national superpave news

Volume 4, Number 1

Spring 2003

NCHRP Projects Piece Together the HMA Puzzle

At the January 2003 North Central Asphalt User Producer Group meeting, **Tom Harman**, FHWA, presented a summary of on-going and recently completed NCHRP and FHWA projects that are addressing the related issues of HMA structural design, materials and construction. The following summary of his talk attempts to provide a concise overview of the various projects and how they are fitting together like pieces of a puzzle to improve pavement performance.

Structural Design

One of the key projects is NCHRP 1-37A, *Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II*, which is developing the proposed AASHTO 2002 Pavement Design Guide. The guide will use mechanistic-empirical principles in the design of new and rehabilitated pavements.

Two other structural design related projects that are currently underway include NCHRP 9-19, *Superpave Support and Performance Models Management* – the so-called models contract — and NCHRP 9-30, *Plan for Calibration and Validation of HMA Models*. The models contract is developing a performance test for permanent deformation and fatigue cracking of HMA. Three candidate tests have been identified and are currently being evaluated. Project 9-30 is developing a statistically based plan to calibrate and validate the performance models used in the 2002 Pavement Design Guide.

Continued on Page 4

Superpave Usage Continues to Grow

Rebecca McDaniel, NCSC Technical Director and Vivek Tandon, Asst. Professor, UTEP

A 2002 assessment of Superpave implementation by the states shows that the implementation of Superpave technology across the country is continuing to increase. This survey, conducted by Dr. Vivek Tandon of the University of Texas at El Paso for FHWA, showed that the Performance Graded binder specifications had been fully implemented in 47 states and the District of Columbia. Two of the remaining states had started implementation, and only one state (California) did not have plans for implementation. As state usage has become routine, many local agencies have also started to use the specifications.

At least 30 states have adopted the consensus aggregate properties outlined in the Superpave system. In some cases, existing specifications already satisfied the consensus properties for fine aggregate angularity, coarse aggregate angularity, flat and elongated ratio and sand equivalent value. Six states modified the consensus properties in some way to allow more use of locally available materials.

As with past surveys, this one also showed that implementation of the Superpave mix design system is not progressing as rapidly as implementation of the binder specifications. Superpave mix design has been implemented in at least 33 states, as shown in Figure 1. Thirteen states report that implementation is underway, including three that hope to have full implementation by 2004. Only four states (California, Idaho, Nevada and Rhode Island) do not currently have firm implementation plans.

The reasons suggested for why some states have not fully implemented Superpave vary. Some states have implemented Superpave for higher volume roadways or surface lifts only and are holding off on implementing it for lower volume roadways or other courses. Other states have implemented some aspects of Superpave, such as the binder or aggregate specifications, but are still debating whether to implement the rest of the system. The option of using Superpave or conventional mixtures is given to the contractors who design the mixes in some states. Implementation is just taking longer in some states than in others.

The number of Superpave projects has risen dramatically since 1996. Nearly 5000 Superpave projects were awarded in 2001. By 2002, Superpave mixtures accounted for over 60% of all of the hot mix produced for state projects.

Initial experience with Superpave mixtures suggested that costs would be rather significantly higher. For example, one study in Ohio indicated that prices for Superpave mixtures in 1996 were 12 to 30% higher than conventional mixtures. It should be noted, however, that this data was collected in the early days of Superpave imple-

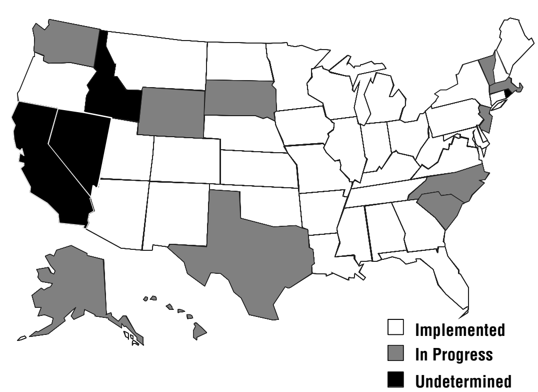

Figure 1 - Superpave Mix Design Implementation Status

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NCHRP Projects *Continued from Page 3*

Materials

The materials puzzle pieces include NCHRP 9-9(1), *Verification of Gyration Levels in the* N_{design} *Table*. This study, underway at NCAT, is looking at further refinements of the N_{design} table, including an evaluation of how well densification at N_{design} matches field compaction. (See article on Page 5.)

