ASPHALT TECHNOLOGY NEWS

A Publication of the National Center for Asphalt Technology, Auburn University Volume 8, Number 2 FALL 1996

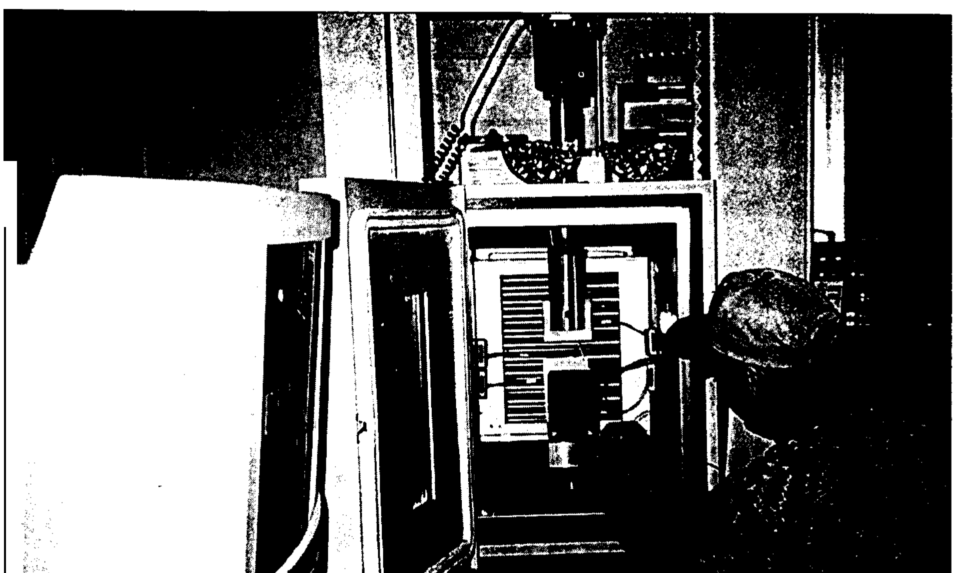
NCAT LABORATORY FULLY GEARED FOR HMA RESEARCH AND DEVELOPMENT

The National Center for Asphalt Technology (NC AT) has a well equipped laboratory for testing hot mix asphalt (HMA) and its constituents: coarse aggregate, fine aggregate. filler. and asphalt binder. Since its inception in 1986, NCAT has acquired a wide variety of testing equipment. NCAT is also the home of the Southeast Regional Superpave Center and houses all Superpave binder and mixture testing equipment. The NCAT laboratory, with a total area of approximately 512 square meters, is located in the Harbert Engineering center on the Auburn University Campus. A brief discussion of the testing and research equipment available at NCAT laboratory follows.

AGGREGATES

NCAT was awarded NCHRP Project 4-19 "Aggregate Tests Related to Performance of Asphalt Concrete in Pavements" in 1994. This project required the evaluation of all current aggregate tests used in U.S. and other countries for HMA pavements to determine their suitability as performance related tests. New tests were also to be

(Continued on page 2)



Indirect tensile tester (IDT) is used in Superpave mix analysis for evaluating HMA's resistance to low-temperature cracking.

In This Issue

NATIONAL CENTER FOR ASPHALT TECHNOLOGY

Superpave shear tester (SST) is used for evaluating HMA's resistance to permanent deformation and fatigue cracking.

(NCAT LABORATORY, Continued from page 1)

evaluated in case the current tests are determined to be unrelated to HMA performance. This project necessitated the acquisition of some specialized testing equipment; as a result, the aggregate testing section of the NCAT laboratory has the following equipment:

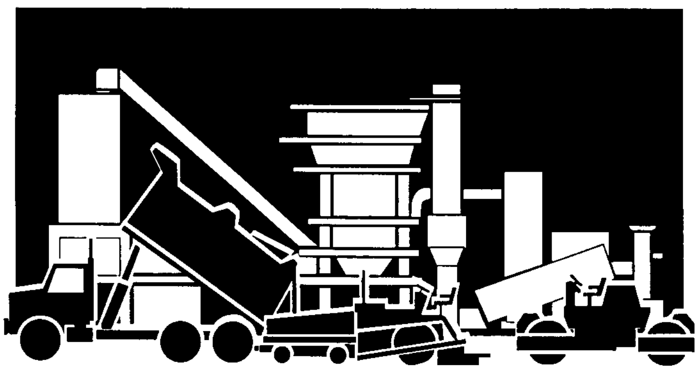
Coarse Aggregate

- Los Angeles abrasion
- Micro-deval abrasion (French)
- Aggregate impact value
- Aggregate crushing value
- Sodium and magnesium soundness
- Unconfined freeze and thaw (Canada)
- Aggregate durability index
- Index of aggregate particle shape and texture
- Flat and elongated particles
- Flakiness index (U. K.)
- Elongation index (U. K.)
- Uncompacted voids in coarse aggregate (equipment fabricated similar to that used for fine aggregate)
- Specific gravity and absorption

Fine Aggregate

- Los Angeles abrasion
- Micro-deval abrasion
- Index of aggregate particle shape and texture
- Uncompacted voids in fine aggregate
- Sand equivalent
- Plasticity index
- Methylene blue (French)
- Specific gravity and absorption

(Continued on page 3)



National Center for Asphalt Technology, 211 Ramsay Hall, Auburn University, Alabama 36849-5354
Phone: (334) 844-NCAT (6228) Fax: (334) 844-6248

ASPHALT TECHNOLOGY NEWS (Library of Congress Catalog No. ISSN 1083-687X) is published by the National Center for Asphalt Technology (NCAT) of Auburn University. Its purpose is to facilitate the exchange and dissemination of information in hot mix asphalt technology, trends, developments and concerns. Opinions expressed in this publication by contributors and editors, the mention of brand names, the inclusion of research results, and the interpretation of those results do not imply endorsement or reflect the official positions or policies of NCAT or Auburn University.

E. Ray Brown, *Director*
Prithvi (Ken) Kandhal, *Associate Director/Editor*
James S. Killian III, *Associate Editor College of Engineering*

Tadayasu Watanabe (left) and Daiji Fujita (middle) of Watanabe-Gumi Co., Tokyo, Japan visited NCAT in August with Ken Kandhal, Associate Director.

