



ASPHALT TECHNOLOGY NEWS

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MILESTONE FOR HMA TECHNOLOGY SHRP COMPLETES ASPHALT RESEARCH

The five-year, \$50 million Strategic Highway Research Program (SHRP) was successfully concluded on March 31. This represents a milestone for the industry and for hot mix asphalt (HMA) technology. When implemented, the SHRP study will change the way the asphalt binder is specified, and the way that HMA mix is designed.

Over the past 100 years, we have graded asphalt binders first by chewing, and then by the empirical penetration test (developed in 1888), and then by the viscosity test (developed in the early

1960s). The major shortcomings in specifying penetration or viscosity graded asphalt cements are: (a) the specified physical properties (such as consistency) are unrelated to HMA pavement performance, (b) there is no safeguard against premature aging of the binder and low temperature cracking, and (c) the specifications are not suited to modified asphalt binders.

The SHRP asphalt binder specifications we will soon have overcome these shortcomings. The selection of SHRP

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Asphalt binder being tested in the NCAT Laboratory with a SHRP dynamic shear rheometer. NCAT has two sets of SHRP binder testing equipment.

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binder grades is based on the lowest and highest pavement temperatures experienced at the project site. As a consequence, these grades are expected to vary from state to state, unlike viscosity-graded asphalt cement, such as AC-20, which is used in a number of states. SHRP binder specifications utilize new testing equipment, such as the dynamic shear rheometer, bending beam rheometer, direct tension device, Brookfield viscometer, and pressure aging vessel (PAV). The implementation of SHRP binder specifications is expected to be relatively easy, because binder testing will primarily be done by the refineries (suppliers) and state highway agencies' (SHA) central asphalt laboratories. It does not involve any testing in the field by SHA personnel or HMA industry. State highway agencies will only need one set of testing equipment in the central laboratory for verifying the suppliers test results. Already several states are participating in the Federal Highway Administration's pooled-fund study to procure this equipment.

In the same five-year study SHRP developed the SUPERPAVE asphalt mix design system. The current standard mix design methods—the Marshall and Hveem

methods—determine mix properties, such as stability and flow, which are indirectly related to pavement performance. However, these methods do not evaluate HMA pavement's resistance to rutting, fatigue, and low-temperature cracking. Since the test is only done at 140°F (60°C), the mix design does not take into account specific local environmental conditions. SUPERPAVE mix design equipment consists of a SHRP gyratory compactor, forced draft oven (to simulate short and long-term aging of the HMA mix), SHRP shear test device (to determine rutting and fatigue resistance), and an indirect tensile creep and strength test device (to determine resistance to low-temperature cracking). The implementation of the SUPERPAVE mix design system will take some time because all testing devices are not yet available commercially, and it involves a large number of HMA contractors, private testing laboratories, and SHA laboratories which normally perform the mix designs as well. An extensive training program is also needed and simple testing equipment needed, for field verification of HMA mixes is not yet developed.

SHRP ASPHALT RESEARCH UPDATE

by

Thomas W. Kennedy, James S. Moulthrop, Ronald J. Cominsky, David R. Jones, IV

The end came so soon for the five-year, \$50 million Strategic Highway Research Program concluded on March 31. To those of us working on the SHRP program, it doesn't seem that five years have gone by. Despite the too swift passage of time, SHRP achieved its goals. A final binder specification has been issued, and the SUPERPAVE mixture design system is being tested. The FHWA has been given the responsibility of implementing the SHRP products. Now the process of improving our nation's highways moves into another phase.

The final binder specification is called version 8D and incorporates the many findings of the SHRP researchers into a concise, one-page specification. Designed to apply

to both modified and unmodified binders, the final specification has been, and will continue to be, validated against field test sections throughout the United States.

The great strides SHRP researchers made in understanding the effects of binder properties on pavement performance are truly impressive and are the product of many institutions and researchers. Of course, we haven't answered all the questions but to quote a recent advertisement, "We've come a long way, baby!"

Our fundamental understanding of asphalt chemistry and its effects on pavement are truly significant, and the specification tests developed are based on the fundamental engineering properties of the binder. The new specification will allow highway engineers to rationally evaluate new binder materials and speed the process of highway design with a new generation of modifiers. It will also help producers determine the benefits of new products without the costly process of test sections and repeated multi-year evaluations.

The SUPERPAVE system will be available through AASHTO late in 1993 and will be designed to run on readily-available desktop computers in conjunction with SHRP mixture and binder test equipment. Those interested in utilizing the products of this SHRP research should contact their regional user-producer groups, the FHWA, or AASHTO for more information. Don't call us, because we've turned out the lights!

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ASPHALT TECHNOLOGY NEWS 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.

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NCAT EVALUATES VARIOUS LONGITUDINAL JOINT CONSTRUCTION TECHNIQUES

by
Prithvi (Ken) Kandhal

Constructing effective longitudinal joints has always been a critical problem in multilane HMA pavements. Poor joint construction leads to the formation of longitudinal cracks along the joint and/or raveling adjacent to the joint. It is believed that longitudinal cracks are caused primarily by the difference in the mat densities on either side of the joint and the overall low density at the joint. This density gradient can be attributed to the low density at the unconfined edge when the first lane is paved, and a relatively high density at the confined edge when the adjacent lane is paved. The problem can be minimized or eliminated when paving is done in echelon (two adjacent pavers) or when a wide paver is used. This is not always possible, however. Various longitudinal joint construction techniques have been proposed, specified, or practiced in various states. However, the relative effectiveness of these techniques has not been well established.

The National Center for Asphalt Technology (NCAT) has now undertaken a research project to evaluate the effectiveness of these techniques. Seven to eight different techniques were used on two paving projects in Michigan and Wisconsin in September and October of 1992. Each project involved a dense graded wearing course and consisted of a series of 500-foot test sections, each section using a different technique.