Another study, NCHRP 9-16(1) also looked at the gyratory. The Asphalt Institute studied the *Relationship Between Superpave Gyratory Compaction Properties and Permanent Deformation of Pavements in Service* in an attempt to use the gyratory as a test to confirm mix quality. This recently completed study found that a parameter called N-SRmax can be used as a screening test to identify gross mix instability but it cannot be used as a fundamental test to predict field rutting, and it is relatively insensitive to changes in binder stiffness. The final report on this project is now available from TRB.

The models contract, 9-19, obviously has a strong tie to materials, as does NCHRP 9-29, *Simple Performance Tester for Superpave Mix Design,* which will evaluate first article performance test equipment for rutting and fatigue cracking and will refine the IDT for low temperature cracking prediction.

Environmental Effects in Pavement Mix and Structural Design Systems, NCHRP 9-23, will evaluate the latest version of the Integrated Climatic Model developed under NCHRP 1-37A and will verify the in-service binder and mix aging simulated by PP1 and PP2.

NCHRP 9-25, *Requirements for Voids in Mineral Aggregate for Superpave Mixtures*, is evaluating the volumetric design criteria to ensure adequate durability and performance. The parameters being considered include VMA, VFA and calculated binder film thickness. NCHRP 9-31, *Air Void Requirements for Superpave Mix Design*, is investigating whether the design air void content should vary with traffic level and climate. So far these studies suggest that defining the optimum binder content at 4% is reasonable. The rut resistance increases as VMA decreases, compaction increases and aggregate surface area increases. Fatigue resistance is mainly related to binder content.

One gap in the Superpave system seems to be the lack of a reliable test for stripping of a designed mixture. AASHTO T283, the currently specified test, has many drawbacks and limitations. NCHRP 9-34, *Improved Conditioning Procedure for Predicting HMA Moisture Susceptibility,* is one approach to fill this gap by refining mix conditioning using the Environmental Conditioning System (ECS) developed under SHRP. The conditioned mixture will then be evaluated using the 9-19 performance test.

Aggregates and their relationship to HMA performance are being evaluated under NCHRP 9-35, *Aggregate Properties and their Relationship to Performance: A Critical Review*, and 4-30, *Improved Testing Methods for Critical Aggregate Shape/Texture Factors.*

Binder aging is the subject of NCHRP 9-36, *Improved Procedure for Laboratory Aging of Asphalt Binders in Pavements*, which seeks to develop and validate a lab method for aging of neat and modified binders.

The contract for NCHRP 9-37, *Using Surface Energy Measurements to Select Materials for Asphalt Pavements*, will soon be awarded, and work can begin on developing a method to use surface energy measurements to characterize aggregates, binders and additives. The method is expected to provide a tool for screening materials in terms of moisture sensitivity and fatigue.

NCHRP 9-33, *A Mix Design Manual for Hot Mix Asphalt*, is a proposed project that will develop a comprehensive mix design method (and documentation) incorporating the current Superpave volumetric mix design plus the performance tests from 9-19 and the tests and models from the 2002 Design Guide.

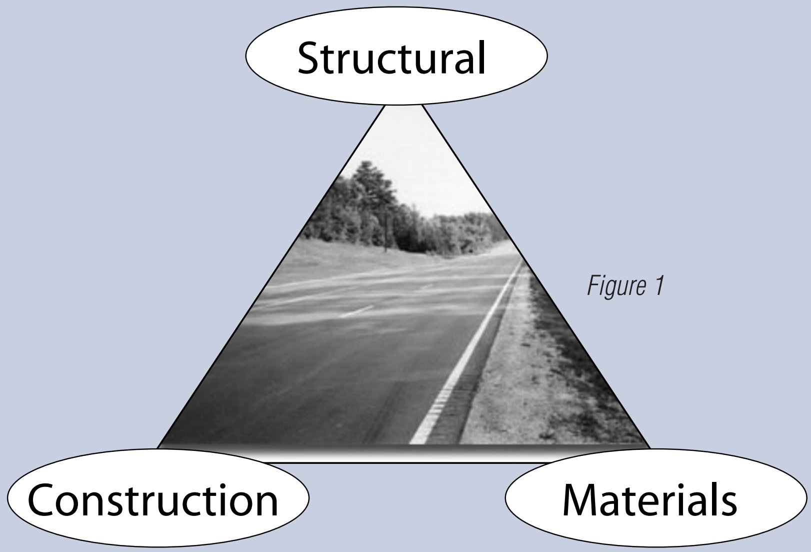

Figure 1

Construction

Construction is addressed through NCHRP 9-22, *Beta-Testing and Validation of HMA Performance Related Specifications (PRS)*, which is following up on the PRS and supporting software developed at WesTrack and integrating the requisite PRS elements into the 2002 Design Guide software. Construction issues also come into play in 9-16, 9-19, 9-29, 9-25 and 9-31 above.