(NCAT LABORATORY, Continued from page 2)

Filler

- Rigden voids
- Automated laser-based particle size analyzer (determines the filler gradation down to 0.5 micron size)
- Plasticity index
- Methylene blue (French)

ASPHALT BINDER

The asphalt binder section has the following testing equipment used for conventional asphalt binder tests: penetration, viscosity at 60°C, viscosity at 135°C, softening point, volubility, flash point, specific gravity, ductility, thin film oven, and rolling thin film oven. Superpave binder and other equipment are also available as shown below:

- Pressure aging Vessel
- Brookfield viscometer
- Dynamic shear rheometer
- Bending beam rheometer
- Direct tension tester
- Cone and plate viscometer

A wide array of blending equipment is available to prepare modified asphalt binders for complete theological characterization.

HMA MIXTURE

The HMA section of the NCAT laboratory has an impressive array of devices used for compaction of asphalt concrete materials. Specimens can be prepared using the following set of compactors:

- Automatic and manual Marshall hammers (capable of preparing 100 mm and 150 mm diameter cylindrical specimens).
- Automatic rotating base/slanted foot Marshall compactor
- Texas gyratory compactor
- Cox kneading compactor (beam specimens as well as 100 mm and 150 mm diameter cylindrical specimens can be prepared)
- Corps of Engineers gyratory shear compactor (both 100 mm and 150 mm diameter cylindrical specimens can be prepared)
- Refusal density vibratory hammer compactor (150 mm diameter specimens are prepared to obtain maximum attainable compaction level in the specimens)

The following equipment is available to test and characterize compacted HMA specimens:

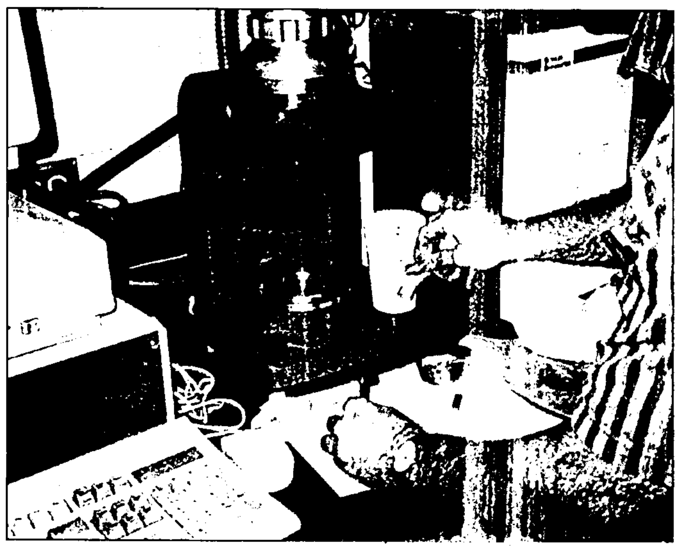
- Marshall stability and flow
- Hveem stabilometer
- Resilient modulus
- MTS Model 810.22 servo-hydraulic material testing system (permits application of dynamic, fatigue, and creep type loadings that are composed of repeated

NCAT ON THE INTERNET

As we informed you in the last two issues of **Asphalt Technology News.** NCAT'S World Wide Web site is located at **http://www.eng.auburn. edu/center/ncat.** Our site can be accessed through Prodigy, Compuserve, America online, other private carriers, and Internet Servers.

NCAT has also established a mailing list devoted to discussion on dilferent aspects of HMA technology. Wc invite you to join this mailing list to exchange questions/answers and comments. To become a member please send the following message to **majordomo@eng.auburn.edu: subscribe ncat@eng.auburn. edu,**

Please direct any questions or **comments** regarding our homepagc to **rajibb@eng.auburn.edu**



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.*

Tennessee (Bob Rorie, Tennessee DOT)

Tennessee placed two Superpave mixes - binder and surface - on a project in June. The Superpave mix design for the binder mix indicated an asphalt content in excess of 5.8 percent with 4.0 percent voids in the total mix. When designed by the 75-blow Marshall, the optimum asphalt content was 5.4 percent with 4.0 percent voids in the total mix. The aggregate met all the Superpave requirements. The asphalt content used was determined by the Marshall method.

The Superpave mix design for the surface mix indicated an asphalt content of 4.9 percent with 4.0 percent voids in the total mix. The mix used on the project had a uniform texture without segregation on the roadway and the aggregate appeared to have an excellent coating of asphalt binder. However, it was difficult to obtain the desired mat density.

Indiana (Tom White, Purdue University)

We believe there are obvious benefits of using rational laboratory wheel tracking testing to validate stripping/rutting potential of HMA including Superpave mixes. At the present time, validation is lacking for existing tests, modifications of existing tests, and new tests adopted for PG asphalt grading and Superpave mix design procedures.

Kentucky (Lori Burke, Kentucky Department of Highways)

How are other states handling polymer modification (and other types of modification) of asphalt binders in conjunction with Superpave binder specifications and analysis? Are other states using the phase angle data from the dynamic shear rheometer (DSR) to detect elasticity in performance graded (PG) binders when polymer modification is specified?

How are other states handling the addition of anti-stripping additives or silicone to Superpave PG binders? Our experience with liquid antistrip additives indicated that they typically reduced the viscosity of the asphalt cement. We currently allow contractors to introduce the additive at their HMA plants. This will complicate determining whether a PG binder fails to meet requirements because the binder is out of specification or because the additive changed the properties.

Are any states having good/satisfactory experiences with their binder testing equipment? If so, which pieces of equipment and who is the manufacturer?

Has any other agency experienced significantly lower air void contents with a modified HMA mixture through the Superpave gyratory compactor (SGC) than the same mixture unmodified?

Does any other agency have experience with a polish-resistant surface mixture containing no natural sand through the SGC? What are the volumetric properties?

When dealing with an asphalt mixture containing aggregates with varying specific gravities, how wide must the spread between gravities be before the mix design is produced volumetrically, instead of by weight of aggregate?

Kentucky's current HMA training and certification program is entering its second year. This effort requires industry and department personnel to demonstrate competency in plant inspection technology and mix design technology before being involved with the work. Teaching assignments are shared by industry and department personnel and there are approximately equal numbers of students from each group in each session.

Kentucky's second Superpave project will be getting under way soon. The mixtures will be a 37.5 mm base and a 9.5 mm surface. Acceptance of the mix will be based on air voids and VMA of Superpave Gyratory compacted specimens, asphalt content, and density.