In the Michigan project, the conventional overlapping procedure was used. This involves placing the mix such that the end gate of the paver extends over the top of the cold lane by about one to one-and-a-half inches. The mix was luted (bumped) to provide extra material at the edge of the hot lane. No overlap was used in Wisconsin, how-

ever, and no luting was performed. No overlap was done on the Michigan project when the wedge joint was constructed. Rolling was accomplished in the static mode on both projects. The following different techniques of joint construction were attempted on each project:

Rolling Technique A

Compaction at the joint was done from the hot side with a 6-inch overlap on the cold mat.

Rolling Technique B

Compaction at the joint was done from the cold side with a 6-inch overlap on the hot mat. This procedure is believed to "pinch" the joint.

Rolling Technique C

Compaction at the joint was from the hot side with the edge of the roller about six inches away from the joint. It is believed that the mix is pushed towards the joint by this technique, and subsequent rolling at the joint pinches the material into the joint leading to high density.

Wedge Joint Without Tack Coat

The wedge joint is formed by tapering the edge of the lane paved first. The taper is then overlapped when the adjacent mat is placed. A taper of 1:12 (vertical: horizontal) was used on both projects. In Michigan, the inclined unconfined face of the wedge was compacted with a small roller attached to the paver. The tapered face was not tack coated in this section. Rolling technique A was used.

Wedge Joint With Tack Coat

This technique is similar to the preceding technique, except that a tack coat was applied to the tapered face.

Restrained Edge Compaction Device

The device consists of a hydraulically powered wheel which rolls alongside the roller's drum while simultaneously pinching the unconfined edge of the first lane towards the drum, thus providing lateral restraint. The adjacent lane is then abutted against the edge. Rolling technique A was then used. This device was used in Wisconsin only.

Cutting Wheel

This technique involves cutting about 1½ to 2 inches of the unsupported, low density edge of the compacted first

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Construction of the longitudinal wedge joint (right lane) on I-69 in Michigan for NCAT research project.

RESEARCH IN PROGRESS

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

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Alaska	Rutting of Asphalt Concrete Pavements	Raad, Alaska DOT	\$28,300	December '93	Evaluate rut resistance of mixes
Arkansas	Blending Aggregates for Skid Resistance	Muradweig, Arkansas DOT	47,000	December '94	Title self-explanatory
	Detection of Anti-Strip Additives, Phase II	University of Arkansas	44,600	January '95	Title self-explanatory
Florida	Determine Worker Exposure Levels due to the Addition of Ground Tire Rubber (GTR) in HMA	Berry, Murphy and Page, FDOT	500,000	June '93	Title self-explanatory
Georgia	Development of a Modified LWT for Evaluating Rutting	Brown, GDOT	48,600	September '93	Develop a modified loaded wheel tester based on improvements suggested by current users
Indiana	Locating the Drainage Layer in Bituminous Pavements	White, Purdue University	150,000	January '95	Evaluate internal drainage layer
	Development of Procedure to Identify Aggregates for Bituminous Surfaces	McDaniel, INDOT and West, Purdue University	125,000	January '95	Correlate British Pendulum to friction numbers
	Second Phase Study of Changes in In-Service Asphalt Pavements	White and Wood, Purdue University	193,000	May '95	Correlate asphalt properties with long term performance (SHRP validation)
	Laboratory Verification of Results of Significant Asphalt Mix Properties	Coree, INDOT	170,000	March '95	Early verification of performance of SHRP and conventional HMA mixes using accelerated pavement testing
Iowa	Evaluation of Recycled Rubber in Asphalt Concrete	Iowa DOT and University of Northern Iowa	74,000	July '96	Title self-explanatory

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Louisiana	Characterization of Asphalt Cements Modified with Crumb Rubber	Daly, Louisiana State University	\$74,700	June '93	Determine compatibility and physiomechanical characteristics of asphalt cement/crumb rubber mixtures.
Ohio	Precision of Biodegradable Solvents in Determining Asphalt Content and Gradation	Jeng, Ohio State University	45,000	October '93	Title self-explanatory
	Performance Evaluation of Fiber Reinforced Asphalt Concrete	Jeng, Ohio State University	129,000	June '93	Title self-explanatory
Ontario, Canada	Effect of Differential Thermal Contraction on Asphalt Paving Mixtures	National Research Council and MTD	45,000	July '94	Study the effect of differential thermal contraction on thermal cracking of HMA pavements
	Comparison of Ontario Wheel Tracking Machine with Hamburg Machine	Tam and Yacyshyn, MOT	60,000	December '93	Title self-explanatory
Pennsylvania	Anti-rutting Mixtures for Intersections	Ramirez, PemDOT	175,000	December '95	Evaluate HMA mixtures to withstand accelerated rutting at urban intersections
South Carolina	Utilization of Waste Tires in Asphaltic Materiels	Amirkhanian, Clemson University	\$327,900	December '93	Title self-explanatory
	Feasibility Study of the Use of Waste Materials in Highway Construction	Amirkhanian, Clemson University	49,900	December '93	Title self-explanatory
Texas	Short Term Guidelines to Improve Asphalt-Rubber Pavements	Estakhri, Texas Transportation Institute	240,000	August '94	Title self-explanatory
	Recycling Second Generation Asphalt-Rubber Pavements	Crockford, Texas Transportation Institute	200,000	August '94	Title self-explanatory
Victoria, Australia	Development of Australian Mix Design Method and Software Package	Oliver, Australian Road Research Board	Part of \$250,000 program	December '93	Title self-explanatory
	Development of a Fatigue Test Method Based on Dissipated Energy Concept	Baburamani, Australian Road Research Board	Part of \$250,000 program	December '93	Title self-explanatory

NCAT's DENSITY AND PERFORMANCE STUDY UPDATE

by
Doug Hanson

Density, or unit weight, is an important component of a properly designed and constructed HMA pavement. Selection of the proper compaction level during the mix design phase is critical for proper pavement performance. The Marshall mix design method, as originally developed by the U.S. Army Corps of Engineers at the Waterways Experiment Station in the late 1940s, was based on evaluation of samples compacted to a relative density that approximated the density developed by a number of repetitions of a selected aircraft. The original method called for compacting samples with 50 blows-per-side for tire pressures up to 100 psi and 75 blows-per-side for pressures over 100 psi. Over the years, the Marshall method has been adapted to highway use with 50 blows-per-side being utilized for low to medium traffic levels and with 75 blows used for heavy traffic.