Lastly, Harman mentioned the related projects being conducted by FHWA under NCHRP funding. These include continuation of the activities of the mobile asphalt labs (the trailers) and the binder lab. FHWA is also conducting a study aimed at improved understanding of the performance of modified asphalt binders using the Accelerated Loading Facility (ALF). Other projects include evaluations of mix tenderness and fine aggregate specific gravity tests.

Project status reports and other information are available on the web at www4.trb.org/trb/crp.nsf/.

Update on NCHRP 9-9(1)

By Brian D. Prowell, Associate Director, NCAT

The goal of laboratory compaction is to match the "ultimate" in-place density of the pavement. Pavements are believed to reach their ultimate density after two to three years of traffic. As in laboratory compaction, the desired ultimate density is approximately 4.0 percent air voids. If the air voids are too high, durability problems may result. If the air voids are too low, bleeding and rutting may occur.

The purpose of NCHRP 9-9, *Verification of the Gyration Levels in the N_{design} Table*, is to verify the revised Superpave N_{design} gyration levels by comparing field densification of in-service pavements with the densification of samples of the same mix tested in the gyratory compactor (SGC). The test plan for this study included the visiting, sampling and testing of 40 paving projects from various regions around the country over a two year period.

The experimental plan called for three samples from each project, though in some cases, only two samples could be obtained. At each sample location, loose mix samples were taken for gyratory compaction, maximum specific gravity, asphalt content and gradation, and three core samples were obtained for determination of in-place air voids. In-place core samples are being taken at 3 month, 6 month, 1 year, and 2 year intervals to evaluate densification under traffic. The two-year samples for the projects sampled in the second year will not be taken until 2003. To date, samples have been taken after one-year of traffic on all forty projects and after two-years of traffic on twenty-two projects.

A cumulative frequency distribution of the as-constructed air voids for the 40 projects is shown in Figure 1. A typical target density for an HMA pavement is 92 percent of G_{mm}. The average as-constructed density was less than 92 percent for 55 percent of the projects tested. Recent work with coarse graded Superpave mixes has suggested that a target density of 93 percent of G_{mm} is preferable to eliminate permeability problems. Figure 1 indicates that the as-constructed density for 78 percent of the projects was less than this level. The as-constructed densities do seem to be grouped by state and may be related to the agencies' density specifications.

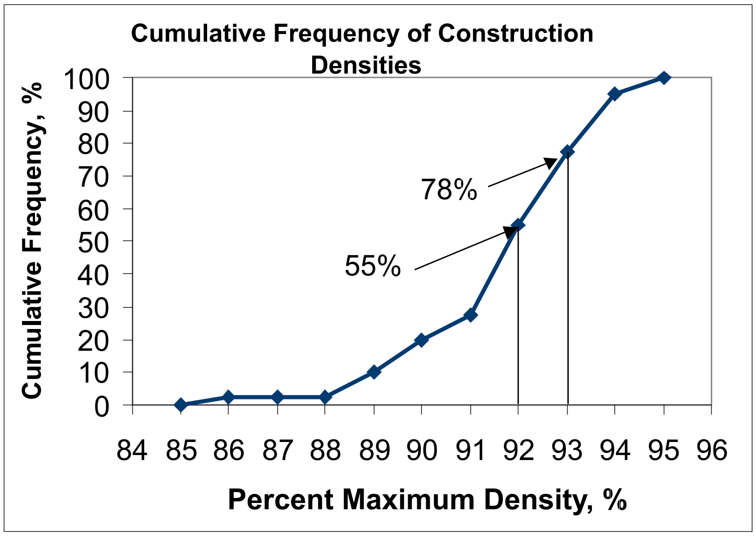

Figure 1. Cumulative Frequency Distribution of As-Constructed Field Projects

Using the heights collected from the SGC with each gyration, it is possible to predict the number of gyrations needed to match the field density of a given section at a given time. Using this methodology, the predicted number of gyrations was calculated to match the field pavement density after one and two years of traffic for 20 of the sections for which two-year data has been collected. In Figure 2, the predicted gyration levels are plotted against the accumulated traffic after one and two years.