Alaska (Matt Reckard, Alaska DOT)

Alaska "DOT is in the process of implementing Superpave technology/procedures. Stone matrix as-

(Continued on page 8)

ASPHALT USER-PRODUCER GROUPS UPDATE

The National User-Producer coordinating group met in Reno, Nevada, in June to discuss the implementation of the Superpave technology throughout the United States. This group consists of representatives (generally the chairpersons) of each of the five Asphalt User-Producer Groups in the United States.

As of February, 1996, four of the 16 states in the Northeast region had their binder laboratories operational. Three states were planning to implement the performance graded (PG) binder specifications in 1997, ten in 1998, two in 1999, and one in 2000. In general, they plan to allow the use of dual grades for a period of time. For cold temperature grading, they intend to use the Canadian algorithm between air temperature and pavement service temperature or will use 50 percent reliability when using the current Superpave binder selection procedure. The use of either of these approaches generally results in the use of the same grade of asphalt binder. New York has placed some PG 58-34 binder in 1994, and feels it has improved resistance to cracking. Five of the states will try to implement Superpave volumetric mix designs totally in 1998, one in 1999, and nine in 2000.

In the North Central region, all states except Illinois plan to implement the PG binder grading system in 1997. Illinois will stay with AC-20 specification, which is equivalent to a PG 64-22, until the decision is made to adopt the PG grading system. Iowa, Wisconsin, and Minnesota are working together in an effort to require the same uniform grades thereby eliminating the proliferation of PG grades. Indiana has built one project in each district designed with the Superpave volumetric mix design method.

In the Southeast region, the plan is to implement the PG binder specification regionwide in 1997. Arkansas had implemented the PG grading system in November 1995. In general, the binder will be the same as used now and will classify as a PG 64-22. Both AC-30 and some AC-20'S will fit into the PG 64-22 grade. Two states have modified the PG system to match the AC-30. Georgia will specify a PG 67-22. The general plan is to implement the Superpave mix design procedures by 2000, with some states implementing in 1997 and 1998. Each of the states has or will be constructing a full Superpave project in 1997 with more to follow in 1998.

In the Rocky Mountain region, all states now have operational binder equipment. Utah and Colorado planned to implement the PG binder specification in September, 1996; Montana and Wyoming will implement in 1997, and New Mexico and North Dakota in 1998. The binder group within the Rocky Mountain User-Producer Group is working on the development of a binder price adjustment schedule to be used in their quality control/quality assurance (QC/QA) specifications.

In the Pacific Coast region, states will probably not implement the PG binder specification as a group until 1998. It appears that Arizona will implement in January, 1997. Oregon, Washington, and Nevada plan to implement in January, 1998. California has not set an implementation date, and is questioning the fatigue parameter (G*sið) in the PG grading system. Arizona has built 19 HMA projects with PG graded binders. Washington has developed a map that narrows the state to three (3) grades: PG 58-22, PG 58-34, and PG 64-28.

The National User-Producer coordinating group spent considerable time discussing some of the unanswered issues associated with the implementation

(*continued on page* 8)

Bending beam rheometer (BBR) is used in the NCAT laboratory to evaluate asphalt binder's resistance to low-temperature cracking.

MARYLAND MOVES AHEAD IN HMA TECHNOLOGY

by

Larry Michael
Maryland Department of Transportation

The Maryland Department of Transportation (DOT) is making major head-way in two hot mix asphalt (HMA) technology areas: (a) implementation of Superpave, and (b) increased use of European stone matrix asphalt (SMA) technology. The progress made and planned for the future is as follows:

Superpave

Maryland DOT started using Superpave performance graded (PG) asphalt binders in 1994. Since then, we have constructed 25 projects (SMA and Superpave) using performance graded asphalt binder specifications. These projects, which total over 300,000 tons of HMA, have experienced little, if any, problems during design, plant production, and placement. During 1995, approximately 50 percent of the asphalt binders failed to meet PG specifications. During 1996, the failure rate decreased to approximately 10 percent. In all cases, failures are minor, and are probably due to lack of test repeatability.

Maryland DOT has designed and constructed projects using the Superpave volumetric mix design system without any significant problems in design or production. Performance to date is excellent.

The following is a list of Maryland's Superpave implementation activities:

Twenty-five projects -- Stone Matrix Asphalt (SMA) and Superpave constructed using performance graded asphalt binder.

Change to performance graded asphalt binders for all HMA mixes effective July 1, 1996.

SMA projects designed and controlled by Superpave criteria using a gyratory compactor.

Baltimore Beltway widening using Superpave 37.5 mm (150,000 tons) and 25 mm (25,000 tons) mixtures.

Superpave 12.5 mm gap-graded mix designed and constructed (10,000 tons).

Two Superpave 12.5 mm mix projects designed and constructed (10,000 tons each) with field quality control (QC) in cooperation with the National Cooperative Highway Research Program (NCHRP) Project 9-7.

Two SMA projects designed with field quality control/quality assurance (QC/QA) in cooperation with NCHRP Project 9-7 and the Federal Highway Administration (FHWA) mobile HMA laboratory.

Purchase of Superpave equipment for laboratory use.

Evaluation of new equipment (such as NCAT ignition oven and Georgia loaded wheel tester) which complements our Superpave work.

To date, and with the assistance of the Office of Technology Applications (FHWA), three-day training workshops have been conducted and 78 people trained. More workshops were planned for the fall of 1996.

In order to meet the national goals of January, 1997 for implementing the PG asphalt binder specifications and the year 2000 for implementing the Superpave mix design system, the Western Regional Laboratory's Superpave Implementation Team has developed a strategy and an implementation plan. In the future, we are looking for a closer working relationship with industry and local governments (such as municipalities) for Superpave training and implementation activities.

Stone Matrix Asphalt (SMA)

Since **1992,** Maryland has constructed over 900,000 tons of SMA using a variety of modifiers and stabilizers in both drum and batch plants. The SMA has been placed at locations on the interstate system where traffic counts exceed 20,000 AADT and the" posted speed is 55 mph or higher. Maryland DOT has duplicated, as

(Continued on *page* 7)

Asphalt binder samples are being prepared for testing in the direct tension tester to evaluate asphalt binder's resistance to low-temperature cracking.

(MARYLAND HMA, Continued from page 6)
nearly as possible, the European technology of design, production, and placement of SMA. Our specification is basically the same as recommended by the FHWA's SMA Technical Working Group (TWG).

