ASPHALT TECHNOLOGY NEWS

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NCAT BEGINS MAJOR RESEARCH PROJECTS ON SMA AND AGGREGATES

The National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board has awarded research contracts to NCAT for two major research projects: NCHRP Project 9-8, "Designing Stone Matrix Asphalt (SMA) Mixtures" and NCHRP Project 4-19, "Aggregate Tests Related to Asphalt Concrete Performance in Pavements." The background and objectives of these two research projects are as follows.

Designing Stone Matrix Asphalt Mixtures

Stone Matrix Asphalt (SMA) is defined as a gap-graded aggregate-asphalt hot mix that maximizes the asphalt cement content and coarse aggregate fraction. This provides a stable stone-on-stone skeletal structure held together by a rich mixture of asphalt cement, filler, and stabilizing agent.

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In this Issue

SHRP gyratory compactor in use at NCAT by Jack Weigel of Payne and Dolan, Inc. during SHRP Binder and Mix Workshop.

NCAT'S NEW SMA AND AGGREGATES RESEARCH

(Continued from page 1)

SMA was developed in Europe and appears to have significant potential as a durable and rut-resistant pavement layer. Several states in the U.S. have recently placed SMA primarily to minimize rutting in hot mix asphalt (HMA) pavements subjected to high traffic volume, heavy wheel loads, and high tire pressures. The approach to date has been to duplicate SMA mixtures developed in Europe, using domestic materials, equipment, and HMA industry expertise. More than 20 SMA pavement projects have been constructed successfully in the U.S. and are now being monitored for their performance. Following European practices, Marshall mix design (50 blows) was primarily used for designing SMA mixtures for the American projects.

The Federal Highway Administration, state highway agencies, and HMA industry have identified the need for better definition of the currently specified components and properties for SMA mixtures and the need to consider new test procedures. Better information is also needed regarding type and amount of stabilizer(s), required compactive effort, and mixture volumetrics for design and placement.

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

The primary objectives of this $500,000 two-year research project are: (a) to define the materials and their properties to maximize durability and rut resistance of SMA mixtures, and (b) to recommend a SMA mix design procedure consisting of tests which can predict durability, performance, and moisture susceptibility of SMA mixtures. Dr. Ray Brown, NCAT director, is the principal investigator of the SMA project.

Aggregate Tests Related to Asphalt Concrete Performance in Pavements

Approximately 85 percent of the total volume of HMA consists of mineral aggregates. The performance of HMA is thus significantly influenced by the properties of coarse and fine aggregates. HMA pavement distresses such as stripping, rutting, and lack of good friction properties can often be attributed to improper aggregate selection and use.

Current aggregate tests are primarily based on experience with their use in various applications such as unbound base courses, portland cement concrete and hot mix asphalt. The empirical characterization of aggregates through these tests does not consider their specific end use or the performance of the specific final product. For example, it is logical to assume that certain aggregate properties desirable in unbound base courses may not be necessary when aggregates are used in HMA applications. Many aggregate tests and specified criteria, therefore, have no relationship to the performance of the final product such as HMA.

It is evident from the literature available that research on the relationship of aggregate properties to HMA performance has been very fragmented. No comprehensive nor coherent research effort has been made to evaluate the existing aggregate tests, nor to develop new tests that relate to HMA performance. The recently completed Strategic Highway Research Program (SHRP) for asphalt—a $50-million, five-year research effort—did not include aggregate research. Although SHRP has developed a performance-based asphalt binder system and SUPERPAVE mix design system, it did not include performance-based characterization of aggregates. SHRP simply convened a meeting of an Aggregate Expert Task Group (ETG) which considered the existing aggregate tests and criteria. Through the Delphi process the ETG recommended guidelines for aggregate testing to be used in the SUPERPAVE mix design system.

This NCHRP project on aggregates is a $500,000 three-year research effort which is expected to result in the recommendation of a set of aggregate tests that relate to the performance of HMA mixtures. The research will include the evaluation of existing aggregate tests (such as Los Angeles abrasion, soundness, sand equivalent, flat and elongated particles, and polishing) to assess their ability to predict HMA pavement performance and, where this predictive ability or clear relationship to performance is lack-

(Continued on page 13)

SHRP ASPHALT BINDER TESTS AND SPECIFICATIONS

The SHRP binder grading system was discussed in the fall, 1993, issue of *Asphalt Technology News*. Now, we will discuss the SHRP asphalt binder tests and specifications.

The following binder tests have been proposed by SHRP to measure various properties:

- High/intermediate temperature properties
  - —Dynamic shear rheometer (DSR)
  - —Rotational viscometer (RV)
- Low temperature properties
  - —Bending beam rheometer (BBR)
  - —Direct tension tester (DTT)
- Durability properties
  - —Rolling thin film oven (RTFO)
  - —Pressure aging vessel (PAV)

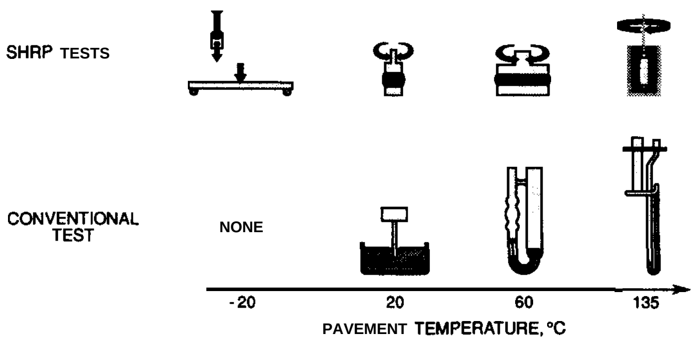


Figure 1

Figure 1 shows the new SHRP binder tests in relation to conventional binder tests in use today. At high construction temperatures such as 135°C (275°F), the viscosity of the binder is measured with a rotational viscometer (RV) in lieu of the kinematic capillary tube viscometer. At high summer pavement temperatures such as 60°C (140°F) which are critical for rutting, the viscoelastic property of the binder is measured with a dynamic shear rheometer (DSR) in lieu of measuring only the viscosity of the binder with a vacuum capillary viscometer. At average pavement service temperatures such as 20°C (68°F) which are critical for fatigue cracking or durability, the viscoelastic property of the binder is measured with a dynamic shear rheometer (DSR) in lieu of measuring the penetration of the binder at 25°C (77°F). At low pavement service temperatures such as -20°C (-4°F) which are critical for low temperature cracking, SHRP has proposed two test methods: bending beam rheometer (BBR) and direct tension tester (DTT). No tests are being used at the present time to measure low-temperature properties of the asphalt binder.