Two SGCs were used to collect data on site at the time of construction, a Pine AFG1A (Baby Pine) and a Troxler 4141 (small Troxler). A third gyratory compactor, a Pine AFGB (Brovold), was used on projects sampled during the second year. As shown in Figure 2, there was a significant difference, on the order of 20 to 30 gyrations, between the predicted gyration levels for the Pine and Troxler SGCs with the Troxler compactor requiring more gyrations to meet the same density level. The internal angles of gyration of the two compactors used throughout the study were measured as 1.24 and 1.15 degrees with the dynamic angle verification kit.

Current specifications suggest that 100 gyrations are appropriate for traffic levels between 3 and 30 million ESAL over a 20-year design life. The data produced with the Pine SGC suggests that this

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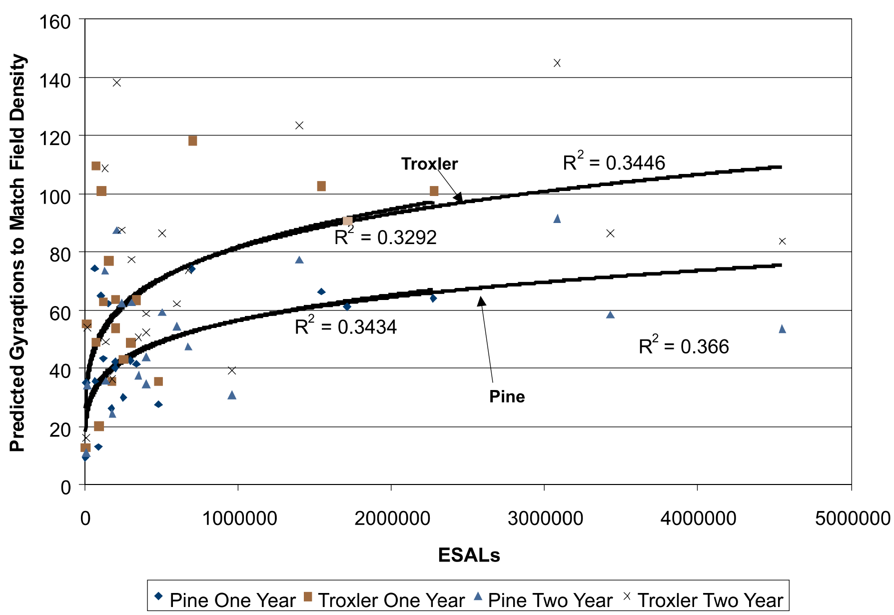

Figure 2. Predicted Gyrations to Match Pavement Density After One and Two Years

In-Place Densification Results for the NCAT Test Track

By Brian D. Prowell, Associate Director, NCAT

The NCAT Test Track offers a unique opportunity to study pavement densification over time, since all of the sections received the same amount and type of traffic, have the same base and subgrade support and are exposed to the same climatic conditions. Thirty-two of the 46 test track sections were designed using Superpave and are included in the following analysis. The 32 sections represent a range of aggregate types, nominal maximum aggregate sizes (NMS), and gradations. Primarily one compactive effort, N_{design} = 100 gyrations, was used to design the sections. However, two sections were designed with N_{design} = 125.

Three binder grades were used at the track, PG 67-22, PG 70-28 and PG 76-22. PG 67-22 is a binder grade used in the southeastern states and is approximately equivalent to AC-30. The high temperature properties for PG 67-22 are tested at 67 °C. The PG 70-28 was only used in two Hveem sections and is not included in the dataset described below. The PG 76-22 was polymer modified, with either SBS or SBR.

One of the objectives of the work at the track is to evaluate densification of HMA. Cores for evaluating densification are taken at various traffic levels from the right wheel path of each section. Figure 1 shows the average test track pavement density as a function of ESALs for the Superpave sections through the conclusion of trucking in December 2002. The results from all of the Superpave sections of a given lift (upper and lower) and a given binder grade (PG 67-22 and PG 76-22) were averaged together to produce the data representing one of the lines in the plot.

The figure indicates that the initial construction densities were slightly lower for the PG 76-22 surface layers as opposed to the other layers. However, a statistical analysis indicated no significant effect of binder grade on as-constructed density. There was also no significant effect of NMS, gradation, aggregate type or lift.

The data seems to indicate distinct rates of densification for each lift/binder combination related to time after construction and temperature (season). There appears to be an initial seating of the mix between the first and third data points taken in September and December of 2000, respectively.