Since the initial development of the Marshall mix design procedure, there have been few studies to evaluate in-place density as a function of traffic and mix design density. Thus, NCAT initiated a study to evaluate eight laboratory compaction techniques to determine if they provide a density similar to that found in the field after a period of time.

The specific objectives of NCAT's study include:

1. Evaluation of in-place density as a function of traffic and laboratory density.
2. Evaluation of changes in asphalt cement properties as a function of mixture properties such as air voids, asphalt film thickness and VMA.
3. Verification of the models developed by NCAT to predict rutting.
4. Comparison of test results with 4-inch and 6-inch cores.
5. Comparison of engineering properties of recompact-ed samples to those of samples compacted from the original mix.

In achieving these objectives the following laboratory compaction techniques are being used:

1. Marshall
 - a. Fixed base - mechanical
 - b. Fixed base - manual
 - c. Rotating base - mechanical
2. Compaction to refusal

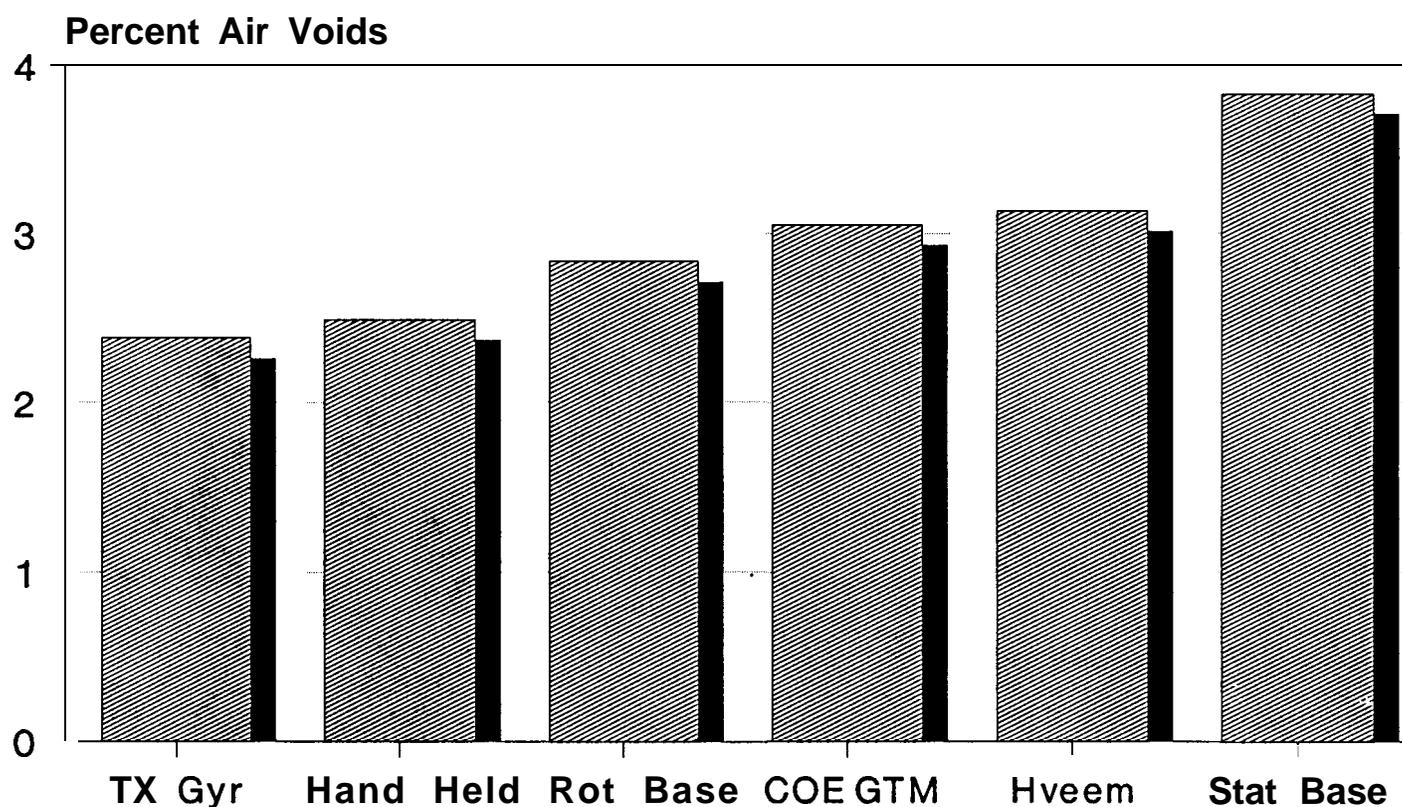
3. Corps of Engineers Gyratory Testing Machine (GTM)
4. Texas Gyratory
5. Kneading compactor
6. SHRP Gyratory compactor (this work will be done this summer when the equipment becomes available).

The study has two major phases. The first phase is to revisit the Asphalt Aggregate Mix Analysis System (AAMAS) study completed by NCHRP in March 1991. That study also looked at the compaction of HMA mixtures using different compaction devices and compared the results obtained with those devices to the field cores. The study looked at the mixtures at time of construction and two years after construction. The NCAT study consisted of sampling the same sites in the summer of 1992 (five years after construction) and recompacting the mixtures using the three types of Marshall compaction, the Texas Gyratory, the kneading compactor and the Corps of Engineers GTM. The preliminary results of this phase of the study are that the Texas Gyratory Compactor and the California kneading compactor best predict the properties of the asphalt mixtures after five years.

The second phase of the study consists of sampling eight new sites. This sampling consists of obtaining aggregates and asphalt cement at the time of construction, samples of the mix at time of construction, and coring the roadway section over a period of four years. Four sites were established and sampled in 1992, and four more will be established and sampled in 1993. In 1993, a site was established in Idaho and one in New Mexico. In 1993, a site will be established in South Carolina and one in Wisconsin. The objective in selecting the sites was to establish a site in each of the four SHRP climatic regions.