SHRP has proposed the rolling thin film oven (RTFO), which is already in use in some western states, to simulate the aging of the asphalt binder during mixing and construction operations. No accelerated laboratory aging procedure was available prior to SHRP to simulate the aging of the asphalt binder in service.

The pressure aging vessel (PAV) was developed by SHRP to simulate binder aging during five to ten years of service life.

A brief discussion of each SHRP binder test and its relevance to the SHRP performance graded asphalt binder specification (given on page 6) follows. It should be noted in the specifications that the test criteria (minimum or maximum limits) for all grades of binder remain the same, and only the test temperature is varied according to the grade selected.

Rotational Viscometer (RV)

This is also referred to as Brookfield viscometer. This test has been used by the polymer industry for many years (ASTM D4402). The rotational viscometer will be used to evaluate the handling and pumping properties of asphalt binders (including modified binders) during construction. It will also be used to establish the mixing and compaction temperatures of the hot mix asphalt (HMA) by conducting the test at two temperatures. Figure 2 shows a schematic of the rotational viscometer.

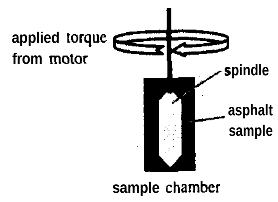


Figure 2

The asphalt binder sample is poured in a sample chamber which is placed in a thermo-container to control the test temperature. A standard spindle is inserted in the sample chamber. Torque is applied from a motor to the spindle to rotate it within the asphalt binder. The torque required to achieve 20 rpm speed of the spindle is measured and the viscometer shows the binder viscosity as a digital read out. The rotational viscometer is more suitable for testing modified asphalt binders (such as asphalt-rubber) than a capillary tube viscometer, which is likely to get plugged. SHRP asphalt binder specifications permit a maximum viscosity of 3 Pa ● s (pascal-second) or 3,000 centipoises at 135°C (275°C) to insure that the binder can be adequately pumped and mixed with the aggregates.

Dynamic Shear Rheometer (DSR)

Asphalt binders exhibit viscoelastic behavior, especially at intermediate temperatures such as 25°C (77°F). Unlike capillary viscometers which only measure the viscosity, the dynamic shear rheometer (DSR) measures both the viscous and elastic properties of the asphalt binders. A sample of asphalt binder is sandwiched between two plates as shown in Figure 3. The bottom plate is fixed. Torque is applied to the top plate so that it oscillates back and forth at a rate of 1.6 cycles per second (representing 55 mph speed of vehicles on the highway). As shown in the figure, one cycle is completed when the top plate goes from A to B, back to A, A to C, and back to A.

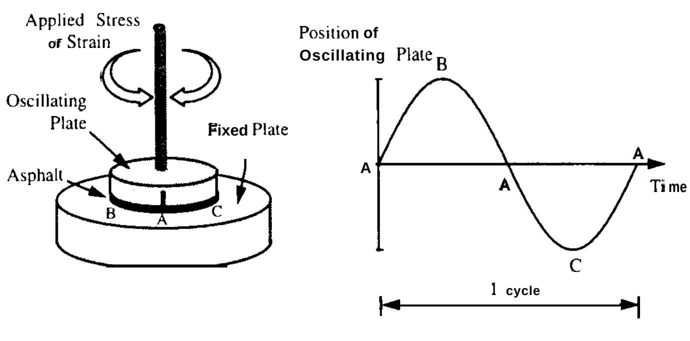


Figure 3

The DSR measures the complex shear modulus G* (G-star) and the phase angle δ (delta). G* is a measure of overall stiffness which includes both viscous and elastic effects. Phase angle δ is used to separate the viscous and elastic components in G*. The higher the elastic component in G*, the greater is the binder resistance to rutting and fatigue cracking.

SHRP specifications specify a minimum value of 1.0 and 2.2 kilo pascals at the designated test temperature for G*/sin δ (G star over sin delta) for the original (neat) binder and RTFO residue, respectively. G*/sin δ is analogous to viscosity at 60°C (140°F). It can be considered as the rutting factor. However, it should be realized that the aggregate structure, rather than the asphalt binder, has a dominant role in resisting rutting.

SHRP specifications specify a maximum value of 5,000 kilo pascals for G* sin δ (G star times sin delta) of an asphalt binder which has been aged in the rolling thin film oven (RTFO), and the pressure aging vessel (PAV). G* sin δ can be considered as the fatigue factor. Values over 5,000 kilo Pascals are likely to cause fatigue cracking. G* sin δ is analogous to the penetration test which is conducted at 25°C (77°F). However, the penetration test is an empirical test, whereas G* sin δ gives test values in fundamental engineering units.

Bending Beam Rheometer (BBR)

HMA pavements develop low-temperature thermal cracking when the asphalt binder is too stiff at low pavement temperatures. SHRP has recommended the use of bending beam rheometer (BBR) to evaluate low temperature stiffness properties (creep stiffness and m-value) of the asphalt binder which has been aged in RTFO and PAV. As shown in Figure 4, a beam of asphalt binder is loaded at mid point and the deflection is noted. By the use of engineering beam principles, the creep stiffness and m-revalue (slope of loading time versus creep stiffness) are measured after a loading period of 60 seconds. The test is conducted at the designated low test temperature to maintain the integrity of the asphalt binder beam. SHRP specifications specify a maximum value of 300,000 kilo Pascals and a minimum value of 0.30 for the m-value to minimize low temperature thermal cracking.