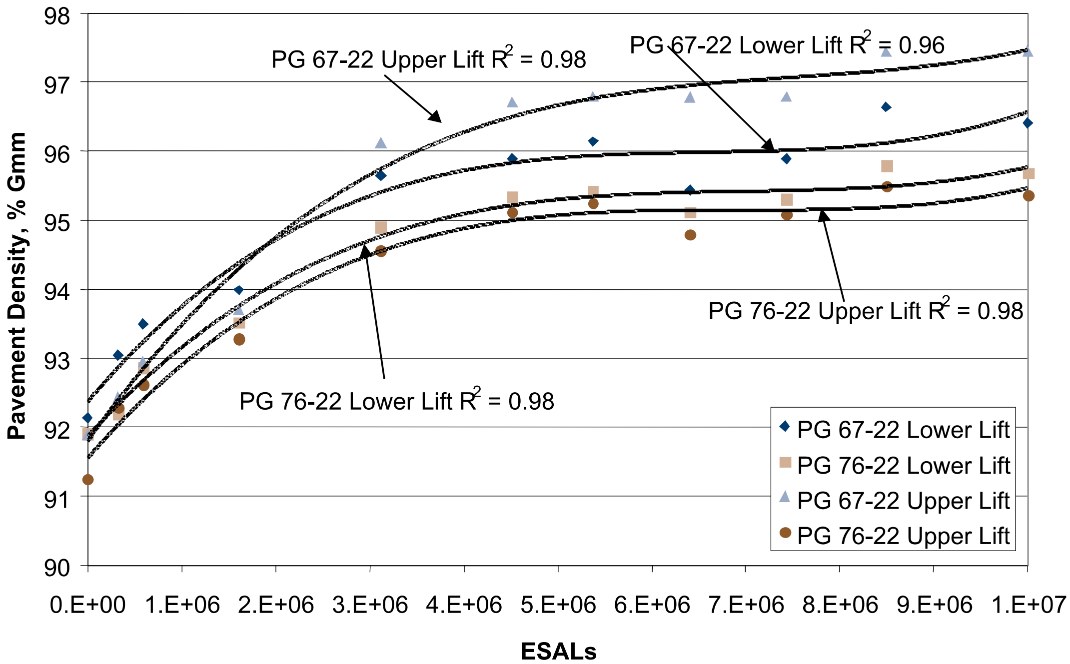

Figure 1. NCAT Test Track Average Densification

The average pavement density appears to continue to increase from December 2000 (third data point) through October 2001 (data point at approximately 4.5 million ESALs). There is little increase in pavement density between October 2001 and June 2002 (data point at approximately 7.5 million ESALs). The change in density during the summer of 2002 (7.5 to 8.5 million ESALs) is similar to that which occurred during the summer of 2001 (3.0 to 4.5 million ESALs). Little densification occurs between 8.5 and 10 million ESALs.

There is a significant difference in the rate of densification based on binder grade and lift. As expected, the sections with the softer binder, PG 67-22, densified faster. This is true for both the upper and lower lifts. Further, it appears that for the PG 67-22 sections, the lower lift, which is 50 mm (2 inches) below the surface of the pavement, did not densify as fast as the PG 67-22 surface lift. The difference in density is approximately one percent from approximately 3.0 through 10 million ESALs. The difference is not apparent prior to 3 million ESALs because the lower lifts were constructed at a higher initial density. The lower densification rate for the polymer modified binder mixes may suggest that more asphalt binder can be placed in mixes containing modified binders, without the potential for excessive densification.

The analysis of the test track densification data and related gyration data will be completed in the near future. A report will be prepared and published by NCAT. The report will refine recommendations on how additional binder may be added to mixes with modified binder to improve durability without sacrificing rut resistance and related effects on N_{design} gyrations.

TRB At Work: Committee Meets to Discuss Asphalt Issues

The Transportation Research Board's Committee on General Issues in Asphalt Technology met in Indianapolis in April to discuss current issues facing the industry. This committee's scope states that it "will establish and utilize positive communication between individuals and groups concerned with the production and use of asphalt materials for the purpose of identifying and exploring issues of mutual interest and concern." The membership on the committee includes a broad range of expertise from industry and agencies. The industry representatives include contractors, binder and modifier suppliers, testing and construction equipment manufacturers, consultants, NAPA and others. FHWA, state agency and academic representatives also participate.

This TRB committee meets mid-year, rather than during the TRB Annual Meeting in January, so that they can devote more time to sharing and discussing issues and experiences. The meeting is typically held outside of Washington, DC, to allow tours of interest to the group. Past tours have included visits to various research laboratories, equipment manufacturing facilities, hot mix plants and paving operations, and, most recently, a tour of the famous Indianapolis Motor Speedway, which is paved with a Superpave mix, and the Heritage Research Group labs.