At each of the four sites, the mix has been compacted with all of the equipment except the British compaction to refusal procedure and the SHRP gyratory compactor. As mentioned, compaction with the SHRP gyratory equipment will be accomplished this summer when the equipment becomes available. As the figure on the facing pages shows, the Texas Gyratory compactor provided mixes with the lowest voids total mix (VTM). Sampling at the time of construction, and at three months after construction, has been completed at all of the sites. Sampling will continue for another three to four years.

Compaction Devices vs Air Voids



JOINTS (Continued from page 3)

lane while the mix is still plastic. The cutting wheel (about 10 inches in diameter) can be mounted on an intermediate roller or a motor grader. An approximately vertical face at the edge is obtained by this process, which is tack coated before placing the abutting lane. Rolling Technique A was used.

AW-2R Joint Maker

This is an automated joint construction technique and is a recent innovation in joint-making technology. The device is attached to the side of the screed, and it pushes sufficient material at the joint by pre-compaction prior to the screed. Rolling Technique A was used.

Six-inch diameter core samples were obtained both at the joint and two feet away from the joint to determine density values. The density data is being analyzed statistically.

Overall, the Michigan wedge joint, cutting wheel, and restrained edge compaction device gave the highest densities at the joint. Among the three rolling techniques, Technique A produced higher joint densities than Techniques B or C.

NCAT plans to obtain additional density data from these projects and to conduct visual performance evaluation of the various joints for four to five years. The final performance rankings will be based on density at the joint as well as performance of the joint.

ASPHALT FORUM

Your comments and questions are invited for this feature of *Asphalt Technology News*. Share your experience with others or send us your questions. Respond to questions asked by others as to how you are dealing with issues and problems. Your responses will be published in future issues of *Asphalt Technology News*. Some are edited for consistency and space restrictions.

Australia (John Bethune, Australian Asphalt Pavement Association)

The move to performance based specifications and QC/QA in constructing HMA pavements will place increased responsibility on contractors who must expand their technical skills. These moves will enable the contractor to use innovative designs, materials, and processes with resulting community benefit.

Several large scale trials of stone matrix asphalt (SMA), NOVACHIP, and foamed asphalt are in progress throughout Australia.

Nebraska (Laird Weishahn, Nebraska Department of Roads)

We would like to eliminate the extraction test. How do the other states determine asphalt content, other than with nuclear gauge?

NCAT: Several states have started to use biodegradable solvents in lieu of chlorinated solvents in the extraction test. You might want to contact Gale Page of the Florida DOT and Ron Collins of the Georgia DOT for details.

Nova Scotia (Gerard Lee, Nova Scotia DOT)

What test methods do other agencies use to determine the stripping potential of asphalt aggregates? Do "freshly" crushed aggregates have a tendency to whip-off when used in chip sealing operations?

NCAT: States use several test methods to evaluate the stripping potential of HMA mixtures: Static-Immersion AASHTO T182, Immersion-Compression AASHTO T165, Tunnicliff and Root ASTM D4867, and Modified Lottman AASHTO T283. SHRP is recommending AASHTO T283. Some aggregates exhibit inadequate adhesion with asphalt cements when freshly crushed.

Maine (Warren Foster, Maine DOT)

The Maine DOT is planning to construct a shredded tire embankment during the 1993 construction season.

What type of HMA levelling mixes are used by other states to shim overlay projects prior to installing the new wearing course? Are sand mixes being used and, if so, are there any thickness restrictions?

Montana (Bob Garber, Montana DOT)

What should be done with old pavement from mill and fill operations, and is it increasingly being regarded as a hazardous waste?

The use of crumb rubber modifier as required by ISTEA is forcing the Department to write specifications for patented processes. This could potentially increase costs without an increase in service life.

New Brunswick (Thomas Gorman, New Brunswick DOT)

What are the pros and cons of using nuclear gauges for determining final compaction results? Is there a consensus that coring is a more accurate method?

Florida (Gale Page, Florida DOT)

Florida DOT is currently rehabilitating a 12-mile section of concrete pavement on I-10 in Gadsden County. The rehab consists of placement of edge drains; crack and seat of existing concrete pavement; and placement of an asphalt rubber membrane interlayer directly over the concrete pavement. This is followed by a 4-inch HMA structural course and an open-graded friction course. The asphalt rubber membrane interlayer is being placed to serve both as a moisture barrier and a crack relief layer. A report comparing this method of rehabilitation to previous methods will be prepared as soon as sufficient performance data is obtained.

Ontario (Kai Tam, Ontario Ministry of Transportation)

In response to the federal ban on using chlorinated solvents effective January 1, 1995, a committee has been established to investigate alternatives. Correlation testing is planned for this summer, and selective contracts will be made for implementing the use of non-chlorinated solvents next year.

Maryland (Samuel Miller, Maryland DOT)

Maryland DOT is currently reviewing candidate rehabilitation projects for placement and evaluation of HMA pavements containing crumb rubber modifier (CRM).

(Continued on page 15)

ASPHALT FORUM RESPONSES

The following responses have been received to questions raised in the previous "Asphalt Forum" (fall, 1992) concerning sampling HMA mixtures from roadway, contamination of asphalt cement and HMA, crack sealing, polymer and fiber modified HMA, and crumb rubber modifier.

Response to the question from Rebecca McDaniel of Indiana DOT, *Have other states obtained HMA samples behind the paver for acceptance testing? Were any problems noted?*

Dean Maurer (Pennsylvania DOT)

We have successfully sampled loose mixture behind the paver for at least 10 years for acceptance testing in our statistically based end result specifications. We obtain approximately 8 lbs. or 3,600 grams of HMA with a flat-bottom high-sided scoop at random locations and place it in a cardboard box. There is an option to use an 18-inch-square metal plate in advance of the paver; however, this is rarely done with dense-graded HMA. The 3,600-gram sample size is sufficient for sampling wearing and binder mixtures. Please contact me for additional details.

