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SHRP BINDER GRADING SYSTEM BASED ON PAVEMENT DESIGN TEMPERATURES

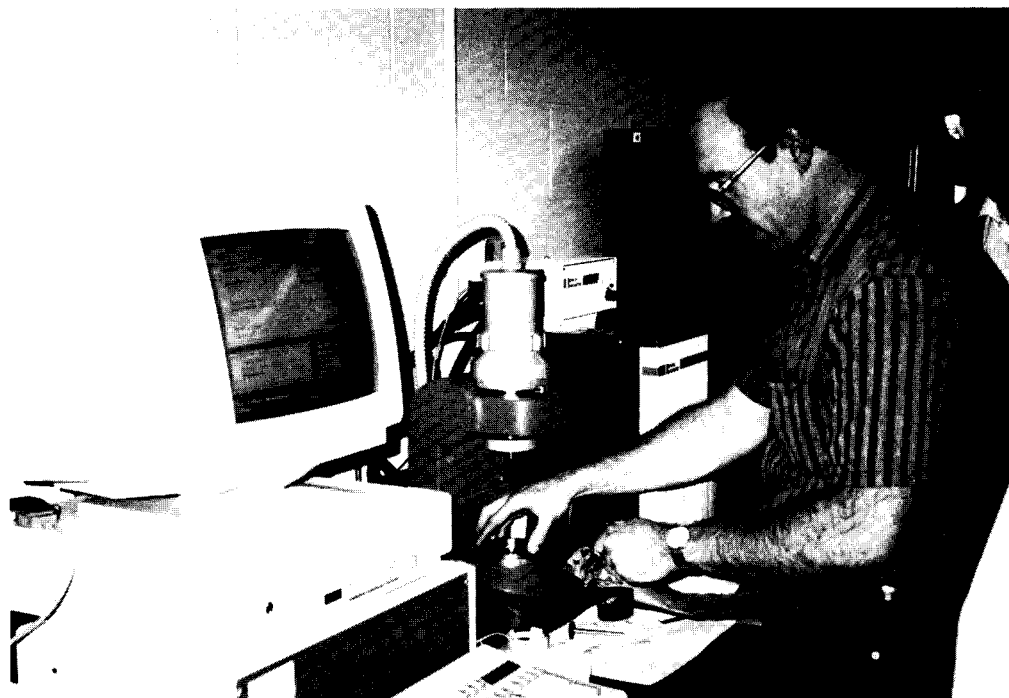
At the present time most states in the U.S. use viscosity-graded asphalt cements for hot mix asphalt (HMA) paving. For grading purposes, the viscosity of asphalt binders is determined at 60°C (140°F) which is considered to be the maximum pavement temperature during hot summer. This has led primarily to the use of two viscosity grades in the U. S.:

AC-10 (or equivalent AR-2000) in the northern tier states, and

AC-20 (or equivalent AR-4000) in the remaining states.

Obviously, the maximum pavement design temperature cannot be 60°C throughout a large country like the U.S. with widely varying climatic conditions. Research conducted by the Strategic Highway Research Program (SHRP) indicates that the average 7-day maximum pavement temperature varies from 52°C to 70°C in the U.S. Therefore, the use of more than two grades is necessary. The U.S. map on page 3 shows various asphalt binder performance grades (PG) recommended by

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SHRP dynamic shear rheometer in use in the NCAT laboratory for testing asphalt binder.

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SHRP for fast transient loads. The first number represents the average 7-day maximum pavement temperature during summer and the second number represents the minimum pavement temperature during winter. For example, PG 64-16 shown for the state of Florida is designed to be used in an environment to offer protection for an average 7-day maximum pavement temperature of 64°C during summer and a minimum pavement temperature of -16°C during winter. Similarly, PG 52-46 shown for northern Michigan is designed for a maximum pavement temperature of 52°C and a minimum pavement temperature of -46°C.

The maximum pavement design temperature is used to select an asphalt binder which will help resist rutting (or permanent deformation). Rutting usually occurs during a hot spell when there are several consecutive very hot days. Therefore, the maximum pavement temperature is based on the average of 7 consecutive hottest days ever recorded at a weather station near the project site. The four maximum pavement temperatures shown on the U.S. map are 52, 58, 64 and 70°C. An increment of 6°C has been used.

The minimum pavement design temperature is used to select an asphalt binder which will resist low temperature cracking. It is the lowest pavement temperature based on

the lowest air temperature ever recorded at a weather station near the project site. The seven minimum pavement temperatures shown on the U.S. map are -10, -16, -22, -28, -34, -40, and -46°C. Again, an increment of 6°C has been used.

How do we determine the pavement design temperatures? The statistical distributions of the yearly 7-day average maximum air temperature and the yearly 1-day minimum air temperature are available in the SHRP SUPERPAVE mix design software for 5,313 weather stations in the United States and 779 weather stations in Canada. Once the project location is identified, SUPERPAVE software will show the required maximum and minimum air temperatures recorded at the nearest weather station. Pavement temperatures are then estimated from air temperatures using an algorithm contained in the SUPERPAVE software.

It is quite likely that some agencies will use less stringent pavement design temperatures (for example, a lower maximum temperature or a higher minimum temperature than that recorded by the weather station). This could be due to the class of highway, the cost or other relevant factors. Selection of less stringent maximum and/or minimum pavement design temperature will involve a degree of probable risk which can also be determined from the SUPERPAVE software. For example, if PG 52-40 is used in lieu of recommended PG 52-46 for northern Michigan, the SUPERPAVE software might show a low temperature design risk of approximately 10 percent (not a real number), or a one in ten probability that the actual air temperature will fall below the design air temperature in an average year.