Based on our experience and performance data, we have significantly modified our SMA specification in two areas:

- Since 1994, Superpave performance graded binders have been and will be specified for all SMA mixes, and
- Fibers are now required in all SMA mixes based on draindown and mix design test results.

Mix designs, production quality control, and field performance are being evaluated in cooperation with the Federal Highway Administration (FHWA) - Office of Technology Applications (OTA) and the National Center for Asphalt Technology (NCAT) at Auburn University. Looking to the future and the adoption of the Superpave system, several SMA projects have been designed and constructed using the Superpave Gyratory Compactor.

To date, evaluation of existing SMA projects indicates that the mix is performing to expectations. After two years of service life, projects with as much traffic as 200,000 AADT have almost zero ruts and have overall better appearance today than when opened to traffic.

Although 99.5 percent of our SMA is excellent, we continue to have occasional problems with fat spots. Since all of Maryland DOT's SMA is in the surface course, these fat spots are a continuing source of concern.

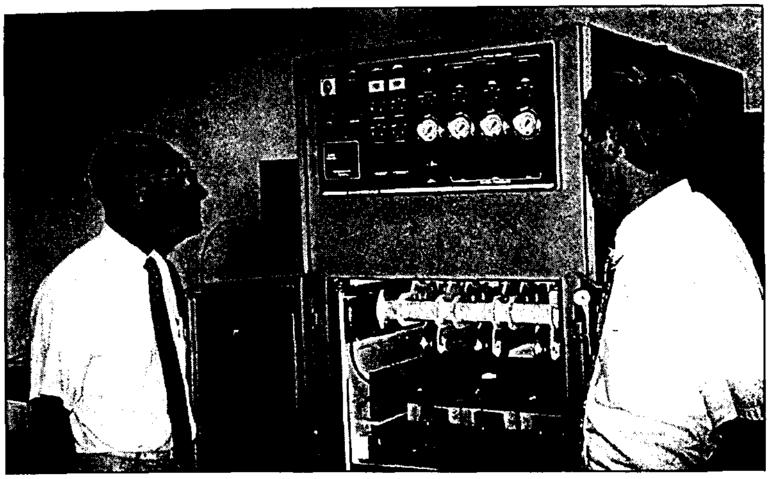
There are two major types of fat spots: cosmetic and functional. Cosmetic fat spots usually occur on just the surface of the mat and wear off with time. Functional fat spots, however, normally affect the full thickness of the SMA and may lead to early deformation and deterioration in a localized area. Fat areas may result from the following conditions:

- Lack of, or inconsistent, distribution of fibers.
- Excess water in the truck bed from release agents.
- Excessive mix temperature, particularly with modified asphalt binders.
- Excessive haul time or having the truck wait on the project for an extended period of time before unloading into the paver.
- Insufficient minus 75 pm material in the mix.

SMA is an excellent product which requires continued QC/QA. The performance to date indicates that the extra cost is justified due to improved pavement performance.

RECYCLING OF HMA PAVEMENTS MUST CONTINUE

Many highway agencies have started or are planning to use Superpave performance grade (PG) asphalt binders to produce HMA in conjunction with the NCAT asphalt content tester (ignition method) for mix compositional analysis during production. However, these two significant changes should not impede the design and construction of recycled HMA pavements. The implementation notes, "Designing Recycled HMA with Superpave Technology" accompanying this issue of **Asphalt Technology News** will be helpful in selecting an appropriate PG asphalt binder for recycling. The NCAT asphalt tester can be used to determine the asphalt content and gradation of the recycled asphalt pavement (RAP) material. A vast majority of aggregates have a calibration factor (aggregate mass loss due to ignition) of 0.2-0.3. Therefore, a calibration factor of 0.2-0.3 can be assumed for most RAP materials unless the source of the aggregate in the RAP and its calibration factor is known. If the percentage of RAP in the recycled mixture is relatively low (for example, less than 30 percent), the effect of the assumed calibration factor is minimal.



Professor Steve Brown of University of Nottingham (U.K.), left, is examining asphalt pavement analyzer (modified version of Georgia Loaded Wheel Tester) in NCAT laboratory with Ray Brown, NCAT Director

(NCAT LABORATORY, Continued from page 3)

The HMA testing section has both hot reflux and cold centrifuge extractors for quantitative extraction of asphalt binders from HMA mixtures. Roto-vap asphalt recovery equipment and Abson recovery equipment is available to recover asphalt binder from the solvent. The laboratory also has three ovens for determining the asphalt content of HMA mixtures by the ignition method developed at NCAT.

NCAT continues to lead the cutting edge of asphalt technology, which means that the latest testing equipment for testing and analysis of HMA must be available.

(ASPHALT FORUM, Continued from page 4)

phalt (SMA) is increasingly being used on urban arterials. This has helped reduce pavement wear caused by heavy studded tire use.

Australia (John Bethune, Australian Asphalt Pavement Association)

With funding assistance from VicRoads and Australian Asphalt Pavement Association, Australian Road Research Board Transport Research (ARRB TR) has completed testing of the VicRoads Troxler NCAT ignition oven, with internal weighing and the ELE ignition oven with external weighing. The results, which are generally favorable, have been reported in a paper prepared, by Peter Tredrea of ARRB TR titled "The, Ignition, Oven -'A Viable Alternative to Solvent-Based Methods."

(ASPHALT UPDATE, Continued from page 5)

of Superpave. These issues include:

- Whether there was a need to implement QC/QA specifications and Superpave volumetric mix design at the same time.
- A concern that the specifications for the aggregates need some work. There was a general consensus that the average criteria for HMA mixes for high volume highways is adequate but may be overly restrictive for low volume roads.
- There was also a suggestion that the criteria for $N_{initial}$ for low volume highways should be evaluated. The current criteria is that the bulk specific gravity of compacted HMA specimens should not exceed 89 percent of theoretical density. It was suggested that 90 or 91 percent might be more appropriate (based on traffic volume).
- The turn-around time for testing samples using Superpave technology has increased significantly. There is a concern that, with the personnel reductions going on inmost DOTS, there will not be sufficient trained personnel to implement Superpave. The number of personnel that need to be trained on Superpave is large and the resources for conducting this training are limited.

—Doug Hanson

Implementation Notes

Note No. 4 (Fall 1996)

Designing Recycled HMA with Superpave Technology

Background

Many highway agencies have initiated programs to implement the Superpave performance grading (PG) system for asphalt binder and Superpave volumetric mix design procedures for HMA mixtures. This research project was undertaken to develop a procedure for selecting the performance grade (PG) of virgin asphalt binder to be used in recycled mixtures.

