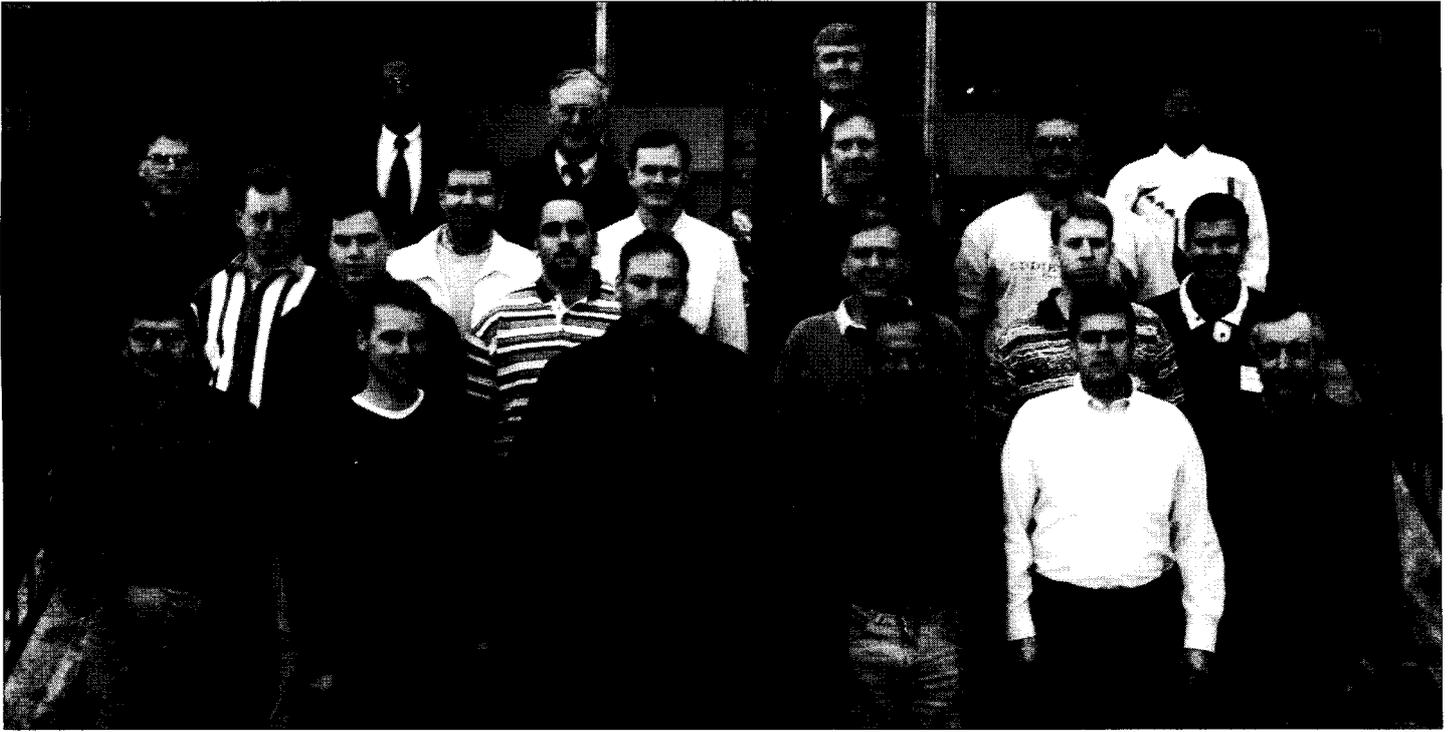
The specific conclusions about the different properties are:

- For fine aggregates, the bulk specific gravity did not change significantly after ignition except in the case of limerock.
 - For coarse aggregate, the bulk specific gravity did not change significantly for gravel and limerock, but decreased significantly after ignition of mix only for granite, and after ignition of both aggregate and mix for traprock.
 - Absorption of fine aggregates did not change significantly for gravel and traprock, but increased significantly after ignition of both aggregate and mix for limerock, and only after ignition of mix for granite.
 - Except in the case of gravel, absorption of coarse aggregates increased significantly after ignition. For limerock and traprock, the increase in absorption after ignition of mix was significantly greater than the increase in absorption after testing of aggregates only.
 - A decrease in specific gravity after ignition is generally accompanied by an increase in absorption.
 - The NAA voids were changed significantly after ignition testing of aggregates and mix for limerock and traprock, and only after testing of aggregate for granite.
 - Fractured face count for gravel increased significantly after testing of both aggregate and mix.
 - The aggregate gradation had no practical change on the 4.75 mm sieve but did have some change on the 0.075 mm sieve. It is suspected that part of this change is due to breakdown during mixing.
- For the users of an ignition oven, it is recommended that caution be exercised in interpreting any results from test on aggregates recovered after ignition test. A study similar to the one reported here can be carried out by the user agencies to evaluate the effect of ignition on the properties of the more commonly used aggregates.

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NCAT's 1998 ASPHALT TECHNOLOGY COURSE ATTENDEES AND INSTRUCTORS



Left to Right: (Front Row) John Langley, Brian Goggins, Joe Bloise, Jitesh Parikh, Pat Upshaw, Terry Arnold. (Row 2) Todd Kirk (behind B. Goggins), Chris Bacchi, Jack Springer (behind J. Parikh), Chad Hawkins, Greg Sholar. (Row 3) Allen Cooley, Brian White, Don Davis, Darrin Grenfell, Dale Wieman (behind J. Springer), Tim Kowalski, Rajib Mallick. (Back Row): Prithvi (Ken) Kandhal, Doug Hanson, Ray Brown



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Auburn University, AL 36849-5354

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