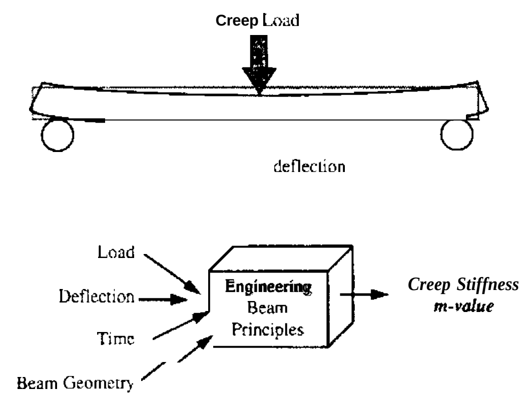


Figure 4

Direct Tension Tester (DTT)

Some modified asphalt binders may be stiff at low temperatures but do not develop low temperature thermal cracking, since compared to neat asphalt cement binders they can stretch more when pulled. As shown in Figure 5, a direct tension test was developed primarily to accommodate modified binders. A small dogbone shaped speci-

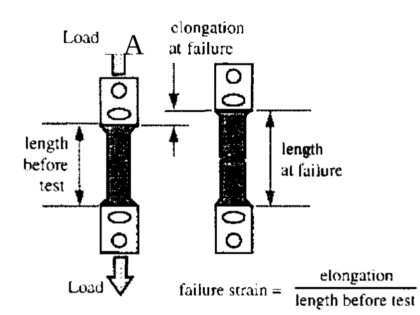


Figure 5

men is loaded in tension at a constant rate until it breaks. Since the failure strains are relatively very small, a laser beam is used to measure the strain at failure. According to the SHRP specifications, the failure strain should be at least 1.0 percent.

Pressure Aging Vessel (PAV)

As mentioned earlier, the pressure aging vessel was developed by SHRP to simulate long-term (5-10 years) aging of the asphalt binders in service. A schematic of the test equipment is shown in Figure 6. Asphalt binder samples which have been subjected to RTFO aging are poured in flat sample pans. These pans are placed in a sample rack which is placed in a pressure vessel. The air pressure in the vessel is increased to 2.1 mega pascals or about 300 psi to accelerate the aging process. The temperature inside the vessel is maintained at 90°C (194°F) or 100°C (212°F) depending on the binder grade. The samples are subjected to 20 hours aging in the pressure vessel and then tested for properties specified in the performance graded binder specifications.

—Ken Kandhal

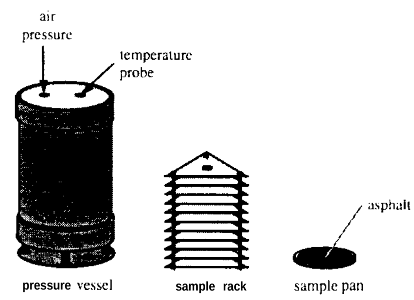


Figure 6

Visit of German engineers to NCAT and laboratories in December.

Performance Graded Asphalt Binder (AASHTO MP1)

Performance Grade	PG-52							PG-58					PG-64					PG-70			
	-10	-16	-22	-28	-34	-40	-46	-16	-22	-28	-34	-40	-16	-22	-28	-34	-40	-10	-16	-22	-28
.verage 7-day Maximum Pavement esign Temperature, °C [a]	<52							<58					<64					<70			
1inimum Pavement Design 'emperature, °C [a]	>-10	>-16	>-22	>-28	>-34	>-40	>-46	>-16	>-22	>-28	>-34	>-40	>-16	>-22	>-28	>-34	>-40	>-10	>-16	>-22	>-28
Original Binder																					
lash Point Temp, AASHTO T48: Min, °C	230																				
'iscosity, ASTM D 4402:[b] Max, 3 Pa-s (3000 cP), Test Temp, °C	135																				
)ynamic Shear, AASHTO TP5:[c] G*/sin δ, Min, 1.0 kPa Test Temperature @10 rad/s, °C	52							58					64					70			
'hysical Hardening Index[d], h	Report																				
Rolling Thin Film Oven Test Residue (AASHTO T 240)																					
1ass Loss, Max, percent	1.0																				
)ynamic Shear, AASHTO TP5: G*/sin δ, Min, 2.2 kPa Test Temp @10 rad/sec, °C	52							58					64					70			
Pressure Aging Vessel Residue (AASHTO PP1)																					
'AV Aging Temp, °C	90							100					100					100/(110) [e]			
)ynamic Shear, AASHTO TP5: G*sin δ, Max, 5,000 kPa Test Temp @10 rad/sec, °C	25	22	19	16	13	10	7	25	22	19	16	13	28	25	22	19	16	34	31	28	25
:reep Stiffness, AASHTO TP1:[f] S, Max, 300,000 kPa, m-value, Min, 0.30 Test Temp, @ 60 sec, °C	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	-6	-12	-18	-24	-30	0	-6	-12	-18
)irect Tension, AASHTO TP3:[f] Failure Strain, Min, 1.0 % Test Temp @1.0 mm/min, °C	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	-6	-12	-18	-24	-30	0	-6	-12	-18

a. Pavement temperatures can be estimated from air temperatures using an algorithm contained in the SUPERPAVE software program or may be provided by the specifying agency.

b. This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

c. For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for dynamic shear measurements of G*/sin δ at test temperatures where the asphalt is a Newtonian fluid (generally above 55° C). Any suitable standard means of viscosity measurement may be used, including capillary or rotational viscometry.

d. The physical hardening index h accounts for physical hardening and is calculated by $h = (S_{24}/S_1)^{m_1/m_{24}}$ where 1 and 24 indicate 1 and 24 hours of conditioning of the tank asphalt. Conditioning and testing is conducted at the designated test temperature. Values should be calculated and reported. S is the creep stiffness after 60 seconds loading time and m is the slope of the log creep stiffness versus log time curve after 60 seconds loading time.

e. The PAV aging temperature is 100° C, except in desert climates, where it is 110° C.

f. If the creep stiffness is below 300,000 kPa, the direct tension test is not required. If the creep stiffness between 300,000 and 600,000 kPa the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of the Transportation Research Board (TRB) in January in Washington, D.C. Observations and conclusions reported from these papers may be of value to field engineers. These comments are obtained mostly from research projects with a limited scope. Before application to practice, it is recommended that the entire paper be read to determine any limitations. Titles of the papers are given, with names of authors in parentheses, followed by NCAT's summary.

1. LABORATORY EVALUATION OF THE ADDITION OF LIME TREATED SAND TO HOT MIX ASPHALT (Hanson, Shields and Brown)

Hydrated lime has proven to be an effective additive for reducing moisture damage susceptibility of HMA mixtures. The current method most often used to add lime to HMA is to add it to the entire aggregate stream. Recent field trials have shown that it is feasible to add hydrated lime just to the sand fraction in amounts that are equivalent to the desired concentration on the total aggregate basis. This would allow set up of a central facility for adding lime to the sand fraction of a HMA aggregate. The lime/sand mixtures could then be transported to a HMA facility and mixed with the remaining aggregate fraction.

The objective of this study was to conduct a laboratory study to determine whether adding the lime just to the sand fraction and then adding the sand/lime mixture to the remainder of the aggregate would produce the same results as when the lime is added to the entire aggregate stream.