Once the high and low pavement design temperatures are selected (with or without some probable risk), the table on page 4 can be used to select the appropriate binder performance grade (PG) for the project. Besides the high and the low pavement design temperatures, the type of loads (three loads are listed in the top left corner of the table) is also used as an input. Fast transient loads consist of an average mix of car and truck traffic moving at moderate to high speeds. Slow transient loads consist of a larger than average proportion of slow-moving, heavy trucks. Other examples are slow-moving, heavy trucks on long steep grades or industrial roads. Standing loads are usually experienced near intersections.

The procedure for selecting the binder grade is given in the table with an example. It should be noted that the binder grades shown in the U.S. Map on page 3 are based on fast transient loads only. When the loads change from fast transient to slow transient, the binder grade (high temperature only) is moved up by one grade to enhance the ability of the binder to resist rutting under those condi-

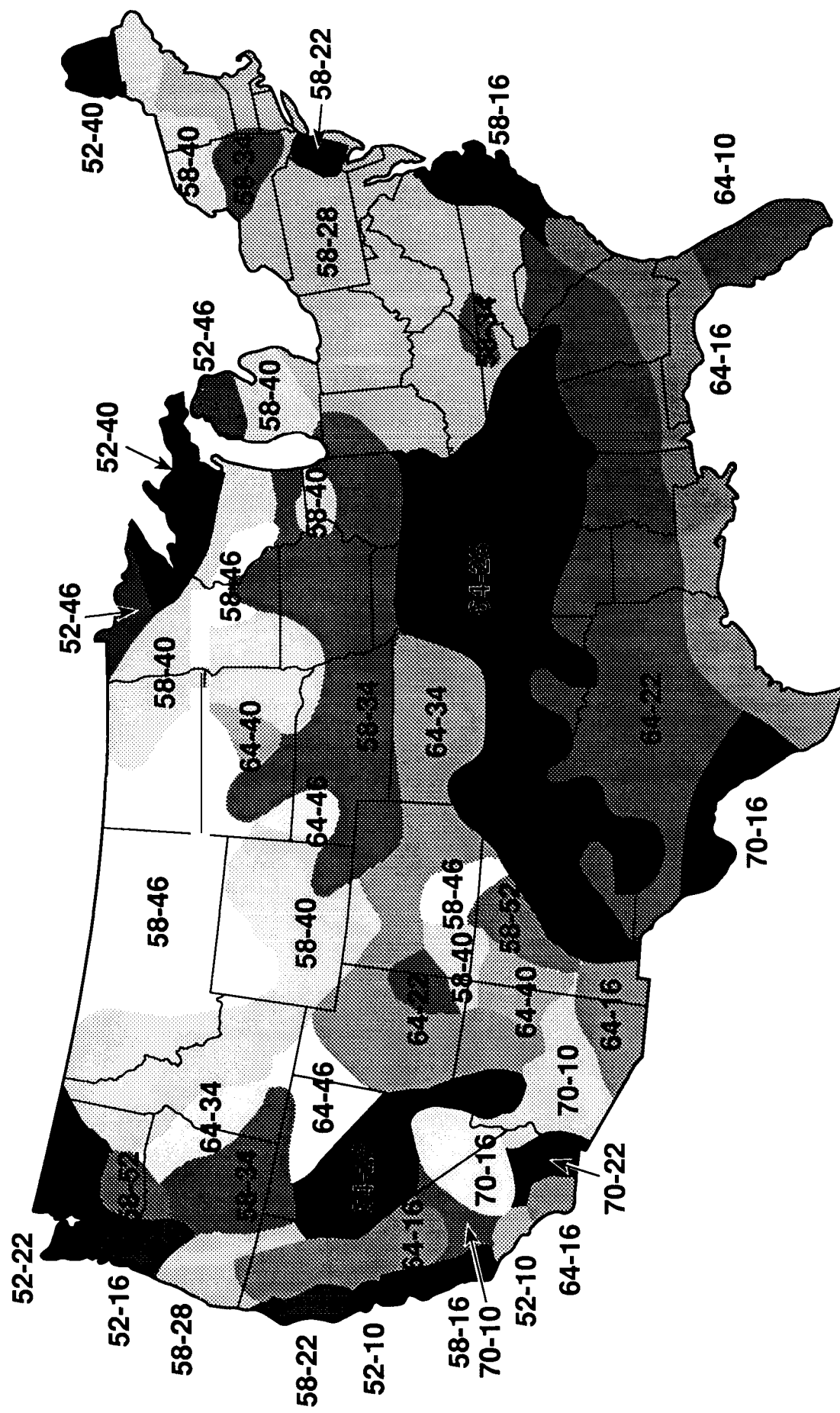
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IDEAL BINDER PERFORMANCE GRADÉS FOR THE UNITED STATES