Responses to the questions from Gerard Lee of Nova Scotia DOT, *How do agencies detect the contamination of asphalt cement and HMA? What size rout is used by other agencies for crack filler?*

Milt Fletcher (South Carolina Dept. of Highways)

We detect contaminated asphalt cement from field samples taken from the asphalt storage tank at the HMA facility. Contaminated asphalt cement samples do not comply with department specifications. A quick method to determine possible contamination with a volatile material would be to conduct a simple flash point test.

Contamination of in-place HMA with a petroleum material (such as diesel fuel or hydraulic fluid) would generally be characterized by flushing or stripping. The recovered asphalt cement may have a lower than normal viscosity. A highly contaminated mix has a distinct petroleum odor.

We do not rout cracks in HMA pavements for crack sealing. We rout cracks less than $\frac{3}{8}$ inch wide in concrete pavements to obtain a cut $\frac{1}{2}$ inch wide by $\frac{3}{4}$ to 1 inch deep.

Jim Chehovits (Crafco, Inc.)

Rout sizes and crack sealant application geometries vary from agency to agency. Typical geometries include no routing for sealant overband applications, standard $\frac{1}{2}$ -

to $\frac{3}{8}$ -inch-wide routing for depths $\frac{1}{2}$ to 1 inch, and wide shallow routes ($\frac{1}{4}$ inch deep and $1\frac{1}{2}$ inches wide) which are typically used in cooler climates. The performance of crack sealants applied using various application geometries and rout sizes was studied in the SHRP H-106 Project for which the final report will be published soon.

Response to the questions from Ron Collins of Georgia DOT, *Which states have a polymer-modified binder specification? Has anyone developed specifications for fibers to be used in HMA mixtures?*

Dave Powers (Ohio DOT)

We are experimenting with several polymer modified binders including latex. We have a fiber specification that has been used for several years.

Response to the summary of paper "Florida's Initial Experience Utilizing Ground Tire Rubber in Asphalt Concrete Mixes" published in the Fall 1992 issue.

Gale Page (Florida DOT)

Although the paper summarizes our experience with 80 mesh crumb rubber modifier (CRM), we have utilized a range of CRM sizes (24, 40 and 80 mesh) and amounts (3% to 17% by weight of asphalt cement binder). We intend to specify nominal size and amount of CRM based on specific application: membrane interlayer (20 mesh, 20%), open graded friction course (40 mesh, 12%), and dense graded friction course (80 mesh, 5%). In comparison to the traditional wet process, Florida's approach can be characterized as smaller amounts of CRM, smaller particle size (amount and size dependent on application), and lower "reaction" temperature and time.



PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of the Transportation Research Board, 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 any limitations. Titles of the papers are given, with names of authors in parentheses, followed by NCAT's summary remarks.

1. BREAKING AND SEATING OF CONCRETE PAVEMENTS: KENTUCKY'S EXPERIENCE (Graves, Allen and Sharpe)

Breaking and seating has been used extensively in Kentucky for rehabilitation of deteriorated concrete pavements for the past 10 years. To date, 836 lane miles of interstate pavements and 292 lane miles of parkway pavements have been rehabilitated. Several test sections have been constructed to evaluate construction techniques and appropriate factors to be used in design procedures.

Three projects (Interstate 71, Interstate 64, and Bluegrass Parkway) have been evaluated for long-term pavement performance (eight to 10 years). Both interstate projects contained test sections with broken slab sizes of 3 to 12 inches, 18 to 24 inches, and 30 to 36 inches, and a control section without any breaking. The parkway project consisted of 18 to 24 inches slab size only. The HMA overlay thickness was 7 inches on interstate projects and 4.75 inches on the Parkway project. The performance evaluation has included Rideability Index, pavement condition rating, detailed crack survey, road rater and FWD deflection measurements.

On Interstate 71, all four test sections were performed in a similar manner from 1983 to 1989. The condition of the control section started to deteriorate rapidly from 1989 to 1991, probably due to an increase in the number of reflection cracks. The other sections are performing well.

The Parkway project, which was constructed with a thin overlay of 4.75 inches in 1985, is currently showing signs of deterioration. Alligator cracking has been observed in numerous areas, indicating base failures. Reflective cracking is evident throughout the project.

The data collected from Interstate 71 illustrates that the 3- to 12-inch breaking pattern provides the best performance (based on the amount of reflective cracking and pavement condition survey). The current Kentucky specifications require the 18- to 24-inch breaking pattern. This pattern has been chosen based on good constructability and overall performance. The current specifications also include: (a) use of impact hammer, (b) water not permitted to detect cracks, (c) 35-ton (seven passes) or 50-ton (five passes) pneumatic tire roller for seating, (d) breaking permitted less than 24 hours ahead

of paving, (e) vertical displacement limited to less than 1/2 inch during the breaking and seating operation, and (f) overnight curing of HMA overlay before opening to traffic. Based on experience, Kentucky will continue to utilize breaking and seating of concrete pavements as a rehabilitation alternative.

2. EFFECT OF AGGREGATE GRADATION ON MEASURED ASPHALT CONTENT (Kandhal and Cross)

It is necessary to control the asphalt content closely in HMA mixtures to obtain optimum serviceability and durability. However, coarser mixtures (binder or base courses) made with larger maximum particle-sized aggregate tend to segregate. The resulting variation in the aggregate gradation of the sampled HMA mixture can significantly affect the measured asphalt content. The objective of this research was to evaluate the effect of aggregate gradation on the measured asphalt content.

Actual mix composition (asphalt content and gradation) data from a major interstate paving project was obtained and analyzed. A total of 547 binder course mix samples were obtained behind the paver and subjected to extraction analysis. A substantial amount of segregation was observed in the binder course mix which provided the opportunity to correlate the aggregate gradation with the measured asphalt content. The binder course mix consisted of 1 1/2-inch maximum aggregate size, 4.8% asphalt content, 39% passing the No. 4 sieve, and 30% passing the No. 8 sieve according to the job-mix formula. Material production variability was considered to be minimal on this project because an automated HMA facility was used, and the HMA mix samples obtained at the facility were reasonably uniform in composition. The testing variability is also considered to be minimal because all extraction testing was done in the DOT central laboratory by essentially the same testing crew.