This study consisted of mixing a known stripping aggregate (Georgia granite) with three sand types (granite, quartz, and limestone fine aggregates) which resulted in three different HMA mix types. The lime was mixed into the aggregates by the following four methods: (a) dry lime added to the entire moist aggregate mixture, (b) dry lime added to the moist sand fraction only, (c) lime slurry added to the entire aggregate fraction, and (d) lime slurry added to the sand fraction only. Four lime contents (0.0, 0.5, 1.0 and 1.5 percent) by weight of the total dry aggregate, were used. HMA mixtures were evaluated for moisture susceptibility using the modified Lottman and Root-Tunnicliff procedures.

The following conclusions can be drawn from this study:

- The two methods of lime addition (lime to sand and lime to total aggregate) produced HMA mixtures that had equivalent reductions in moisture damage susceptibility.
- The greatest reduction in moisture susceptibility of the HMA mixtures studied occurred from increasing the lime content from 0.5 to 1.0 percent, with less effect resulting from a 1.0 to 1.5 percent increase.
- The addition of lime in the form of a slurry, in most cases, proved to be better (in terms of higher retained strengths) than the addition of lime to a moist aggregate.

2. RATIONAL METHOD FOR LABORATORY COMPACTION OF HOT MIX ASPHALT (Blankenship, Mahboub and Huber)

This paper is based on a study titled, "Gyratory Compaction Characteristics: Relation to Service Densities of Asphalt Mixtures," conducted as Task F of the SHRP Contract A001. A SHRP gyratory compactor with the following specifications was used:

- Angle of gyration, 1.00°
- Speed, 30 rpm
- Vertical pressure, 0.6 MPa (87 psi)
- 100-mm and 150-mm diameter molds

The primary objective of this study was to determine the number of gyrations (N_{Design}) required to represent various traffic levels in different climates.

N_{Design} is defined as the compactive effort (number of gyrations at a specified pressure) at which the air void level of the compacted HMA mixture is measured for volumetric design and mix characterization in SHRP SUPERPAVE mix design.

Cores were obtained from existing HMA pavements which had more than 12 years of traffic exposure to represent pavements that have densified to their design percent air voids. It was assumed in this experiment that the pavements were designed to have final air voids of 3 - 5 percent, and the pavements were placed at 7 - 9 percent air voids. The testing matrix incorporated 18 cores representing three climates (hot, warm and cool), three traffic levels, and upper and lower layers.

Air void contents of the pavement cores were determined by measuring the bulk specific gravity and maximum specific gravity of the cores. The aggregate was recovered from the cores by solvent extraction. The recovered aggregate was mixed with a neat AC-20 asphalt cement. The mixture was subjected to short term aging and then compacted in the SHRP gyratory compactor to obtain compaction curves (number of gyrations versus air void content). The field air void contents were used to establish the design number of gyrations (N_{Design}). Again, it was assumed that the air void content was 8 percent for the gyration level at zero traffic. The lower layer data (more than four inches from the surface) showed no real relation to traffic (gyrations). Hence a total of 30 data points (two data points x15 cores) were used to obtain three regression lines (for hot, warm and cool climates) of traffic in ESALs versus number of gyrations. These regression lines were used to prepare the table for determining N_{Design} for a specific traffic category and climatic conditions to be used in SHRP SUPERPAVE Level I mix design. It should be noted that only 15 cores were used to develop this table and, therefore, additional work is needed to increase the precision of N_{Design}.

3. INVESTIGATION OF AASHTO T283 TO PREDICT THE STRIPPING PERFORMANCE OF PAVEMENTS IN COLORADO (Aschenbrener and McGennis)

Moisture damage to HMA pavements has been a sporadic but persistent problem in Colorado even though laboratory testing is performed to identify moisture susceptible mixtures and liquid antistripping additives are used if needed. The laboratory conditioning (AASHTO T283) was often less severe than the conditioning the HMA pavements encountered in the field.

Twenty sites of known field performance with respect to moisture susceptibility, both acceptable and unacceptable, were identified. Materials from these sites were tested using several versions of AASHTO T283. The standard AASHTO T283 procedures included short-term aging (16 hours at 60°C for loose mixture and 72 to 96 hours at 25°C for compacted specimens), limits on air voids (6-8 percent), limits on saturation (55-80 percent), and freezing. The variations to AASHTO T283 included: (a) no freeze, (b) vacuum saturation for 30 minutes regardless of the saturation level achieved, and (c) no short-term aging. The following conclusions and recommendations are drawn from this study:

- Generally, AASHTO T283 is a reasonable predictor of moisture susceptibility of HMA mixtures. Known well performing mixtures (Sites 1-7) exhibited higher retained tensile strength (TSR) values. Poor performing mixtures (Sites 13-20) exhibited lower TSR values. For these sites showing well and poor performing mixtures, any of the variations in the AASHTO T283 procedures (that is, freeze, no freeze, 30-minute vacuum saturation with freeze) would have adequately predicted observed moisture susceptibility.
- Marginally performing HMA mixtures (Sites 8-12) were not as well identified by the standard AASHTO T283 test, with or without a freeze cycle. However, the standard procedure modified to include a 30-minute vacuum saturation period was more effective in predicting the performance of these marginal sites.
- Use two test severity levels. For HMA pavements experiencing high traffic, high temperature-s and high moisture, Severity Level 1 should be used, which includes no short-term aging, vacuum saturation for 30 minutes with 610 mm of mercury, and a freeze cycle. For HMA pavements with low traffic or areas without extremely high temperatures, a Severity Level 2 should be used, which corresponds to ASTM D4867 (Root-Tunnicliff procedure) without the optional freeze cycle.