RECOMMENDATION FOR SELECTING BINDER PERFORMANCE GRADES

LOADS		HIGH PAVEMENT DESIGN TEMPERATURE °C										
Standing	→	28 to 34	→	34 to 40	→	40 to 46	→	46 to 52	→	52 to 58	58 to 64	64 to 70
Slow Transient		34 to 40		40 to 46		46 to 52		52 to 58		58 to 64	64 to 70	70 to 76
Fast Transient		40 to 46		46 to 52		52 to 58		58 to 64		64 to 70	70 to 76	76 to 82
LOW PAVEMENT DESIGN TEMPERATURE °C	>-10	PG 46-10	PG 52-10	PG 58-10	PG 64-10	PG 70-10	PG 76-10	PG 82-10				
	-10 to -16	PG 46-16	PG 52-16	PG 58-16	PG 64-16	PG 70-16	PG 76-16	PG 82-16				
	-16 to -22	PG 46-22	PG 52-22	PG 58-22	PG 64-22	PG 70-22	PG 76-22	PG 82-22				
	-22 to -28	PG 46-28 →	PG 52-28 →	PG 58-28 →	PG 64-28 →	PG 70-28	PG 76-28	PG 82-28				
	-28 to -34	PG 46-34	PG 52-34	PG 58-34	PG 64-34	PG 70-34	PG 76-34	PG 82-34				
	-34 to -40	PG 46-40	PG 52-40	PG 58-40	PG 64-40	PG 70-40						
	-40 to -46	PG 46-46	PG 52-46	PG 58-46	PG 64-46							
REGION		Alaska - Canada Northern U.S.		Canada North U.S.	Southern U.S.	Southwest U.S. Desert Continental U.S.- Slow Traffic						

1. Select the type of loading.
2. Move horizontally to the high pavement design temperature.
3. Move down to the low pavement design temperature.
4. Identify the binder grade.

- ☐ Prevalent North American Grades
☒ Special Grades

Example: Standing Load, High Design Temperature = 57°C,
 Low Design Temperature = -25°C
 Grade = PG 70-28

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
Average 7-day Maximum Pavement Design Temperature, °C ^a	<52							<58					<64					<70			
Minimum Pavement Design Temperature, °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																					
Flash Point Temp, AASHTO T48: Min, °C	230																				
Viscosity, ASTM D 4402: ^b Max, 3 Pa-s (3000 cP), Test Temp, °C	135																				
Dynamic Shear, AASHTO TP5: ^c G*/sin δ, Min, 1.0 kPa Test Temperature @10 rad/s, °C	52							58					64					70			
Physical Hardening Index ^d , h	Report																				
Rolling Thin Film Oven Test Residue (AASHTO T 240)																					
Mass Loss, Max, percent	1.0																				
Dynamic 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)																					
PAV Aging Temp, °C	90							100					100					100/(110) ^e			
Dynamic 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
Creep 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
Direct 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

- Notes:
- 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 $h = (S_{24}/S_1)m^{1/m24}$ 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.

SHRP IMPLEMENTATION UPDATE

by
Dr. Haleem Tahir, AASHTO

As the Strategic Highway Research Program (SHRP) neared completion early this year, the American Association of State Highway and Transportation Officials (AASHTO) was preparing to receive and evaluate SHRP's work from the point of view of implementation. Recognizing that most of the SHRP asphalt research was done in the materials area, the AASHTO Subcommittee on Materials (SOM) took the lead to assure that the SHRP products are scrutinized and adopted.

The SOM took three steps to speed up the implementation process. First, it prioritized the SHRP products into a first and second priority product. Second, it proposed the idea of adopting the standards on a provisional basis (provisional standards). Third, it converted the products into formal standards and set up a mechanism to ballot them as provisional standards.

Eleven standards were expected to be balloted and adopted provisionally by AASHTO in October 1993. These standards consist of seven asphalt binder and four mix design protocols. The remaining standards would be balloted as provisional standards at a later date.

With regard to the SHRP binder and mix design, a number of states have already received some equipment and others are scheduled to receive it under the Pooled Fund Program managed by the Federal Highway Administration (FHWA). Items to be noted include the following.

- Twenty-five states have received most of the asphalt binder equipment. The remaining participating states (about 22) are scheduled to receive it by the summer of 1994.
- The procurement of direct tension devices and research grade dynamic shear rheometers is temporarily on hold.
- FHWA has come up with a better design of pressure aging vessel (PAV) and oven which combines the two into a single unit. Two prototypes of the improved units have been ordered by the FHWA on a trial basis.
- Gyratory compactors with a 1.25 degree angle and an ability to mold only 6" diameter specimens will be used for the compaction of mixes. FHWA's first stage procurement of this equipment is limited to six compactors which will be

available in January or February of 1994. This will be followed by a second stage purchase with an availability date of July 1994.

- The National Asphalt Training Center (NATC) at the Asphalt Institute has begun giving a training course on binders. Two sessions, one in July and one in August, have been held. Three more are planned this year.

Besides the standardization process, equipment procurement and training, AASHTO is working with the FHWA and Transportation Research Board (TRB) on three additional elements as part of the implementation process:

- (1) Post SHRP era data management issues.
- (2) Development of a college/university curriculum on the SHRP and Highway Innovative Technology for civil engineering students.
- (3) Future research needs as applied to the SHRP Superpave mix design system.

The data management project has two components. First, it is essential to develop mechanisms for an orderly transfer of the large database that SHRP has developed. The questions on the format, sharing, upkeep, responsibilities, etc., must be answered. Second, many states and agencies have moved into an operative mode vis-a-vis the use of SHRP products. As the SHRP products are used in the production laboratories and real world, additional field data will continue to be available on a continuing basis. A mechanism needs to be established to manage this information. AASHTO, FHWA and TRB have set up a task force to handle these issues.