Statistical analysis of the test data indicates a significant relationship between the change in gradation particularly, the percentages of the material passing No. 4 (P4) and No. 8 (P8) sieves, and the measured asphalt content.

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SPECIFICATION CORNER

Colorado—Three projects will be let in 1993 which will be controlled in the field based on air voids, VMA, and asphalt content. The projects will be designed using a gyratory compactor.

South Carolina—Placement of HMA will be based on the lift thickness and the minimum existing surface temperature in an attempt to extend the HMA paving season. Surface temperatures will be measured with a hand-held infrared non-contact thermometer.

Texas—Five HMA projects will be constructed in 1993 under the QC/QA specification being developed. Bonus and deduction factors will be applied to asphalt content, percent passing No. 10, percent passing No. 200, roadway density, and ride quality.

Nova **Scotia, Canada**—A bonus/penalty specification for pavement smoothness was implemented in 1992 using the California Profilometer, which resulted in improved pavement smoothness.

Maryland—Standard specifications have been revised to allow the use of recycled crushed glass in base HMA mixtures. The crushed glass must meet specified gradation and L.A. abrasion requirements and should not contain more than one percent contaminants.

Maine—Use of 20% RAP (reclaimed asphalt pavement) will be allowed in surface mixes when used on shoulders.

Montana—Aggregate gradation has been changed as follows to minimize rutting on heavy duty pavements: (a) no natural fines permitted, (b) increased percentages of 3/4-inch and 1/2-inch material, and (c) development of an algebraic difference formula to eliminate mixture gradations that cross the maximum density line.

New York—QC/QA specifications are being introduced in lieu of method type specifications in 1993. Pilot projects involving approximately 100,000 tons of HMA are scheduled this year. The producer will be responsible for quality control, and the Department will perform quality assurance at the HMA facilities. Complete transition to the QC/QA system is scheduled for 1995.

Hawaii—Specifications have been revised to permit the use of 10% recycled glass in HMA mixtures as required by law.

Florida—The sodium sulphate soundness requirement for aggregates to be used in HMA has been deleted from

the standard specifications. Research is being proposed to develop a better test method for predicting aggregate durability.

The Department is implementing a requirement that shoulder warning devices be used on all interstate and turnpike facilities. Specifications have been developed for indented rumble strips which will be used on new HMA shoulders, and for ground-in rumble strips for use on existing shoulders.

New Jersey—Effective January 1, 1993, NJDOT has implemented a requirement for a certified paving technician to represent the contractor on the construction site for paving operations. The Glasphalt incentive program will be extended through the 1993 season. The specification for glass will be changed to a maximum 3/8 inch size without a requirement for an antistripping agent.

Nebraska—The development of QC/QA specifications for HMA is on schedule. During the 1993 and 1994 construction seasons, contractors will be compensated for field verification testing (primarily for void properties) of heavy duty mixes. The data gathered and the experience gained will aid in the specification development process and letting QC/QA projects in 1996.

Ohio—Field trials of heavy duty mixes (specifications were reported in the Fall, 1992 issue) have been completed in nine projects. These mixes designated as Type 1H will be used in most jobs in 1993. SMA specifications were revised after the first job in 1992.

West Virginia—End result specifications based on field density, thickness, and smoothness are being implemented.

Vermont—Crumb rubber modifier (CRM) will be used on a HMA project in 1993 using the wet process.

Ontario, Canada—Special provisions are being developed for recovered penetration, compaction, and smoothness to implement end result specifications.

Alaska—Statewide adoption of VMA criteria and more open gradation limits for HMA mixes are planned for 1993.

Australia—The test methods for resilient modulus and dynamic creep using the Australian developed Materials Test Apparatus (MATTA) are currently under review for

(Continued on page 15)

PRACTICE (Continued from page 10)

Equations were developed for these relationships, and are given in the paper. The equations indicate that the measured asphalt contents of the binder course mix increased by 0.06 and 0.08% with each one percent increase in P4 and P8 respectively from the job-mix formula (JMF). Conversely, there will be a similar decrease in the measured asphalt contents if the sampled mix is coarser than the JMF. These so-called "correction factors" can be used to correct the measured asphalt content for each one percent deviation from the JMF. Either P4 or P8 should be used to "correct" the measured asphalt content.

3. APPLICATION OF CRACKING AND SEATING AND USE OF FIBERS TO CONTROL REFLECTIVE CRACKING (Jiang and McDaniel)

This study evaluated two methods for reducing reflective cracking of a HMA overlay over a 12.5-mile section of reinforced jointed concrete pavement on I-74 in Indiana. The first method involved cracking and seating of the concrete pavement. The pavement was required to be cracked transversely at 18 to 24-inch spaces. Initially, the pavement was cracked with a whip hammer which gave poor results. Therefore, a 7-ton guillotine-type drop hammer was used. A 50-ton rubber-tired roller was used to seat the pavement. The second method involved addition of 0.4-inch-long polypropylene fibers (0.3% by weight of mix) to the HMA overlay. Since the construction of the project in 1984-85, it has been monitored by performing deflection tests, roughness tests, visual inspections, and rutting measurements.

The following conclusions have been drawn from this study:

- The cracking and seating technique delayed most of the reflective transverse cracks for 5 years.
- The sections cracked with the whip hammer developed more transverse cracks than the sections cracked with the drop hammer.
- Use of polypropylene fibers in the HMA overlay mix further reduced transverse cracks on cracked and seated sections, but did not improve the cracking resistance of the control sections. Adding fibers in the base layer of the HMA overlay on cracked and seated sections proved to be as effective for cracking control as adding fibers in both base and binder layers.
- There were no significant differences in pavement roughness either between the control sections and the cracked and seated sections, or between the sections with and without fibers.
- The deflection data did not indicate higher strength for fiber modified HMA overlays compared to the overlays without any fibers.
- The increase of overlay thickness from 5 to 8½ inches improved pavement strength, as expected. However, thicker overlays increased the construction costs significantly but did not reduce the reflective crack intensities. It is recommended that the thickness of HMA overlay be determined only by the pavement strength requirement, but not be increased as a means of cracking.