Approach

Three aged asphalt binders recovered from reclaimed asphalt pavement (RAP) and three performance grade (PG) binders: PG 64-22, PG 58-22, and PG 52-28 were physically blended in different proportions to obtain various recycled binders. The recycled binders were subjected to a temperature sweep using the dynamic shear rheometer near high pavement service temperatures (that is, measuring G*/sin6 or rutting factor at various temperatures) to determine their high temperature grade, and near the intermediate service temperatures (that is, measuring G*sini5 or fatigue factor at various temperatures) to determine their intermediate temperature grade. The recycled binder which was close to the specified PG grade was selected, thereby establishing the proportions of virgin asphalt binder and aged asphalt binder (from the RAP) to be used in the recycled HMA mixture.

Findings

As the amount of RAP (or aged asphalt binder) was increased in the recycled mixture, the rutting parameter (G*/sin@ of the recycled binder continued to increase as expected, thereby providing improved resistance to rutting. Therefore, this parameter cannot be used to establish the maximum amount of RAP (or minimum amount of virgin asphalt binder) in the recycled mix. It was hoped that the fatigue parameter (G*sini5) of the recycled binder, which increases as the amount of RAP is increased in the recycled mix, would establish' the maximum amount of RAP corresponding to the maximum allowable value of 5000 kPa for G*sin6 at intermediate temperatures. However, this criteria (5000 kPa) appears to be on the liberal side because it allowed as much as 43 percent RAP in the recycled mix without any need to change the grade of the virgin asphalt binder to a softer grade. Therefore, an alternate method has been recommended to establish the maximum amount of RAP (or minimum amount of virgin asphalt binder) in the recycled mix until additional research is done. The alternate method consists of using 2.0 kPa as the maximum allowable value of G*/sinð (rutting factor) for the recycled binder.

It was concluded that the construction of a “temperature sweep” blending chart is very time consuming. It involves conducting a temperature sweep on both aged asphalt binder in the RAP as well as proposed virgin asphalt binder to determine the temperature at which G*/sin& = 1.0 kPa. The inconvenience of running temperature sweep tests can be eliminated by constructing a “specific grade” blending chart as shown in the figure. The Y-axis of this chart is in log-log scale (similar to viscosity or penetration blending charts). The information needed to construct a “specific grade” blending chart is the G*/sin6 (rutting factor) of aged asphalt binder and virgin asphalt binder only. Both G*/sin& values must be measured at the high pavement service temperature indicated by the specified PG grade.

For example, measurements must be made at 64°C and 58°C if the <u>specified</u> binder grades are PG 64 and PG 58, respectively.

Example

Suppose a PG 64-28 was specified for a paving project. The G*/sini5 values measured at 64°C for the aged asphalt binder in the RAP and virgin asphalt binder (PG 64-28) were 100 kPa and 1.13 kPa, respectively. These values were plotted as point A and point B as shown in the figure. The line AB intersects the 2.0 kPa stiffness line at 85 percent. Therefore, the amount of the virgin asphalt binder PG 64-28 that can be added in the recycled mix will be 85-100 percent (about O-15 percent RAP if the asphalt contents of RAP and recycled mix are about the same). Suppose an asphalt binder PG 58-34 was selected as the virgin asphalt binder. The G*/sini5 value measured at 64°C for the PG 58-34 was 0.65 kPa and plotted as point C in the figure. The line AC intersected the 1.0 kPa and 2.0 kPa stiffness lines at 72 percent and 89 percent, respectively. Therefore, the amount of the virgin asphalt binder PG 58-34 that can be used in the recycled mix is 72-89 percent (about 11-28 percent RAP).

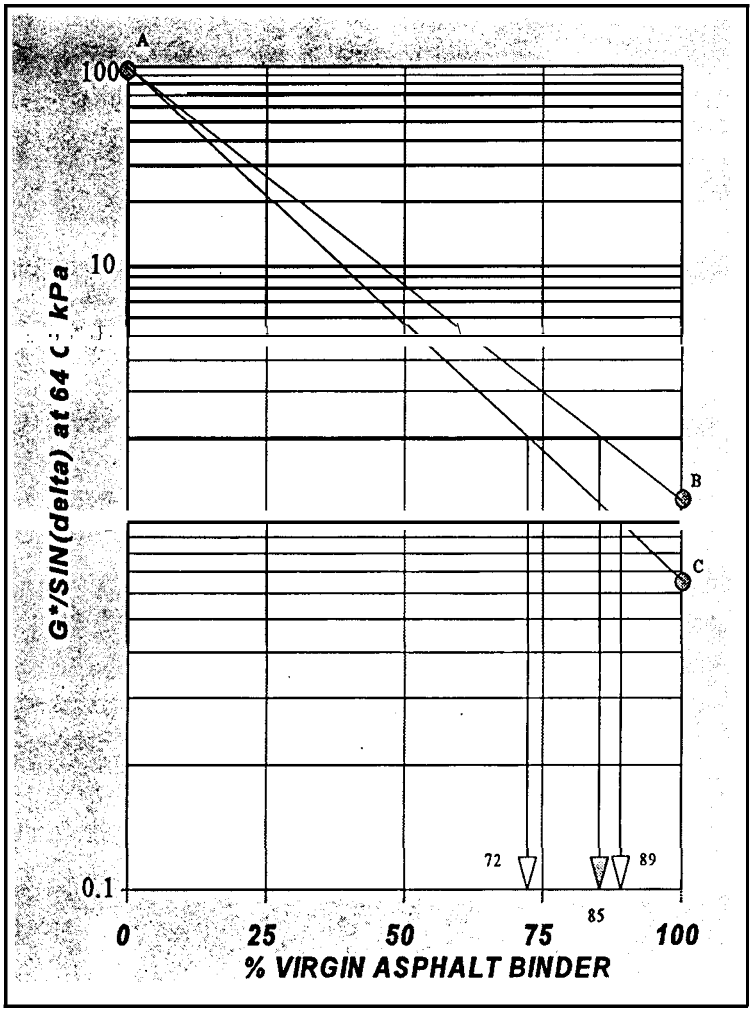


Figure. Graphical method to determine minimum and maximum amount of virgin asphalt binder in the recycled asphalt binder.