The second element which deals with the education of civil engineering students in SHRP technology is being tackled by another task force established by the TRB. This task force is expected to have its first meeting before the end of the year.

The third and final element dealing with the "research needs" was initially addressed by SHRP. Of the six top priority projects identified, the study on the quality control and assurance part of the Superpave has already begun. The remaining five projects which are expected to move forward in the near future are:

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SPECIFICATION CORNER

Texas—Three HMA specifications have been developed: (i) a crumb rubber modified HMA with gap gradation using wet asphalt-rubber process, (ii) a stone matrix asphalt mixture using cellulose fiber, and (iii) a coarse matrix high binder (CMHB) mixture utilizing stone-on-stone contact and avoiding the necessity for polymers or fibers.

Ohio—The following items are being considered for implementation in the future: (i) a new heavy duty intermediate course with design gradation control to minimize segregation, (ii) potential use of loaded wheel tester in lieu of crushed material requirement for heavy duty surface mixtures, (iii) use of hydrated lime in surface mixtures to minimize stripping, and (iv) evaluation of asphalt contents for HMA pavements carrying light and medium traffic.

Florida—The minimum VMA requirement is being increased by 0.5% for structural type HMA mixtures. This will allow the optimum asphalt content to be established at 4.5% air voids, thereby providing more tolerance between design and minimum air void content during production.

Alaska—The department has dropped price-adjustment based HMA specifications and returned to more direct oversight and field testing in cooperation with the contractors. Price adjustments are considered to be applied too late in the contracts to detect and correct problem pavements at an early stage. Gradation price adjustments are also difficult to support in court since a gradation deviation from the target values may provide an equal or better HMA paving mix.

The VMA portion of the specifications was also dropped due to a perceived lack of real benefits in mix performance. This may be due to Alaska's lower pavement temperatures, rut damage primarily from studded tire wear, and the occurrence of fatigue and thermal cracking.

Georgia—The first project using SMA as a standard item has been let. The project is located on I-95 near Savannah. The department is also using the SHRP binder specification for one project. If proven acceptable, it will be more widely used in the state.

Kentucky—The department is developing a quality management program for control and acceptance of HMA mixtures.

Ontario, Canada—New end-result specifications for HMA were used in field simulations during 1993, and will be used in contracts advertised for 1994. The specifications include acceptance based on asphalt content and aggregate gradation obtained from a cluster of 4 cores.

Australia—Draft Australian standard test procedures for preparation of 100 and 150 mm diameter HMA specimens using a gyratory compactor have been prepared.

West Virginia—End-result specifications based on field density, thickness, and smoothness will be implemented in the 1994 paving season. Crumb rubber modifier (CRM) will be used in two projects in 1993 using a generic dry process.

South Carolina—The maximum amount of reclaimed asphalt pavement (RAP) permitted in hot recycled HMA mixes will be increased to 25% in 1994.

Kansas—The National Aggregate Association (NAA)'s flow test has been modified and is being considered to replace the percent crushed faces requirement for the aggregate passing No. 4 sieve. The new method is believed to be quick and well suited for field use.

NCAT'S SHORT COURSE IN ASPHALT TECHNOLOGY

NCAT is offering a two-week course to provide a general understanding of all phases of HMA technology: asphalt cement, aggregate, hot mix asphalt, construction, and SHRP research. The course will be taught February 28–March 11, 1994, at Auburn University, Alabama. NCAT is accepting applications from practicing engineers from both private and public sectors in the U.S. and abroad. It is recommended that the participants have an undergraduate degree or at least ten years experience in HMA technology. Please write or call NCAT for further information on this two-week course. Call NCAT at 205-844-6228.

NCAT'S SHRP BINDER AND MIX TESTING WORKSHOP At Auburn University

NCAT is conducting a 4-day SHRP Binder and Mixture Testing Workshop from November 30 to December 3, 1993. This workshop is sponsored by the FHWA and the National Asphalt Pavement Association. The purpose of this workshop is to provide a general understanding and hands-on training on testing asphalt binders and HMA mixtures (volumetrics portion only) using the SHRP technology.

Since this first workshop is already filled, a second workshop has been scheduled from January 25 to 28, 1994. If you want to participate, please contact NCAT at (205) 844-6228 for details.

SHRP IMPLEMENTATION UPDATE

(Continued from page 6)

- (a) Effect of aggregate properties on HMA mixes.
- (b) Linking Superpave with structural design of pavements.
- (c) Relating traffic levels to gyratory compaction.
- (d) Moisture sensitivity of HMA mixes.
- (e) Asphalt modifiers.

There is no question that SHRP's work has advanced the state of the art in the highway technology. Its accomplishments are unprecedented. However, the new technology payoff is only proportional to the extent that it will be applied in the field. AASHTO is committed to work towards this end, and, as stated here, has taken a number of initiatives to move research into practice and operation. The results of these efforts have been encouraging.

SHRP BINDER GRADING SYSTEM

(Continued from page 2)

tions. When the loads change from fast transient to standing, the binder grade is moved up by two grades. This is evident from the high pavement temperature ranges for different loads shown in the table on page 4. Because of this requirement two additional grades PG 76 and PG 82 appear in the table and not in the U.S. map which is based on fast transient loads only. For example, PG 64-16 shown in the U.S. map for Florida is for fast transient loads. If the asphalt binder is used near intersections (standing loads) in Florida, this grade has to be moved up by two grades to PG 76-16.