4. EVALUATION OF LONGITUDINAL JOINT CONSTRUCTION TECHNIQUES FOR ASPHALT PAVEMENTS (Kandhal and Rao)

Common problems associated with longitudinal joints in HMA pavements are the formations of cracks along the joint, ravelling, and widening of cracks due to subsequent ingress of water. It is believed that these problems occur when there is a substantial difference in densities on either side of the joint or overall low joint density. Although several longitudinal joint construction techniques are specified and practiced in different states, the relative effectiveness of these methods has not been established. This study was undertaken to evaluate seven techniques in a project in Michigan and eight techniques in a project in Wisconsin. Both projects involved a dense-graded HMA surface course overlay. Each technique was used on a 500-foot (152-m) test section. The following different techniques were used in both projects:

- Rolling the joint from the hot side (Technique A).
- Rolling the joint from the cold side (Technique B).
- Rolling the joint from the hot side six inches (152 mm) away from the joint (Technique C).
- Michigan wedge (1:12 slope) joint without tack coat.
- Michigan wedge (1:12 slope) joint with tack coat.
- Restrained edge compaction with a hydraulically powered wheel which rolls alongside the compactor's drum (Wisconsin project only).
- Use of a cutting wheel to cut off 11/2-2 inches (38-51 mm) of the unconfined, low density edge of the

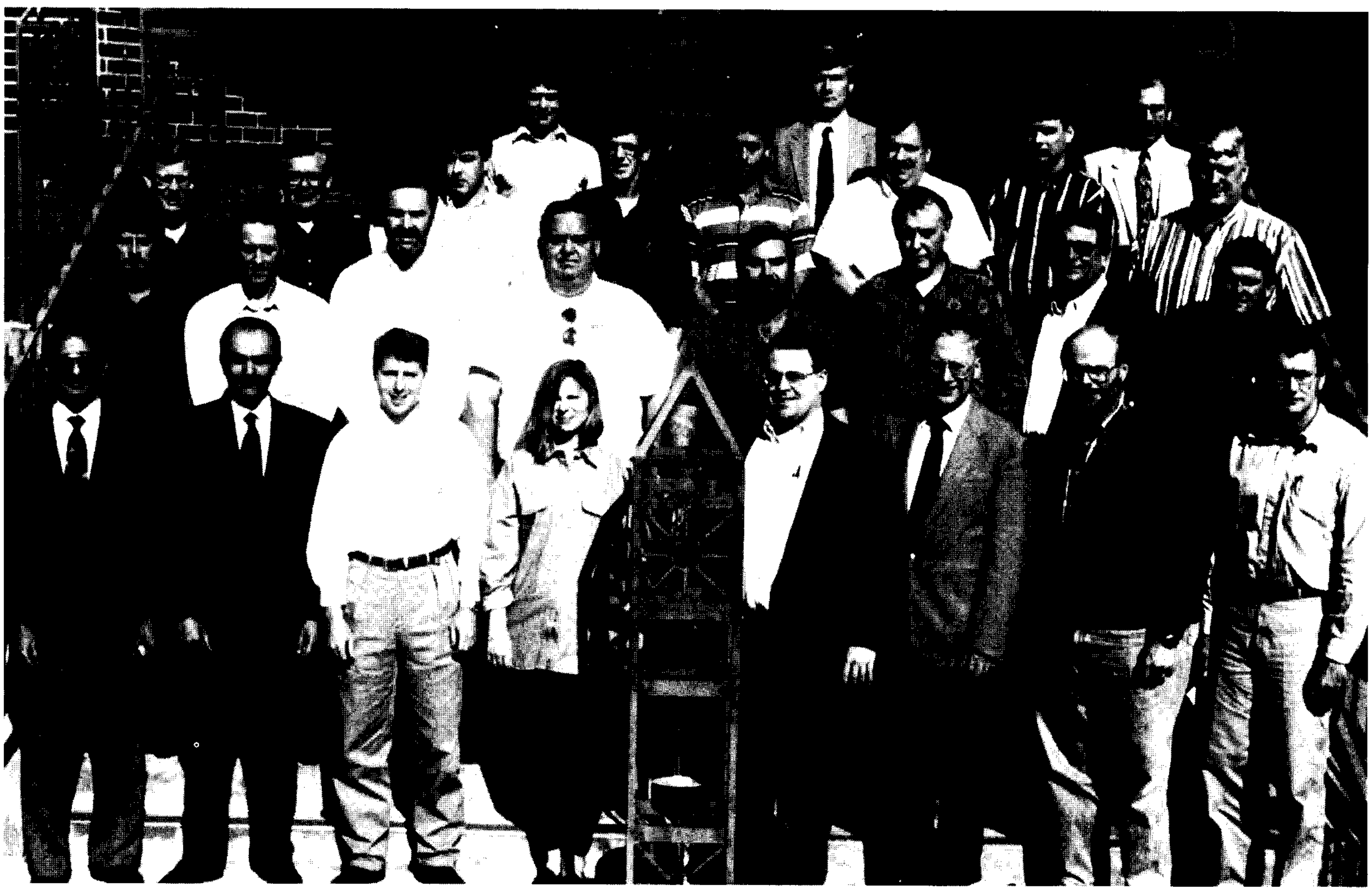
initial lane after compaction while the mix is still plastic.

- Use of a AW-2R joint maker, which consists of a device attached to the side of the screed at the corner. The device forces extra material at the joint through the extrusion process prior to the screed.

Based on the density data at the joint and visual inspection of the joints after the first winter the following conclusions were drawn:

- The cutting wheel and Michigan wedge joint sections appear to be the best on the Michigan project.
- The edge restraining device and the cutting wheel sections appear to be the best on the Wisconsin project.
- Among the three rolling techniques attempted, Technique A gave the highest density at the joint followed by Technique C, on both the Michigan and Wisconsin projects.

The visual evaluation of joints on both projects will be continued for at least five years. It is quite possible that the tentative rankings reported in this paper may change based on the long-term field performance.



Attendees and instructors at NCAT's Binder and Mix Workshop in December Left to right: (Row 1) Ken Kandhal, Hussain Bahia, Jay Winford, Sarah Williams, Randy Mountcastle, Doug Hanson, Jack Weigel, Hugh Gallivan, (Row 2) Mark Ishee, Jim Davis, Morris Steward, Jeff Frani, Richard Maddox, Mike Novak, Darren Phillips, (Row 3) Timothy Sauer, Gene Danicich, Jeff Barr, Earl Russell, Trent Baldwin, Larry Shively, Stephen Russell, Kevin Suitor, (Row 4) Mikael Thau, Ray Brown, and Bob McGennis. Not pictured: Dale Gifford.

ASPHALT FORUM

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

Australia (John Bethune, Australian Asphalt Pavement Association)

Six different asphalt surfacing types have been placed on a rigid plain concrete pavement on a major Melbourne metropolitan arterial road. The following surface characteristics will be measured initially and at regular intervals thereafter for comparative purposes: (a) noise, (b) skid resistance, (c) spray generation, (d) roughness, (e) texture, and (f) durability.