Based on the test data obtained in this study, the following guidelines are recommended for selecting the PG grade of the virgin asphalt binder:

Tier 1: If the amount of RAP in the HMA mix is equal to or less than 15 percent, the selected PG grade of the virgin asphalt binder should be the same as the Superpave specified PG grade.

Tier 2: If the amount of RAP in the HMA mixis more than 15 percent but equal to or less than 25 percent, the selected PG grade of the virgin asphalt binder should be one grade below (both high and low temperature grade) the Superpave specified PG grade. For example, if the Superpave specified PG grade is PG 64-22 than a PG 58-28 asphalt binder should be selected. The use of “specific grade” blending chart to select the high temperature grade of the virgin asphalt binder is optional.

Tier 3:If the amount of RAP in the HMA mix is more than 25 percent, use the “specific grade” blending chart to select the high temperature grade of the virgin asphalt binder. The low temperature grade should beat least one grade lower than the binder grade specified by Superpave.

The preceding recommendations of binder selection are based on this interim study which considered high and intermediate pavement service temperatures only. The recommended procedures are considered to be adequate at this time until additional research related to low service temperature is completed. Blank copies of the recommended “specific grade” blending chart can be obtained from NCAT.

Reference

P. S. Kandhal and K. Y Foo. Designing Recycled Hot Mix Asphalt Mixtures Using Superpave Technology. Paper prepared for publication in ASTM STP 1322, 1997.

NCAT LIST OF PUBLICATIONS

Report No.	Title	Authors	cost*
88-1	Preventative Maintenance of Asphalt Concrete Pavements	E. R. Brown	$5.00
88-2	Stripping in HMA Mixtures: State-of-the-Art and Critical Review of Test Methods	B. M. Kiggundu & F. L. Roberts	11.00
89-1	Water Damage to Asphalt Overlays: Case Histories	P. S. Kandhal, C. W. Lubold & F. L. Roberts	7.50
89-2	A Study of InPlace Rutting of. Asphalt Pavements	E. R. Brown & S. A. Cross	6.00
89-3	Investigation and Evaluation of Ground Tire Rubber in Hot Mix Asphalt	F. L. Roberts, P. S. Kandhal, E. R. Brown & R. L. Dunning	22.00
89-4	Testing and Evaluation of Large Stone Mixes Using Marshall Mix Design Procedures	P. S. Kandhal	11.00
90-1	Design of Large Stone Asphalt Mixes to Minimize Rutting	P. S. Kandhal	7.50
90-2	Evaluation of Bituminous Pavements for High Pressure Truck Tires (Executive Summary)	P. S. Kandhal, S. A. Cross & E. R Brown	2.50
90-2	Evaluation of Bituminous Pavements for High Pressure Truck Tires	P. S. Kandhal, S. A. Cross & E. R. Brown	32.00
90-3	Density of Asphalt Concrete - How Much is Needed	E. R. Brown	5.00
90-4	Large Stone Asphalt Mixes: Design and Construction	P. S. Kandhal	8.50
90-5	Comparative Evaluation of 4-inch and 6-inch Diameter Specimens for Testing Large Stone Asphalt Mixes	P. S. Kandhal & E. R. Brown	2.50
91-1	Comparison of Laboratory and Field Density of Asphalt Mixtures	E. R. Brown & S. A. Cross	6.00
91-2	Criteria for Accepting Precoated Aggregates for Seal Coats and Surface Treatments	P. S. Kandhal	7.50
91-3	Evaluation of Particle Shape and Texture: Manufactured Versus Natural Sand	P, S. Kandhal, J. B. Motter & M. A. Khatri	5.00

NCAT LIST OF PUBLICATIONS (Continued)

Report No.	Title	Authors	cost*
91-4	Evaluation of Asphalt Absorption by Mineral Aggregates	P. S. Kandhal & M. A. Khatri	5.00
91-5	Design of Large Stone Mixes for Low-Volume Roads	P. S. Kandhal	5.00
91-6	Evaluation of Variability in Resilient Modulus Test Results (ASTM D 41 23)	E. R. Brown & Kee Y. Foo	7.50
91-7	Evaluation of Pavement Bleeding. on 1-55 in Illinois	E. R Brown, S. A. Cross & J. G. Gehler	3.50
92-1	Moisture Susceptibility of HMA Mixes: Identification of Problem and Recommended Solutions	P. S. Kandhal	9.00
92-2	Relating Asphalt Absorption to Properties of Asphalt Cement and Aggregates	P. S Kandhal & M, A. Khatri	5.00
92-3	Improved Rice Method for Determining Theoretical Maximum Specific Gravity of Asphalt Paving Mixtures	P. S, Kandhal & M. A. Khatri	$4.00
92-4	Evaluation of Particle Shape and Texture of Mineral Aggregates and Their Blends	P. S. Kandhal, M. A. Khatri & J. B. Motter	5.00
92-5	A National Study of Rutting in Hot Mix Asphalt (HMA) Pavements (Summary)	E. R. Brown & S. A. Cross	7.50
92-6	Waste Materials in Hot Mix Asphalt - An Overview	P. S. Kandhal	3.00
93-1	Effect of Aggregate Gradation on Measured Asphalt Content	P. S. Kandhal & S. A. Cross	5.50
93-2	Heavy Duty Asphalt Pavements in Pennsylvania: An Evaluation for Rutting	P. S. Kandhal, S. A. Cross & E. R, Brown	5.50
93-3	Evaluation of SMA Used in Michigan	E. R. Brown	5.50
93-4	Experience with Stone Mastic Asphalt in the United States	E. R. Brown	5.50
93-5	Evaluation of Laboratory Properties of SMA Mixtures	E. R. Brown & H. Manglorkar	5.50
94-1	Evaluation of Longitudinal Joint Construction Techniques for Asphalt Pavements (Michigan and Wisconsin Projects)	P. S. Kandhal & S. S. Rao	4.50

NCAT LIST OF PUBLICATIONS (Continued)