The latest SHRP binder specification is given in the table on page 5. This is being expanded to include PG 76 and PG 82. We will discuss the SHRP specification requirements in the next issue of the *Asphalt Technology News*.

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PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of the Association of Asphalt Paving Technologists (AAPT) held in Austin, Texas, in March. Observations and conclusions are being reported 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, 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 remarks.

1. VARIATION IN HOT MIX ASPHALT MIX DESIGN (Brown, Gabrielson and Adettiwar)

This was a round robin study undertaken by NCAT in which 41 laboratories participated. The primary objectives were:(a) to evaluate the variability of optimum asphalt content when different mix design procedures are used, and (b) to evaluate the variability of the mix properties at a specified asphalt content. Two wearing course mixtures (crushed limestone and crushed gravel) were evaluated. Twenty preweighed batches of dry, graded aggregates and a sample of AC-20 asphalt cement were supplied to each laboratory to make 20 compacted specimens of each mix type. The mixes were to be designed for heavy duty pavements (75 blows or equivalent), and the optimum asphalt contents were to be obtained at 4% air voids content. The following different laboratory compaction devices were used by the laboratories in designing the two HMA mixtures. The number of laboratories using the particular device is given in parenthesis.

- Mechanical Marshall compactor (17)
- Manual Marshall compactor (10)
- Rotating base Marshall compactor (5)
- Hveem kneading compactor (4)
- Texas gyratory compactor (3)
- Corps of Engineers gyratory compactor (2)

The following conclusions have been drawn from this study:

- The optimum asphalt content for limestone mix ranged from 4.4 to 4.8%. The optimum asphalt content for gravel mix ranged from 4.8 to 5.4%. Mechanical, fixed base Marshall compactor gave the highest average optimum asphalt content whereas the Texas gyratory compactor gave the lowest average optimum asphalt content.

- At 5% asphalt content, the Marshall stability ranges from 1900 lbs.(Corps of Engineers gyratory compactor) to 2900 lbs.(Rotating base Marshall compactor) for the gravel mix. The corresponding range for the limestone mix was 2100 to 3000 lbs.
- At 5% asphalt content, the VMA ranged from 14.4 to 15.7% for the gravel mix, and 12.6 to 14.6% for the limestone mix.
- Existing ASTM precision values for mix properties (such as bulk specific gravity and maximum theoretical specific gravity) were generally confirmed in this study.
- Generally, the precision of existing HMA test methods is not satisfactory. Better test methods are needed.

2. CORRELATION OF SELECTED LABORATORY COMPACTION METHODS WITH FIELD COMPACTION (Button, Little, Jagadam and Pendleton)

It is well established that the method of compaction affects the physical properties of the compacted HMA specimens. Therefore, when evaluating HMA mixtures in the laboratory, it is desirable to fabricate compacted specimens that closely duplicate the properties of the actual HMA road pavement. This study was primarily undertaken to compare specimens compacted using the Exxon rolling wheel compactor and gyratory compactor with field cores. However, additional limited work was performed to compare specimens prepared using the rotating base Marshall compactor and the Elf linear kneading compactor with field cores.

Field cores were obtained from five different roadway pavements in the United States and Canada. Laboratory specimens were fabricated using materials and mixture designs identical to those used in the
(Continued on page 12)

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	Tire Rubber Benefits in Pavements	Esch, Alaska DOT	\$139,000	December '94	Measure engineering properties of 12 existing rubber-modified pavements
Arkansas	Effects of Rubber on Asphalt Mixes	Elliot, Rural Transportation Research Center	189,000	September '95	Evaluate effect of crumb rubber on HMA properties
	Improved SMA with Limestone	Hardison, Arkansas DOT	52,100	December '96	Develop SMA primarily with limestone aggregate
Colorado	European Asphalt-Aggregate Mixture Analysis System	Colorado Dept. of Highways	1,471,000	December '96	Improve the quality of flexible pavements by demonstrating European AAMAS
Florida	Occupation Exposure Assessment of Ground Tire Rubber/Asphalt Use in HMA Construction	Radian	250,000	July '93	Title self-explanatory
Georgia	Optimum Design of SMA Mixes	Barksdale, Georgia Tech and Caylor, Georgia DOT	117,200	October '94	Title self-explanatory
	Performance of Recycled Mixtures in Georgia	Kandhal, NCAT and Young, Georgia DOT	93,100	December '93	Title self-explanatory
	Evaluation of RAP in SMA	Brown, Georgia DOT	72,200	December '96	Evaluate feasibility of using RAP in SMA
Kentucky	Development of Guidelines and Performance of Asphalt Pavement Containing Recycled Rubber	Mahboub, Kentucky Transportation Center	120,000	December '93	Title self-explanatory
Maryland	Development of Demonstration Projects with Scrap Tire Rubber in Highway Pavements	Witczak, University of Maryland	404,000	April '95	Title self-explanatory