Virginia (John Muhlke, Q/C Resource)

The modified Rice test developed for SHRP by NCAT for determining maximum theoretical specific gravity of HMA mixtures, requires maintaining 30 ±1 mm vacuum for 15 minutes. I have found that a vacuum bleed-off valve installed in the line between the pump and the vapor trap helps to maintain the vacuum consistently while the pump is running full time. Also, the use of a vibrating table (available commercially) gives repeatable results and frees up 15 minutes of the technician's time that would otherwise be spent agitating the pycnometer every two minutes.

Kentucky (Dwight Walker, Kentucky Transportation Cabinet)

We intend to work with available SHRP binder and mixture equipment to gain experience. We are placing a trial project using hydrated lime as an antistripping additive.

Texas (Maghsoud Tahmoressi, Texas DOT)

We have developed a new HMA mixture design called Coarse Matrix High Binder (CMHB) which is considered ideal for designing crumb rubber modified (CRM) mixtures and stone matrix asphalt (SMA) mixtures.

Does any DOT have specifications or approval processes on hot mix truck release agents?

Rhode Island (Francis Manning, Rhode Island DOT)

Has anyone looked into snow plow damage to pavements and their markings? Do any states use skid blocks to raise plow blades off the pavement?

Hawaii (Frank Uyehara, Hawaii DOT)

The disposal of rubber tires in landfills will be prohibited after July 1, 1994.

The following responses address the question from Samuel Miller of the Maryland State Highway Administration, *"What experience do other state DOTS have using crushed gravel in hot mix asphalt surface mixtures ?"*

Ontario, Canada (Kai Tam, Ontario Ministry of Transportation)

Crushed gravel surface mixes are mainly used in secondary highways with traffic less than about 3,000 AADT. This is because of the poor friction and mix stability characteristics of gravel aggregate. Also, there could be a need for an antistripping agent in the HMA mixture. Performance of the crushed gravel mixtures has been good when mixes are properly designed.

New Jersey (Eileen Connolly, New Jersey DOT)

The New Jersey DOT has used crushed gravel in friction course mixes for about 20 years. The gravel is required to have less than 20 percent carbonates and have at least one crushed face. The friction courses have performed well in increasing the frictional characteristics.

Texas (Maghsoud Tahmoressi, Texas DOT)

The Texas DOT allows the use of crushed gravel in HMA mixtures provided that the gravel has a minimum of 85 percent particles retained on the No. 4 sieve with two or more mechanically produced crushed faces. According to our experience, gravel mixtures have a tendency to be tender and susceptible to moisture damage.

The following responses address the question from Eileen Connolly of New Jersey DOT, *"Have* *other states which have constructed SMA pavements experienced post-construction bleeding ?"*

Georgia (Ronald Collins, Georgia DOT)

The Georgia DOT has not experienced post-construction bleeding on SMA projects, but we have experienced some loss in surface friction for our coarse SMA used as an intermediate layer in a test section placed in 1991. As a result, we typically select optimum asphalt content corresponding to 3.5 to 4.0 air voids based on the 50-blow Marshall compaction. We are also convinced that the field verification of the mix design is just as critical for SMA mixtures as it is for conventional dense-graded HMA mixtures.

Wisconsin (Stephen Shober, Wisconsin DOT)

Wisconsin placed its first SMA in 1991 on I-94 near Waukesha. Since then we have constructed seven other SMA projects using different mixtures. We have not experienced any "post-construction bleeding" in any of these projects. However, we have experienced flushing during construction on several occasions. This problem has been limited to the polymers and seems to be temperature related, except for one instance that can be traced to problems with the feed mechanism for the additives at the HMA facility.

Virginia (Bill Maupin, Virginia Transportation Research Council)

Virginia's SMA pavement constructed in 1992 started to bleed at stop lights in 1993. An investigation by NCAT revealed no obvious causes. However, slight changes were made in the job mix formula gradation (less material passing the No. 4 and 200 sieves) and AC-30 asphalt cement was substituted for AC-20 for a SMA placed by Virginia DOT in 1993.

Connecticut (Charles Dougan, Connecticut DOT)

We have been using a solvent called *Premium Safe Solv* in extraction tests for the past two years as an alternative for chlorinated solvents. This is a product which does not require rinsing with water and, therefore, does not increase testing time.

Warren Foster of the Maine DOT had asked, *"Are other states having flushing problems when using AC-10 asphalt cement in hot weather?"* We use AC-10 only in mixes containing reclaimed asphalt pavement (RAP) material so that the resulting recycled asphalt cement meets the specified penetration range of 60 to 100.

South Carolina (Milt Fletcher, South Carolina DOT)

Richard Downs of Hughes Asphalt Company asked the question, *"Many states are adopting the specifications that have reduced the amount of material passing No. 200 (P200). With this practice, should not the design air voids in the total mix be increased to reduce the rutting potential because replacing the P200 material with asphalt cement could result in an unstable mix?"* The reduction in P200 does not necessitate that the asphalt content be increased to fill air voids. Air voids can be adjusted by changing the VMA (voids in the mineral aggregate) of the HMA mixture. The VMA can be changed by using different proportions of coarse and fine aggregates.

Georgia (Ronald Collins, Georgia DOT)

Eileen Connolly of the New Jersey DOT asked the question, *"Are there HMA quality control procedures being used that allow the contractors to obtain samples and test them for acceptance ? What testing is done by the state to verify the contractor's test results ?"*

Georgia has established a procedure to allow for contractor acceptance sampling and testing of hot mix asphalt. Nineteen projects where the contractor is required to perform extraction acceptance testing have been let to contract. While all the projects have not been completed yet, early indications are that a significant savings in manpower can be realized without sacrificing quality.

The contractor's technician must pass a written examination as well as demonstrate, by hands-on tests, a proficiency in the performance of the required sampling and testing procedure. The contractor's laboratory is certified to assure that all equipment used is in calibration and meets departmental testing standards.

Companion samples are taken during the day's operation and are randomly selected by department personnel for testing, and these are compared to the contractor's results. When the sample selected compares favorably with the contractor's results, the department accepts the contractor's results for that lot of material. When the results do not compare, additional companion samples are tested and DOT results are used for acceptance, and an investigation is made to determine why the results varied.