At the January 2003 TRB Meeting, the committee sponsored or co-sponsored sessions on cold in-place recycling and reclamation, testing procedures and long term performance of mixes with modified binders. They also sponsored a workshop on asphalt pavement warranties reflecting worldwide experience. This list gives some indication of the wide range of issues addressed by the committee.

The topics of discussion at the April 2003 meeting covered a similarly broad range. Some of the discussions concerned alternate designs and life cycle cost analysis, volumetric acceptance of HMA, the life of Superpave pavements, longitudinal joint construction and testing, design and analysis of stone skeleton mixes, moisture sensitivity, pavement preservation, sulfur extended asphalt and more.

This committee looks to the future to address issues looming on the horizon while also sharing experiences, lessons learned and issues from today. By bringing a wide range of backgrounds and expertise together, they can help to address these current and impending issues through research and technology transfer.

More information on all of the TRB committees, the annual meeting and more is available on the TRB website at http://www.nas.edu/trb/.

Summer Meetings Offer Tight Focus

Typically for the asphalt industry, winter is the prime time for meetings and conferences, since little paving is underway. There are a few meetings, however, that break with tradition and offer warm weather forums focused on particular topics. Three of those summer meetings are highlighted below since they may be of particular interest to our readers. Contact information for these meetings is provided in the calendar.

Low-Volume Roads

The Transportation Research Board will sponsor its Eighth International Conference on Low-Volume Roads in Reno, Nevada, June 22-25. Speakers from six continents will address a wide range of issues related to low-volume roadways, including materials, pavements, maintenance, management, environmental and geotechnical issues, structures and more during 26 sessions. A half-day pre-conference workshop will spotlight Superpave for Low-Volume Roads. The workshop will address why, when and where to use Superpave; how to get the most out of it; how it applies to low-volume roads; and where to learn more. Another session focuses mainly on Superpave with papers on 4.75mm mixes, implementation of gyratory mix designs in Iowa and use of the gyratory for cold in-place recycling mix design. The meeting is hosted by the University of Nevada, Reno.

Beneficial Use of Recycled Materials

The TRB Committee on Waste Management is sponsoring a summer workshop, hosted by the Recycled Materials Resource Center, on the beneficial reuse of recycled materials, assessing and dealing with contaminated sites, and environmental management in transportation. Topics will include use of RAP and concrete debris, foamed asphalt, fly ash, glass, scrap tires, municipal solid waste incinerator residue and more. The workshop will include sessions and poster presentations. One of the highlights of the meeting is a field trip to Boston's Big Dig. See the website at http://www/rmrc.unh.edu/summer2003/overview.asp for more information.

Asphalt Aging

Western Research Institute will host the 40th Peterson Asphalt Research Conference in Laramie, Wyoming, in July. This conference provides a forum for researchers to share their current research related to asphalt chemistry, rheology, test methods and pavement performance. Participants represent academia, highway agencies, producers and others. Immediately after the 2½ day Peterson Conference, WRI and FHWA will host a two-day Symposium on Asphalt Pavement Aging discussing how aging of asphalt binders and mixtures contributes to pavement failure.

Analysis of Viscosity Values During Mixing and Compaction

Dr. Yetkin Yildirim, Program Manager and Jason H. Ideker, Graduate Research Assistant
Superpave and Asphalt Research Program, The University of Texas at Austin

Most asphalt mix designs use equiviscous temperature ranges for determining mixing and compaction temperatures. That is, temperatures are selected for various binders to produce a viscosity within a certain range. The Asphalt Institute began recommending lab mixing and compacting temperatures in 1962 based on Saybolt-Furol viscosity. In 1974 the Asphalt Institute switched to the more fundamental unit of centistokes. The MS-2 manual gave viscosity ranges of 170 +/- 20 centistokes and 280 +/- 30 centistokes for mixing and compaction, respectively. These values were applied for the Marshall mix design method and are still in use today as specified by ASTM D1559. Superpave mix designs recommend the same values, except the units are in Pascal-seconds (Pa•s). (One Pa•s equals 1000 centistokes) The estimation of mixing and compaction temperatures is governed by ASTM D2493 *Calculation of Mixing and Compaction Temperatures*, which develops a temperature viscosity relationship for asphalt binders.

With modified binders, however, "these viscosity ranges are not valid," as noted in the Institute's Superpave Mix Design manual (SP-2). Viscosity measurements based on the current procedure predict relatively high mixing and compaction temperatures that can lead to deterioration of the binder, safety issues, and environmental concerns. Instead, the manual suggests contacting the binder manufacturer to determine the appropriate mixing and compaction temperatures for modified binders. Suppliers work with contractors to recommend temperatures that are mainly based on trial and error, resulting in extremely high temperatures to obtain required viscosity values. Furthermore, these predicted values do not accurately match the viscosity values seen during mixing and compaction [Yildirim et. al., 2000]. Currently, a standard for binders with high viscosities has not been established [Bahia, et. al., 2000].