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Michigan	Polymers in Bituminous Mixtures	Hawley and Drzal, Michigan State University and Barak, MDOT	900,000	December '96	Evaluate the benefits of polymers and identify test procedures
	Reduction of Rutting	Baladi and Havichandran, Michigan State University	226,000	September '94	Title self-explanatory
	Crumb Rubber Asphalt	Coleman, MDOT	350,000	December '93	Evaluate air quality and worker exposure when using crumb rubber in HMA.
Nova Scotia, Canada	Glassgrid for HMA Overlay	Garby and Reynolds, Nova Scotia DOT	50,000	August '96	Evaluate Glassgridgeotextile for preventing reflective cracking
Ontario, Canada	Evaluation of Non-chlorinated Solvents for Extraction	Yacyshyn and Tam, Ontario Ministry of Transportation	30,000	February '94	Title self-explanatory
Texas	Development of Ride Quality Specification Criteria for HMA Overlays	Fernando and Scullion, Texas Transportation Institute	300,000	August '96	Title self-explanatory
	Testing Methods for Reclaimed Asphalt Pavements	Nazarian, University of Texas-El Paso	137,000	August '95	Evaluate physical mixture tests to determine binder rejuvenation
Virginia	Process Tolerances for Nuclear Asphalt Content Measurement	Powell, Virginia Transportation Research Council	34,000	August '94	Precision limits for nuclear asphalt content gauge using Marshall specimens
Wisconsin	Evaluation of SMA with Loaded Wheel Tester	Faherty and Wenzol, Marquette University	23,000	December '94	Title self-explanatory
Transportation Research Board	Use of Antistripping Additives in Asphaltic Concrete Mixtures	David Tunnicliff	677,200	June '94	Research started in 1981 is being continued to complete field evaluation
Australia	Accelerated Loading Facility (ALF) Testing Program to Assess Rut-Resistance of HMA	Sharp, Australian Road Research Board	520,000	May '94	Title self-explanatory

pavement cores. Laboratory compactive effort for each compaction method was varied to obtain the same air voids range as the pavement cores. This was done by varying the number of gyrations and the applied pressure with the Texas gyratory compactor, by varying the number of passes with the Exxon rolling wheel, by varying the number of blows with the Marshall compactor, and by compressing a known weight of the HMA mixture into a predetermined volume with the Elf linear kneading compactor. Physical properties of the pavement cores as well as the laboratory compacted specimens were measured using the following test methods: (a) indirect tension at 25°C, (b) resilient moduli at 0 and 25°C, (c) Marshall stability, (d) Hveem stability, (e) cyclic creep at 40°C, and (f) direct compression at 40°C.

The following conclusions were obtained from this study:

- When all the data, as reflected by the various mix properties measured, are considered collectively, the difference between field cores and the specimens produced by the four laboratory compaction methods is relatively small. Based on the statistical analysis it cannot be stated with confidence that any one laboratory compaction method more closely simulated field compaction than any one of the other three methods.
- Although not statistically significant, the laboratory compaction methods ranked (in decreasing order of probability of producing specimens similar to pavement cores) as follows: Texas gyratory compactor, Exxon and Elf compactors, and rotating base Marshall compactor.
- The Exxon rolling wheel compactor exhibited difficulty in controlling air voids in the finished specimens. Comparatively low air void levels were obtained with this compactor. About 100 kilograms (220 pounds) of HMA mix is required to prepare one set of specimens (one slab) making it a very labor-intensive and material-intensive operation.

3. CONTROL OF STRIPPING WITH POLYMER TREATMENT OF AGGREGATES (Dunning, Schulz and Gawron)

This paper presents an alternative method for treating HMA mixtures to reduce or eliminate stripping of asphalt cement from the aggregate. Normally, liquid,

amine-based, antistrip agents are added to the asphalt cement binder. If hydrated lime is used it is applied directly to the aggregate or added to the hot mix. In this study very small amounts of a polymer were applied to the aggregate surface to alter its surface chemistry thereby increasing its adhesion to the asphalt binder. A polymerized polybutadiene was used in the form of a latex emulsion. The latex was diluted to about 2-3 percent polymer solids, then mixed with the aggregate in sufficient amount to obtain the desired amount of dried polymer on the aggregate. The coated aggregate was then dried at appropriate temperatures and mixed with asphalt binder.

Laboratory studies incorporating various levels of polymer indicated that 0.1% polymer solids, based on the weight of aggregate, were effective in preventing stripping of some aggregates which required antistrip agents in the past. Texas boil test and modified Lottman procedures were used to evaluate the mix resistance to stripping.

Two field trials were conducted in Idaho to verify the encouraging results obtained in the laboratory with this alternative method. It was also necessary to determine whether the polymer would retain its antistrip ability after being subjected to the harsh environment in the drum mixer. Diluted polymer was sprayed directly onto the aggregate as it dropped onto the belt introducing the aggregate to the drum mixer. The drum mixer provided the mixing action for the polymer and aggregate. The amount of dry polymer, based on aggregate, was varied from 0 to 0.09% on the first project. The amount was 0.07% on the second project.

Results from the Texas boil tests and modified Lottman tests conducted on the field mixtures indicated that the mix resistance to stripping was adequate in the range of 0.025-0.075% dry polymer, based on aggregate. The cost of the polymer application is within the range of costs encountered when using other antistrip agents. Limited air quality tests on the second project showed no adverse effect on the emissions from the drum mix plant.



RECENTLY COMPLETED RESEARCH PROJECTS

The Colorado Department of Transportation (**CDOT**) has published Final Report No. CDOT-DTD-R-92-13, dated October 1992, "Factors That Affect the Voids in the Mineral Aggregate (VMA) in Hot Mix Asphalt," by Timothy Aschenbrener and Charles MacKean. A total of 101 of the mix designs performed by CDOT during 1992 were analyzed to determine the most appropriate method for drawing the maximum density line. The Texas reference gradation line and the line drawn from the origin to the actual percent passing on the nominal maximum aggregate size provided the best correlation with measured VMA. Deviating from the maximum density line at the No. 30 sieve and the fourth largest sieve to retain some material has been advised. In addition, 24 laboratory mix designs were prepared to examine the effect of four variables (gradation, quantity of the material passing No. 200 sieve (P200), size of P200, and fine aggregate angularity) on the VMA. The gradation provided the largest changes in VMA followed by the quantity of P200 and the fine aggregate angularity.