Report No.	Title	Authors	cost"
94-2	Stone Matrix Asphalt Properties Related to Mixture Design	E. R. Brown & R. B. Mallick	15.00
95-1	Performance of Recycled Hot Mix Asphalt Mixtures	P. S. Kandhal & S. Charkaborty	4.00
95-2	Historical Development of Asphalt Content Determination by the Ignition Method	E. R. Brown, N. E. Murphy, Li Yu, & Stuart Mager	5.00
95-3	Asphalt Content by Ignition-Round Robin Study	E. R. Brown & Stuart Mager	5.00
95-4	Field Management of Hot Mix Asphalt Volumetric Properties	P. S. Kandhal, K. Y. Foo, & J. A. D'Angelo	5.00
96-1	Effect of Asphalt Film Thickness on Short and Long Term Aging of Asphalt Paving Mixtures	P. S. Kandhal & S. Charkaborty	5.00
96-2	Prediction of Low-Temperature Cracking Using Superpave Binder Specifications	P. S. Kandhal, Raj Dongre & Mark Malone	5.00
96-3	A Study in Longitudinal Joint Construction Techniques in HMA Pavements (Interim Report - Colorado Project)	P. S. Kandhal & R. B. Mallick	5.00
96-4	Evaluation of Voids in the Mineral Aggregate for HMA Paving Mixtures	P. S. Kandhal & S. Chakraborty	6.00
96-5	Hot Mix Recycling Design Using Superpave Technology	P. S. Kandhal & K. Y. Foo	8.00

Cost includes shipping and handling within U.S.A. International orders must be prepaid by an international money order or by a check payable in U.S. funds and drawn on a U.S. bank. Shipping and handling costs, whether surface or air, for international orders are paid by the customer at cost. Please send your order to NCAT, 211 Ramsay Hall, Auburn University, AL 36849 U.S.A.

SPECIFICATION CORNER

Maine - Work is continuing on quality control/quality assurance (QC/QA) specifications. At the present time, five projects are utilizing full QC/QA specifications. A bonus will be paid for density only. No disincentives will be assessed. The gradation and asphalt content of the hot mix asphalt (HMA) will have to meet an acceptable composite pay factor before a bonus will be paid for density.

The material transfer vehicle (MTV) is being proposed to be included in some interstate projects.

Kentucky - Beginning in 1997, all asphalt binders must comply with the PG graded binder specifications.

Hot-in-place recycling (HIPR) specifications were revised in 1996 to include the mixture volumetric and other performance related properties similar to HMA acceptance procedures. HMA and HIPR were bid as alternates on two projects. No HIPR bids were received.

Work is continuing toward the development of statistically based HMA acceptance procedures. About 65 projects were constructed in 1996 using such acceptance procedures. It is hoped that in 1997 all HMA acceptance will be based on the mix volumetric of the plant produced HMA rather than mix composition (gradation and asphalt content). A percent within limits (PWL) approach is being considered. Under this system, payment may be based on air voids, voids in the mineral aggregate (VMA), asphalt content, and density (except thin overlays of minor routes).

South Carolina - South Carolina has developed a volumetric specification for accepting HMA. Contractors will have an option of using the current statistical acceptance specification or the volumetric acceptance specification.

Superpave binder specifications will be implemented in the January, 1997, letting. The standard binder will be a PG 64-22.

Pennsylvania - Pennsylvania revised its conventional specifications for HMA courses in March, 1996, to include the following provisions: (a) contractor is required to provide a quality control (QC) plan with specified minimum requirements for paving construction operations in addition to previously required plant production QC, and (b) contractor is required to document the running average of the asphalt content and aggregate gradation over the past five consecutive tests and to maintain these within specified tolerances. Additionally, the revisions addressed pattern segregation, the specific ways to determine if pattern segregation exists, and the corrective action necessary if pattern segregation is found unacceptable.

Pennsylvania has also revised its statistically based specifications for HMA courses to require the contractor to construct a minimum 400-ton test section at the beginning of every job and verify that the test section meets all specified criteria before continuation of any additional work.

These revisions were jointly initiated by the department and industry to improve the quality of HMA paving in Pennsylvania. The department plans to develop a HMA paving specification with a warranty clause after consultations with the personnel from Wisconsin DOT and Indiana DOT. Several pilot projects are being planned for 1997 with the warranty clause.

Missouri - Four HMA overlay projects involving Superpave were awarded in 1996. Two of these projects were also pilot projects for a new QC/QA specification. The department's Superpave specification is being updated to include a 25-mm HMA mix for full depth asphalt pavements. Six projects will be let for the 1997 construction season with Superpave HMA. Two of these six projects will have full depth Superpave, two will have Superpave overlay, and two will have concrete/full depth Superpave alternate.

Missouri is also implementing Superpave asphalt binder specification in 1997.

Georgia . Georgia plans to implement the Superpave binder specification in January, 1997. Several projects are currently under contract with a provisional Superpave binder specification. This provisional specification requires the standard binder grade to be PG 67-22 for all virgin mixes. Also, PG 76-22 and PG 82-22 are specified in certain mix types and traffic conditions.

In July, 1997, Georgia plans to implement contractor acceptance testing statewide, which will turn over to the manufacturer the quality control process while Georgia DOT continues to monitor quality acceptance. The contractor will be responsible for testing the plant-produced mix. The contractor's test results will be used for acceptance as long as they satisfy Georgia DOT verification tests.

Utah - Contractors will submit their own mix designs for HMA in 1997 based on Superpave mix design requirements. Consultant laboratories will be allowed to test asphalt binder samples under Utah DOT's new Asphalt Binder Quality Management System.

Nebraska - Contractor design and quality control testing of HMA has been going very well. Split sample testing by the state personnel has correlated well with the contractor test results. As aggregate quality decreases, the correlations of test results show more variation.

Ontario, Canada - A new end-result specification combining asphalt content, gradation, compaction. and air voids based on percent within limits has been developed. It is being implemented on approximately 15 contracts at the present time with full implementation planned for 1997.

A new end-result specification for smoothness based on the California Profilograph has also been developed and is being implemented on selected contracts in 1996. The full implementation of the smoothness specification is planned for 1997.

The development of a new specification for visually defective mix including quantification of segregation using a macrotexture test is almost complete. Implementation on selected contracts is planned for 1997.