In 1998 the Texas Department of Transportation (TxDOT), established laboratory mixing and compaction temperatures for each PG binder, as shown in Table 1, in an effort to alleviate the difficulties with establishing appropriate temperature ranges for modified binders. The concern was that mixing and compaction temperatures established using ASTM D2493 would be unreasonably high for modified binders.

Table 1: TxDOT Laboratory Mixing and Compaction Temperatures for PG Binders

Binder	Compaction Temperature		Mixing Temperature	
	°F	°C	°F	°C
PG 64-22	250	121	290	143
PG 70-22	275	135	300	149
PG 76-22	300	149	325	163
PG 64-28	275	135	300	149
PG 70-28	300	149	325	163

Researchers at the University of Texas at Austin wanted to determine the corresponding viscosity values for the recommended mixing and compaction temperatures above. Do the temperatures above give a uniform viscosity value for different binder types within each performance grade?

Viscosity values for each binder within a performance grade were determined at the specified temperatures. To calculate the mixing and compaction temperatures, the method developed by Center for Transportation Research (CTR) at the University of Texas at Austin and reported in CTR Research Report 1250-5 was used. Modified binders exhibit a phenomenon known as pseudoplasticity. At these temperatures, viscosity values depend on the shear rate [Yildirim et. al., 2000]. Viscosity values at 500 1/s shear rate were estimated based on the relationship between viscosity and shear rate. It was found that wide ranges of viscosities were achieved at these fixed temperatures. The viscosity values obtained depended largely on binder type and not on the performance grade of the binder. Figures 1 and 2 show the viscosity values for mixing and compaction temperatures, respectively and their frequencies for all the binders tested in the study.

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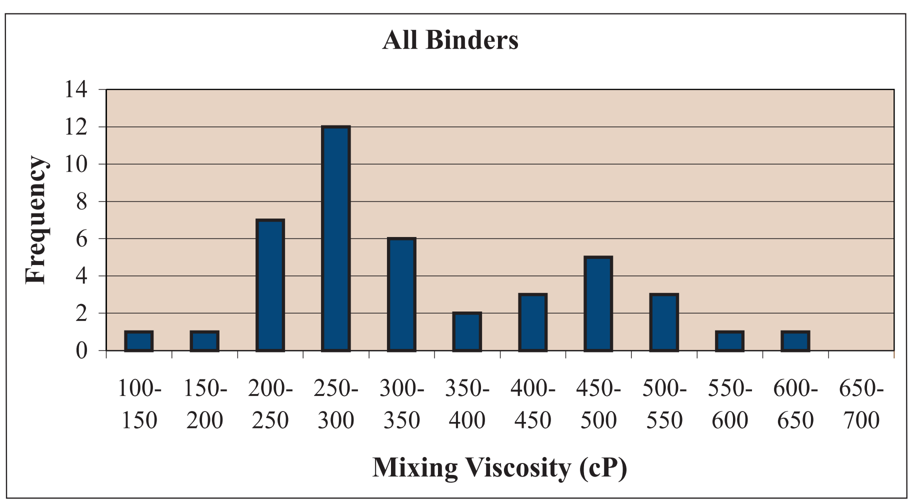

Figure 1: Mixing Viscosity Frequencies for all Binders Tested

Needed Research: Uniformity in Hot Mix Asphalt

By E. Ray Brown, Director, NCAT

One of the things that is noticeable to the traveling public, as they travel over roadways, is the lack of uniformity (segregation in materials, variability in compaction, etc.) on the pavement surface. The public may not understand what affects the performance of hot mix asphalt but they can clearly see when there is a uniformity problem and this gives the traveler an overall impression of lower quality. Even though surface uniformity is not a control item during construction it is very important because lack of uniformity generally indicates other problems that may significantly affect performance. Improved surface uniformity will result in better overall performance.

It is important that we control density, asphalt content and aggregate gradation, while we minimize segregation and other problems. Sometimes, one can look at a hot mix asphalt surface and see that it is not uniform but it is not clear if this problem will or will not cause loss in performance. However, if there is a problem with materials and/or compaction it will likely show up on the pavement surface as a uniformity problem.