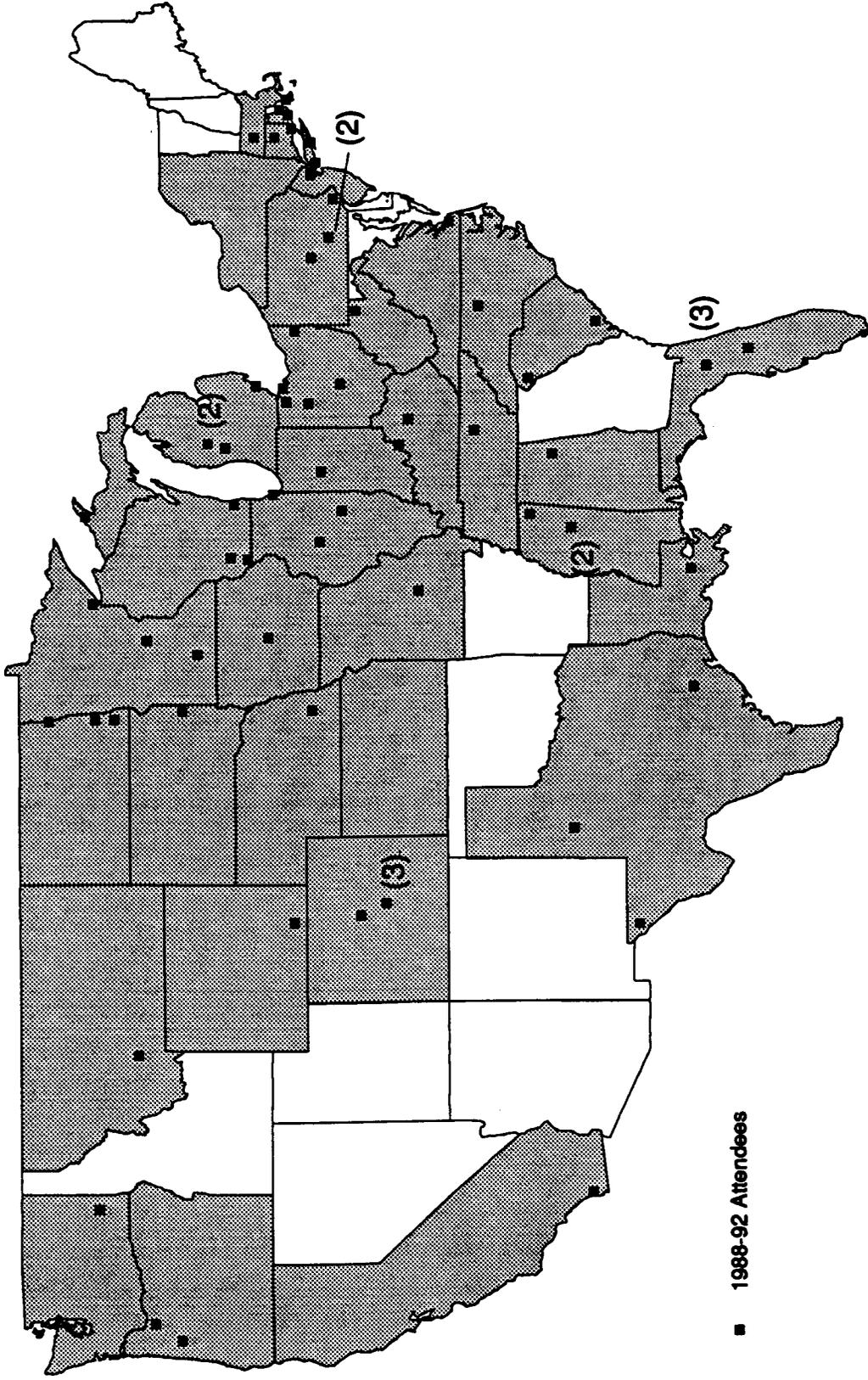


FHWA engineers visited NCAT in October 1992. From left to right: Roy Griffith, Ray Brown (NCAT Director), Harvey Phlegar, Ron Evers and Gordon Brown.

GRADATION CHART

NCAT uses the 0.45 Power Gradation Chart (facing page) for plotting the HMA mix gradation. This chart has been prepared to accommodate large stone mixes (maximum aggregate size of 3 inches). A millimeter scale has been provided which will be helpful in changing to the metric system. The chart is reprinted here for use by those who receive *Asphalt Technology News*. You are welcome to make copies.

Professor Training Course 1988-92 Attendees



This map shows the locations of universities from which a total of 85 faculty members have been trained in HMA at the NCAT during the 1988-1992 period. If more than one faculty member attended the course from the same institution, the number of attendees is given in parenthesis.

FORUM (Continued from page 8)

These projects will incorporate single and multi-lift construction on low and high volume highways.

New Jersey (Eileen Connolly, New Jersey DOT)

The use of crumb rubber modifier (CRM) in HMA pavements has resulted in three successful projects in New Jersey. However, there have also been failing projects for unknown reasons. How can we guarantee successful CRM hot mix asphalt pavements? The question of worker safety when working with CRM also needs to be addressed.

Georgia (Lamar Caylor, Georgia DOT)

Laboratory work to identify a preferred approach for incorporating CRM in HMA pavements is in progress. Findings to date indicate that about 16 to 20% of 80-mesh CRM mixed into asphalt cement at about 350°F, tends to produce characteristics similar to polymer modified binders.

Wisconsin (John Pope, Wisconsin DOT)

The concept of warranty is gaining national interest. With advice from European contacts, Wisconsin DOT and a paving contractor entered into an innovative two-year pavement warranty for a seven-mile long, two-lane HMA pavement. The warranty document was jointly developed by both parties when it was observed that the minus 200 material did not meet the Department's plasticity index requirement (less than 3), and the paving on the heavily travelled highway had to be completed before the onset of winter. The warranty involves five joint inspections by a review team composed of Wisconsin DOT and contractor representatives and a neutral third party. The review team has made the first inspection and found the pavement in excellent condition. Wisconsin DOT is continuing to explore possibilities for further use of this concept on future paving projects.