Publication No. FHWA-RD-93-070 dated June 1993, "Evaluation of Natural Sands Used in Asphalt Mixtures," by Kevin Stuart has been published by the Federal Highway Administration (FHWA). The following five test methods were evaluated for measuring the particle shape and surface texture of fine aggregates: National Aggregate Association (NAA) Method A, Direct Shear, ASTM D3398, Michigan DOT Method MTM118-90, and Flow Rate (Shape-Texture Index). HMA mixtures containing different fine aggregates were also evaluated for resistance to rutting using the Gyratory Testing Machine, Georgia Loaded Wheel Tester, and the French LPC Pavement Rutting Tester. It has been recommended that agencies try the NAA Method A or the Flow Rate method (both use the same equipment) for evaluating their natural sands. ASTM D3398 can also be tried, but it is very time consuming.

The South Carolina Department of Highways & Public Transportation (**SCDHPT**) has published Final Report No. FHWA-SC-92-05, dated September 1992, "A Study of Re-Use of Moisture-Damaged Asphalt Mixtures," by Serji Amirkhanian and James Burati, Jr. This study confirmed that reclaimed asphalt pavement (RAP) which is already moisture damaged can be recycled without creating increased risk of moisture damage in the recycled hot mix. The finding is based on the use of a relatively small per-

centage of RAP (15-20%) in binder mixes only. SCDHPT has also published Final Report No. FHWA-SC-92-04, dated May 1992, "A Feasibility Study of the Use of Waste Tires in Asphaltic Concrete Mixtures," by Amirkhanian. This report contains a literature review, results of a questionnaire, and interviews with experts on this subject.

The Indiana Department of Transportation (**INDOT**) has published a final report, "Evaluation of Sawed and Sealed Asphalt Overlay on I-80," dated July 1992, by Yi Jiang. This report summarizes the pavement performance for a five-year period of a sawed and sealed HMA overlay on concrete pavement. The performance based on pavement roughness and visual inspection suggests that INDOT should adopt this technique as an approach to reflective cracking control. INDOT has also published a final report, "Evaluation of Cracking and Sealing Technique and Use of Polypropylene Fibers in Bituminous Mixtures on I-74," dated June 1992, by Jiang and Rebecca McDaniel. This I-74 overlay project, constructed in 1984 and 1985, used two methods for reducing cracking in the HMA overlay over concrete pavement: cracking and sealing prior to overlay and fiber reinforcement of the overlay mixture. A control section, using conventional overlay procedures, was also constructed for comparison. The seven-year pavement performance data indicates that the cracking and sealing technique was successful in this project in reducing cracking. Use of fibers further reduced cracking on the cracked and sealed sections, but did not improve the cracking resistance of the control sections.

The Connecticut Department of Transportation has published Final Report No. 116(33)-F-93-1, "Performance Evaluation of Five Materials for Retarding Reflective Cracking in Overlays I-95 Southbound, Guilford," dated March 1993, by Donald Larsen. This 11-year study included five proprietary products: (a) Hercules Fiber Pave 5010 sealant for joints and cracks, (b) Royston Membrane #108, (c) Royston Membrane #1 O-AR, (d) Hercules Fiber Pave 3010 hot mix paving fiber, and (e) BoniFibers B hot mix paving fiber. The first three products were used in the passing lane to suppress the reflection of the existing transverse cracks. However, these products could not be evaluated due to some inconsistencies in construction. The last two products were used in the slow lane to suppress alli-

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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 later issues of *Asphalt Technology News*. Some are edited for consistency and space restrictions.

New Jersey (**Eileen Connolly, N.J. DOT**)

We placed our first SMA pavement in October 1992. Although there were no problems at the time of construction, there was evidence of bleeding during hot weather. Have other states which have constructed SMA pavements experienced post-construction bleeding?

New Jersey DOT has also proposed four projects for 1993 to evaluate four different crumb rubber technologies: generic dry system, Plus Ride, wet system, and the continuous blend system.

Maryland (**Samuel Miller, Jr., Maryland SHA**)

What experience do other state DOTs have using crushed gravel in hot mix asphalt (HMA) surface mixtures?

Nova Scotia (**Gerard Lee, Nova Scotia DOT**)

How do other agencies deal with excessive moisture in drum mix plants?

Florida (**Gale Page, Florida DOT**)

The occupational exposure assessment of the crumb rubber modifier (CRM) in HMA recently completed by Florida DOT did not indicate any problems. Three demonstration projects have been planned to familiarize everyone in the industry and department with the process before total implementation.

(NCAT: In comparison to the traditional wet process, Florida DOT uses smaller amounts of CRM, smaller particle size, and lower "reaction" temperature and time.)

Kentucky (**Dwight Walker, Kentucky Dept. of Highways**)

We have placed a demonstration section in which SMA was used in base and surface courses. Two demonstration sections using CRM were also placed.

Indiana (**Rebecca McDaniel, Indiana DOT**)

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 contractors' test results?