SPECIFICATION CORNER

Vermont-The Vermont Agency of Transportation (VAOT) is moving forward with the QC/QA (quality control/quality assurance) concept based on the mutual desire by both the HMA industry and VAOT to produce the best product possible. HMA compaction specifications, which include bonus payments as well as reduced payments based on compaction quality, have been developed. Specifications which will include a surface tolerance (ride) criterion and the HMA mix quality (based on air voids) are being developed.

Georgia-The Georgia DOT has let to contract its first project (I-95 near Savannah) using SHRP binder specifications. Performance grade (PG) 70-22 was specified for the open-graded friction course, and PG 76-22 was specified for the SMA mixtures. These paving grades are higher than can be met with our conventional asphalt cements. However, they are recommended by SHRP for high-traffic situations in Georgia's climatic conditions.

Wisconsin-Asphalt cements will be specified in 1994 based on a dual specification for either penetration-graded or viscosity-graded materials. Beginning in 1994, the Wisconsin DOT (WisDOT) will specify, by special provision, an optional notched and tapered (12:1) longitudinal joint for HMA pavements. Depending on the results, this method could become a standard, possibly by 1995. The WisDOT has implemented a policy to pay contractors for the asphalt cement contained in the reclaimed asphalt pavement (RAP) used in hot-mix recycling to encourage the use of RAP in mix designs.

Ontario, Canada—The new end result specification for pavement compaction developed in 1993 has been discussed with the HMA industry, and is being implemented on selected contracts in 1994.

Hawaii-State law now requires the use of glass in HMA base course mixtures when the cost is less. Hawaii DOT accepts alternate bids for base course mixtures: virgin mixtures, recycled mixtures with 50 percent maximum RAP, and mixtures with 10 percent maximum glass.

Texas-Implementation of QC/QA specifications will begin this year with 50 projects anticipated to be let. Full implementation will take place in 1995. More than 10 projects will be built this year using the coarse matrix high binder (CMHB) mix design philosophy. About ten projects will also be constructed in 1994 incorporating crumb rubber modified (CRM) in HMA by the wet and dry processes.

Kentucky-An extensive training and certification program for contractors and state personnel involved with controlling and accepting HMA has been initiated. Work is being done to achieve greater stone-to-stone contact in large stone base course mixtures. It has been planned to use effective specific gravity of the aggregate in VMA calculations.

Maine-Specifications are being developed for crumb rubber modified HMA mixtures. A committee has been formed to develop QC/QA specifications.

Nevada—An end result specification for HMA will be implemented on three projects this year. Specifications have been developed for a polymer-modified asphalt cement, designated AC-30P, which will be used on one project this construction season.

Indiana—SHRP specifications for asphalt binder and HMA mixture will be used for three projects to be constructed in 1994. One project will require SUPERPAVE Level 1 mix design procedure and field verification of the design. The other two projects will also use Level 1 mix design procedure to further verify the mix designs using the Marshall method. The SHRP asphalt binder grades to be used on these projects are PG 58-28, PG 58-34, and PG 64-34.

K**ansas—**The NAA (National Aggregate Association) flow test was modified to measure the particle shape and surface texture of the fine aggregate (material passing No. 4 sieve). A volumetric flask will be used in lieu of the bulk specific gravity test as an input in the test method. This new test and specification has been implemented to replace the percent crushed faces test (for fine aggregate) which was not indicative of the mix performance in the field.

Montana-Specifications for hot-mix recycling have been revised to allow up to 50 percent RAP in base mixtures, 35 percent RAP in low-volume road surface mixtures, and 10 percent RAP in high-volume road surface mixtures. The use of polymer-modified asphalt cements, which are specified generically, is on the increase especially for highways carrying heavy traffic.

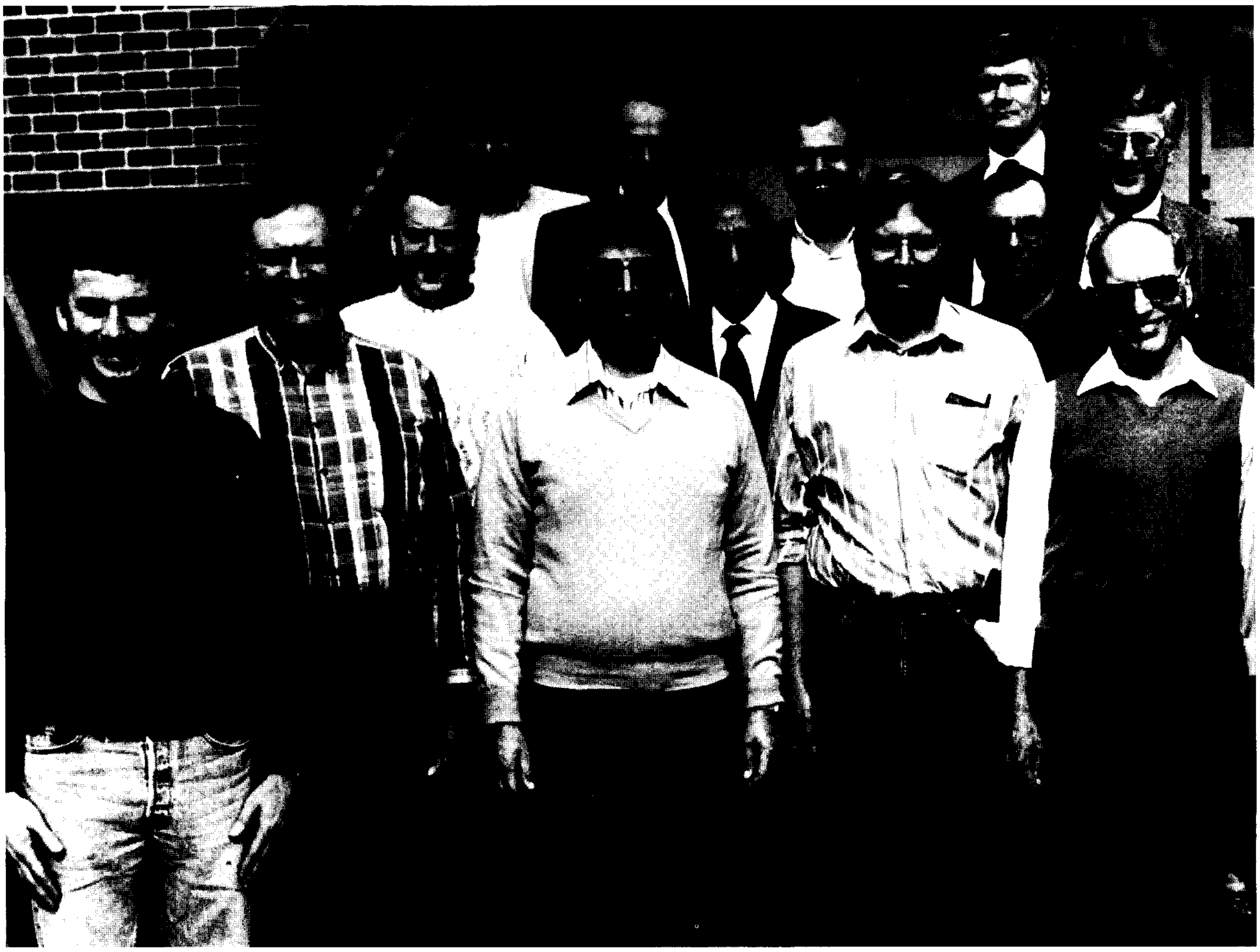
Oregon-The Environmental Conditioning System (ECS) developed by SHRP will be used in 1994 in lieu of the Index of Retained Strength (IRS) (modified AASHTO T 165) to measure the moisture susceptibility of open-graded mixtures. A minimum ratio of 0.80 after ECS will be specified. Dense-graded mixtures will continue to be designed using the IRS.