Fifth Overseas Pavement Study Group of Japanese Road Contractors Association visited NCAT in October 1992.

SPECIFICATIONS (Continued from page 11)

adoption as Australian Standards. The Federal Airports Corporation has adopted the guidelines for dynamic creep in their specification requirement. The property specified is the minimum slope of the creep curve based on various categories of traffic and operating temperatures.

Wisconsin—Three HMA mix specifications: HV (high volume), MV (medium volume), and LV (low volume) were developed for the intended traffic volume. Grading bands were widened to incorporate more asphalt cement to obtain increased durability. A new viscosity-graded asphalt cement specification will be introduced in 1994.

Arkansas—Specifications were developed for SMA binder and wearing courses based on laboratory work. Specifications are being developed for HMA containing crumb rubber modifier. Field trials are scheduled for April, 1993 to include PlusRide II, Ecoflex, and Rouse Rubber.

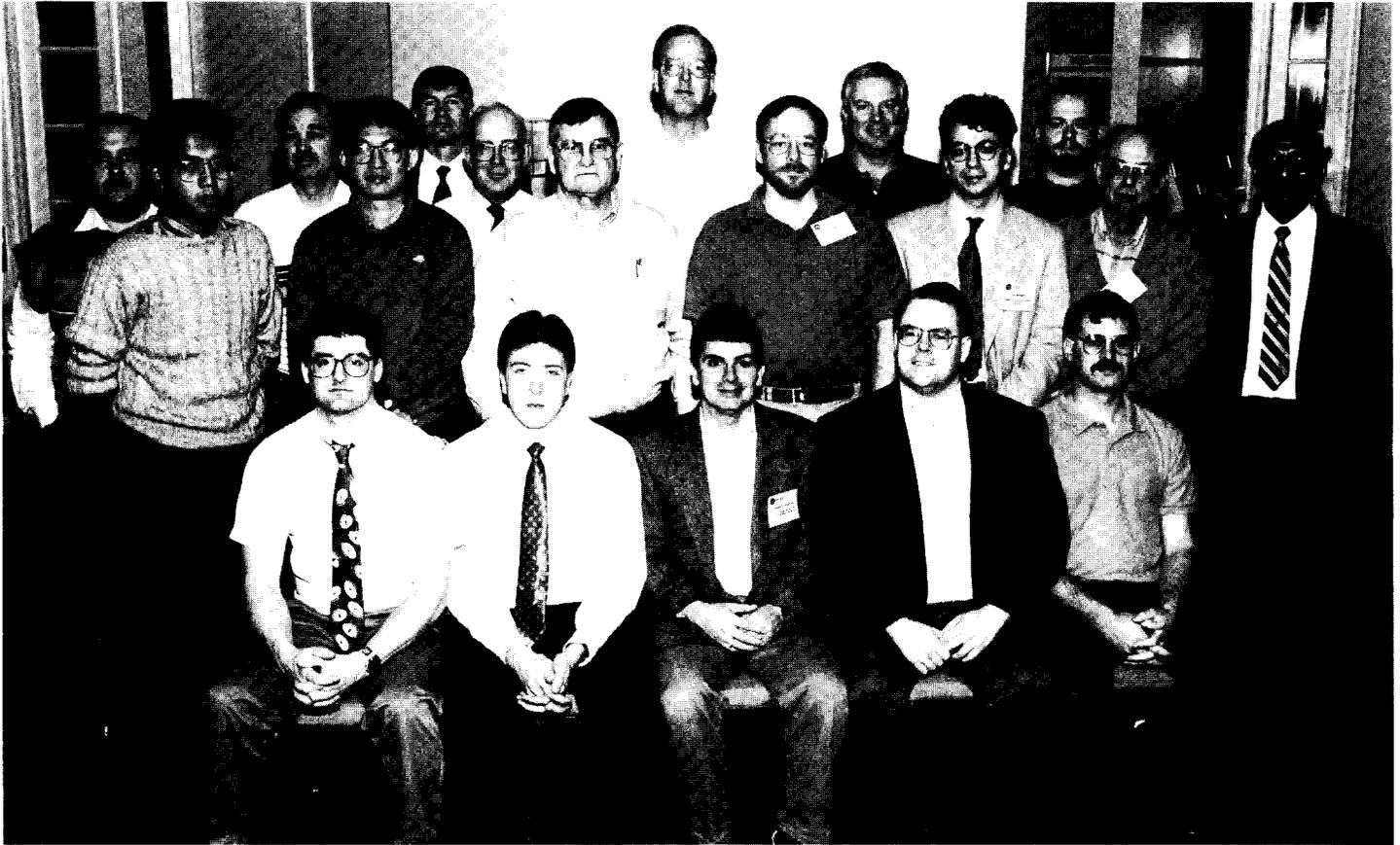
Utah—Performance based asphalt cement (PBA) specifications were developed in 1992. A smoothness special provision was tried on one paving project in 1992 utilizing an electronic profile graph. The retention time requirement for the pugmill to mix hydrated lime has been deleted.

**JOIN US!**

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Attendees of the Short Course in Asphalt Technology held at NCAT (February 15-26, 1993). Participants included seven State DOT engineers, three FHWA engineers, three engineers from industry, and 4 engineers from overseas.



Left to Right: (Row 1) Reid Kiniry, Edward Blondin Jr., Michael Boudreaux, Randy Mountcastle, Bernard Kuta; (Row 2) Hock Kin Kong, Yap Kim Chong, Floyd Strickland, Evan Wisniewski, Ezio Santagata, Bill Hammett, Ken Kandhal; (Row 3) Atef Abdulaziz, John Nichols, Ray Brown, Robert Zambon, Lonnie Hendrix, Mike Leslie, Sam Johnson; Not Pictured: Brian Lynch and Doug Hanson.

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