Nebraska (**Laird Weishahn, Nebraska Dept. of Roads**)

An article on longitudinal joint was published in Spring, 1993, issue. A maximum aggregate size must be specified when referring to a wedge joint. Any mix with aggregate greater than 1/2" is likely to cause placement and density problems. Nebraska has had problems with the wedge joint because of large aggregate (up to 1") in the mix.

Kai Tam of Ontario Ministry of Transportation brought up the non-chlorinated solvents issue in the last Asphalt Forum. We have experimented with many different "biodegradable" solvents and have the following comments: (a) Each supplier has a different procedure for their extraction process. Training for and control of different laboratory procedures would be unmanageable. (b) The residue is considered a hazardous waste. (c) A massive amount of water is needed for rinsing and control of the resulting by-product would be monumental.

Maine (**Warren Foster, Maine DOT**)

Are other states having flushing problems when using AC-10 asphalt cement in hot weather?

Australia (**John Bethune, Australian Asphalt Pavement Association**)

Large scale SMA trial sections were placed in Victoria in 1993, and their performance is being monitored. A SMA test section has been included in the proposal prepared by the Australian Road Research Board for an accelerated loading facility (ALF) testing program to assess the rut-resistant properties of various HMA mixes.

As part of our education program, we are attempting to include more training on HMA and flexible pavements in university courses.

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Georgia (**Lamar Caylor**, Georgia DOT)

Response to the question from Gerard Lee of Nova Scotia DOT, *What test methods do other agencies use to determine the stripping potential of aggregates?* The Georgia DOT measures the moisture susceptibility of HMA mixtures using a Diameter Tensile Splitting Test (GDT-66) which is a special variation of the ASTM D4867-88 and the AASHTO T283-89 tests. The test was developed by Georgia DOT and has proven very effective.

Response to the question from Warren Foster of Maine DOT, *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?* Georgia DOT specifications indicate a maximum and minimum permissible layer thickness for each HMA mix type. The mix type used for a shim to establish a crown or cross slope depends on the thickness of the shim. Sand asphalt mix is only allowed on very low volume roads and is not allowed for spot levelling or patching.

Response to the question from Bob Garber, Montana DOT, *What should be done with the milled old pavement, and is it increasingly being regarded as a hazardous waste?* Georgia DOT does not consider milled HMA pavement as a hazardous material and allows the use of recycled material in all standard dense-graded mixtures.

Response to the question from Thomas German of 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 more accurate?* Georgia DOT uses nuclear gauge results (calibrated with cores) for final acceptance purposes. Rejected areas of compacted HMA based on the nuclear gauge results are cored for verification.

Now, a question from us. Have other states developed a procedure to evaluate and quantify segregation in HMA? Is a pay reduction applied in marginal situations?

Virginia (**Bill Maupin, Jr.**, Virginia Transportation Research Council)

Response to the question mentioned earlier from Warren Foster of Maine DOT regarding the mix used for levelling or shim in overlay projects. Virginia DOT usually levels with the same mix used in overlay normally 1/2" maximum aggregate size. Most roadways subjected to heavy traffic are milled before overlay.

Virginia DOT will overlay a 4.5-mile section using a conventional dense graded mix, a dense graded mix with asphalt rubber, and a gap graded mix with asphalt rubber. Each mixture will be used with and without an asphalt rubber SAMI (stress absorbing membrane interlayer).

Rhode Island (**Francis Manning**, Rhode Island DOT)

Our Asphalt-Rubber Ad-Hoc Committee, which consists of representatives from the DOT, the construction industry and the University of Rhode Island, has met twice. We are looking into ways of satisfying the Chafee Amendment requirement of incorporating CRM in HMA mixtures.

Kentucky (**Richard Downs**, Hughes Asphalt Co.)

Many states are adopting specifications that have reduced the amount of the material passing No. 200 (P200). With this practice, should not the design air voids in the total mix be increased to reduce rutting potential? It seems that as the P200 material is decreased, the only thing to replace it is an increased amount of asphalt cement that could result in an unstable mix.

Pennsylvania (**Neal Kern**, City of Allentown)

The City of Allentown recently completed a demonstration project using 10% crushed glass in a dense-graded surface mix. If successful, glass will be used more widely in the future.



**RECENTLY COMPLETED
RESEARCH PROJECTS**

(Continued from page 13)

gator cracking. In comparison with the control sections, both fiber sections have developed more raveling and deterioration. The Abson recovery tests showed the asphalt cement recovered from the fiber sections to be harder than the control sections. It was concluded that additional attention should be paid to reaching the recommended field compaction when fibers are used in HMA mixtures. If the compaction cannot be reached, then modifications to the mix containing fibers such as increasing the asphalt content, will have to be made.

NCAT'S 1993 Professor Training Course Attendees and Instructors



Left to Right: (Row 1) Kevin Hall, Jeffrey Russell, Theodore Marotta, Nader Ghafoori, Ronney Spencer; (Row 2) Barry Mines, Gabriel Alungbe, Randy West, Hussain Bahia; (Row 3) Charles Matrosic, Matt Muthusubramanyam, Mark Zitzka, Imad Al-Qadi; (Row 4) Brian Swanson, Walter Boyd, Jay Lindly, Mustaque Hossain, Thornas Papagiannakis; (Row 5) Ken Kandhal, Chaim Poran, Rafael Pezo; (Row 6) Ray Brown, Doug Hanson.

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