NCAT'S NEW SMA AND AGGREGATES RESEARCH

(Continued from page 2)

ing, to develop new tests. The characterization of mineral fillers including baghouse fines will also be attempted.

A wide variety of aggregates will be evaluated in this project. Prithvi (Ken) Kandhal, NCAT assistant director, is the principal investigator. NCAT would like to identify aggregates which do not meet conventional aggregate specifications but otherwise give satisfactory performance in HMA pavements, and vice versa. If you have such information please contact NCAT at (205) 844-6228.



Engineers, technicians, and instructors at SHRP Binder and Mix Workshop at NCAT, January, 1994. Left to Right: (Row 1) Jerry Hancock, Edward D. Brummitte, Robert D. Bistor, Mike Bailey, William R. Coy; (Row 2) Michael Bambrick, Ken Kandhal, Frank Butler; (Row 3) Hamad Abdul-Wahab, Hussain Bahia, Ibrahim Asi, Doug Hanson; (Row 4) Ray Brown.

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 Pavements	Esch, Alaska DOT	$190,000	December '94	Evaluate the contribution of studded tire wear and displacement to rut development.
	Performance Based Asphalts	Sterley, Alaska DOT	45,000	December '94	Determine the ability of modifiers to produce different PBA and SHRP grades from Alaskan North Slope crude oil.
Arkansas	Anti-Strip Additives: Phase II	Ulrich, University of Arkansas	45,000	April '95	Quantify the presence of anti-strip additives in HMA.
	New Martial Equipment Technology	Austin, Arkansas DOT	50,000	July '95	Evaluate the new SHRP equipment, procedures, and products.
Georgia	Round Robin Testing of Modified Georgia Loaded Wheel Tester	Lai, Georgia Tech and Caylor, Georgia DOT	130,000	February '97	Title self-explanatory
	Evaluating Methods of Modifying HMA Pavements Using Rubber Modifiers	Brown, Georgia DOT	64,600	December '96	Evaluate the performance of HMA pavements containing crumb rubber of different gradation and concentration and mixed differently.
Kansas	Full Depth Bituminous Recycling of I-70	Fager, Kansas DOT	75,000	December '99	Evaluate various additive combinations in hot and cold recycling.
Oklahoma	Engineering Properties of Blended Asphalt Cements	Ayers, Oklahoma State University	70,000	1994	Determine the effects of mixing different asphalt cements.
Oregon	Implementation of SHRP Asphalt Binder Tests	Oregon State University	91,600	January '95	Evaluate SHRP binder test in terms of repeatability, reliability and relation to mix performance.
	Crumb Rubber Modifiers in Asphalt Concrete Pavements	Hunt, Oregon DOT	150,000	June '99	Determine the most cost effective crumb rubber modified HMA mixture.

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Oregon	Porous Pavements	Hicks, Oregon State University	114,000	September '94	Develop improved guidelines for the use of porous pavements.
	Overlay Design for Unstable HMA Mixes	Bell, Oregon State University	83,100	July '94	Evaluate the effectiveness of overlays of rutted HMA pavements and develop criteria for their design.
Rhode Island	Viable Use of Crumb Rubber for Highway Construction	Lee, Kovacs and Marcus, University of Rhode Island	158,000	November '94	Laboratory evaluation of HMA mixtures containing different amounts and types of crumb rubber.
South Carolina	Utilization of Waste Tires in Asphaltic Materials	Amirkhanian, Clemson University	333,800	December '95	Investigate the use of waste tires in HMA and develop a generic, rubber modified mix design system.
Texas	Recyling Second Generation Asphalt Rubber Pavements	Crockford, Texas A & M	200,000	August '94	Title self-explanatory
Wisconsin	Development of Safety Based Standards for Rutting	Berg, University of Wisconsin and Schmiedlin, Wisconsin DOT	70,200	January '95	Determine the degee of rutting at which safety is affected and maintenance is required.
	Performance Evaluation of Rut-Resistant Asphaltic Concrete Pavements	Johnson, Wisconsin DOT	100,000	December 2000	Monitor the long-term performance of rut-resistant HMA mixtures on interstate highways.
Transportation Research Board	Field Procedures and Equipment to Implement SHRP Asphalt Specifications	Cominsky, Brent Rauhut Engineering	900,000	September '96	Develop QC/QA procedures for controlling the quality of SHRP HMA mixture production.
	Design and Evaluation of Large Stone Mixtures	Button, Texas A & M	300,000	November '94	Title self-explanatory
Australia	Asphalt Fatigue	Sharp, Australian Road Research Board	A $250,000	June '96	Develop a simple fatigue test method to enable ranking of conventional and modified HMA mixtures.
	Australian Precision Study	Oliver Australian Road Research Board	A .$120,000	September '95	Determine the precision of the dynamic creep test and resilient modulus test for laboratory samples.

NCAT's 1994 Asphalt Technology Course Attendees and Instructors

Row 1: Mark Swanlund, William C. Quillin, Burean F. Huff, Frank M. Kreis, Brian Egan, James Cravens. Row 2: Terry Hughes, Larry Steven Moore, Dan Wegman, Ken Kandhal, Gary L. Owens, John Haddock, Stan Graczyk, Doug Hanson.

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