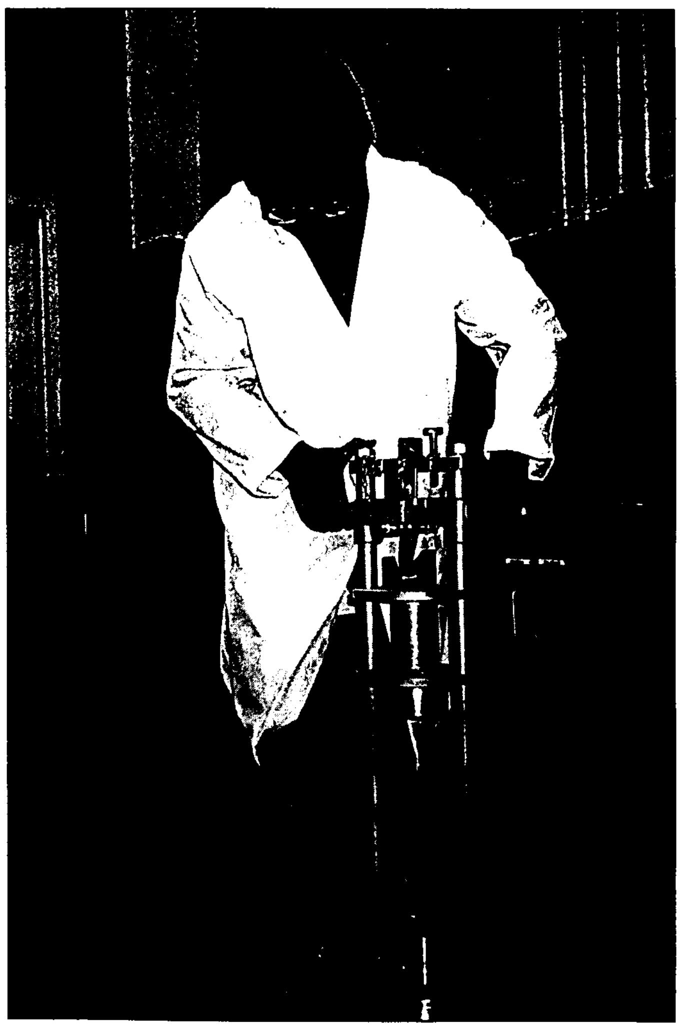
A warranty specification for HMA pavements has been completed and is being implemented on a few (4 to 5) selected contracts in 1996. The warranty will be for three years.

Australia - Five guides are being developed by various groups in Australia: (a) Selection and Design of Asphalt Mixes - Australian Provisional Guide, (b) Open-Graded Asphalt Mix Design Guide, (c) Cold Bituminous Granular Materials, (d) Asphalt Recycling Guide, and (e) Asphalt Guide (a reference text for students and practitioners).

Details can be obtained from the Australian Asphalt Pavement Association.

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 will be conducted at NCAT June 16-27, 1997. 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**



British impact tester is used to evaluate aggregate toughness.

RESEARCH IN PROGRESS

The following research projects pertaining to hot mix asphalt (HMA) pavements are currently in pr

STATE	PROJECT	RESEARCHERS)	COST	COMPLETION DATE	
Alaska	SHRP Evaluation of Asphalt Paving Mixes	Leahy, Oregon State University	$100,000	June 1997	Evaluate Su comparison Scandinavia
	Low Temperature Cracking of Polymer Mixes	Raad, University of Alaska	80,000	August 1996	Evaluate lov of existing without moc
Georgia	Evaluation of GDOT Specifications and Test Procedures for Polymer Modified Asphalt Cements	Jones, PRI and Santha, Georgia DOT	55,400	July 1997	Title self-ex
	Evaluation of Asphalt Mixtures' Permanent Deformation in the "WesTrack" Project Using the Georgia Loaded Wheel Tester .	Lai, Georgia Tech and Santha, Georgia DOT	59,900	December 1997	Title self-ex
Indiana	Stripping of HMA Mixtures	White, Purdue University	164,100	January 1998	Evaluate str mixtures usi wheel tracki AASHTO T
	Long Term Pavement Climatic and Drainage Factors	White, Purdue University	53,800	April 1998	Evaluate su systems of HMA Pavem
Kansas	Full Depth Bituminous Recycling of 1-70	Fager, Kansas DOT	75,000	December 1999	Evaluate var in hot and c
Missouri	Evaluation of the Binder Ignition Method	Netemeyer, Missouri DOT	103,000	January 1997	Compare th method with nuclear gau
Oklahoma	Experimental Evaluation of Asphalt Binders	Williams, Oklahoma DOT	200,000	June 2000	Compare pe with differen

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	(
Oklahoma	Thin Asphalt Concrete Overlays	Brewer, Oklahoma DOT	130,000	September 1996	Compare du overlay witl HMA overla
	Construction and Performance of Coarse Aggregate Mixes	Brewer, Oklahoma DOT	80,000	November 1996	Title self-ex
	Break and Seat Asphalt Concrete Overlay Evaluation	Brewer, Oklahoma DOT	75,000	December 1996	Title self-ex
Pennsylvania	Polymer Modified Asphalts	Ramirez, Pennsylvania DOT	80,000	December 1997	Field evalua modified as resistance a
	Anti-Rutting Materials for Intersections	Ramirez, Pennsylvania DOT	68,000	June 1998	Field evalua asphalt bind intersection
	Stone Matrix Asphalt (SMA)	Ramirez, Pennsylvania DOT	60,000	December 1998	Field evalua containing a binder
	Fiberglass Asphalt Shingles in Binder and Wearing Course	Ingram, Pennsylvania DOT	25,000	June 1997	Field evalua fiberglass a
South Carolina	Study to Improve Asphalt Mixes	Hanson, NCAT	189,700	June 1998	Improve Sou by evaluat identifying a
	Baghouse Fines in Asphalt Mixes	Hanson, NCAT	177,600	January 1997	Evaluate p fines and mixes.
Canada (Ontario)	Evaluation of Superpave Mixes	Virani and Tam, Ontario Ministry of Transportation	485,000	December 1996	Construct a sections us convention
Israel	Reformulation of Asphalt Cements for Paving	Ishai, Technion-Israel Institute of Technology	50,000	April 1997	Recomposit cements fro vacuum tow and oils.

NCAT'S 1996 ASPHALT TECHNOLOGY COURSE ATTENDEES AND INSTRUCTORS

Left to Right: (Row 1) Subhi Bazlamit, Jim Lundy, Hani Nassif, Chuck Jahren, Lesley Rosier, John Weavil, Ken Fladie (Row 2) Joe Akinmusuru,Vivek Tandon, Joseph Saliba, George Veyera, Paul Tikalsky, Walt Hislop (Row 3)Attoh-Okine, Anne Ewalt, Rita Leahy, Jim Travis, Moayyad Al-Nasra, Steve Von Stein, Chris McCurdy (Row 4) Doug Hanson, Tom Van Dam, Arti Patel, Fouad Bayomy NOT PICTURED: E.R. Brown, Ken Kandhal, Ali Maher, Bob Schmitt, Jim Vivian

---