There are now several ways that have been used to look at various uniformity issues. For example, non-destructive tests have been used to measure density, mix temperature and texture. While temperature by itself is not a performance property, it does affect compaction. The amount of texture alone does not relate to mixture quality, but high variability in texture does indicate when something in the process is not being well controlled.

A method is needed to quantify uniformity, and this can likely be done with two types of equipment: non-destructive measurement of density and non-destructive measurement of surface texture. One or both of these tests would likely be affected by changes in gradation, asphalt content and/or compaction. A density measurement for uniformity should not take the place of the normal density acceptance, but should be used to evaluate the variability in density as it relates to uniformity. Hence, the accuracy of the density measurement is not so important as long as relative density can be accurately determined. The temperature variation in the mixture can also be used as a non-destructive method, but one must be careful when using this approach. The primary problem with measuring temperature segregation is that the temperature testing must be conducted during construction. In addition, it must be done before the mat is rolled and the temperature cools due to the water used on the rollers.

There is a need for a device that moves down the roadway and measures uniformity (density and texture) on a continuous basis. This process should be treated much the same way as we treat smoothness. For smoothness, we generally measure the number of inches/mile of roughness and then quantify the roughness for the entire pavement. Using this approach allows the smoothness to be quantified and the results used for determining incentives and disincentives. This is the approach that we need for uniformity. We need a device that continually measures the uniformity and that quantifies the results. If segregation is a problem, it would likely show up as a texture problem, but may also show up as a density problem. If temperature segregation is a problem, it may show up as a texture problem, but more likely would show up as a density problem.

The technology is available to construct a device that can be used to measure texture and density. Lasers have been used to continually measure texture, and there are a number of density meters that have the potential to be used on the run. The process needs to be finalized, and the criteria need to be developed. This will help quantify one problem that has been a big issue for a long time—segregation. This segregation problem will not be solved until it is quantified. This uniformity concept will also help to quantify areas of low density such as that caused by temperature segregation. The uniformity concept would allow one to continually measure the uniformity of a pavement surface and to quantify these measurements.

Viscosity Values

Continued from Page 8

It can be seen that the established temperatures for each performance grade, while providing a straightforward answer to the mixing and compaction temperatures issue, fail to take into account the viscosity susceptibility of modified asphalt binders within each grade. The viscosity values seen are highly dependent on the modified binder type and not the performance grade alone. Therefore, it is necessary to establish a more rigorous yet easily attained standard for mixing and compaction temperatures for modified asphalt binders. An ongoing study at The University of Texas at Austin seeks to develop a more reliable method to establish compaction and mixing temperatures using measured viscosity values, not just the trial and error based predictions on which we currently rely.

Editors note: This topic is also a continuing concern of the Binder Expert Task Group. Watch for further developments.

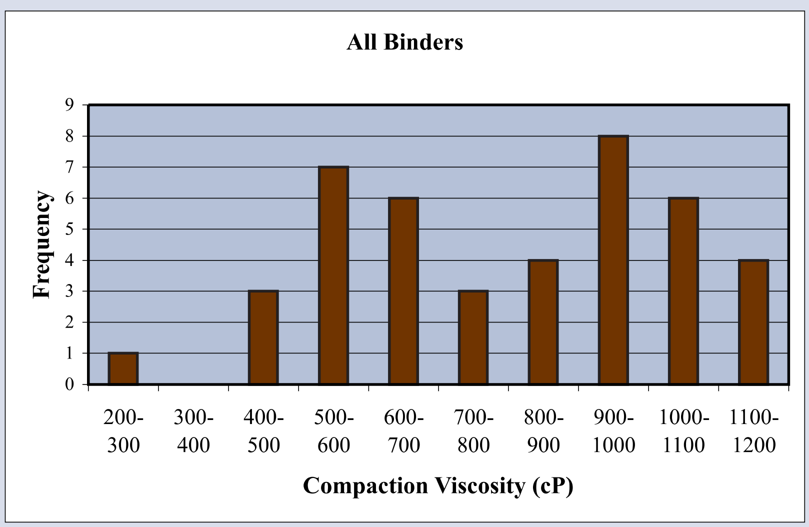

Figure 2: Compaction Viscosity Frequencies for All Binders Tested

Superpave Usage *Continued from Page 3*

mentation. A more recent study by the New York State DOT found that average prices in 2000 were about 3% higher for Superpave mixes than for conventional mixes. Similarly, Utah reported in 2001 that costs for Superpave mixes are 2-4% higher than for conventional mixes. The survey concludes from these reports, and others, that the costs associated with the use of Superpave have decreased as experience has grown and that now the costs are not significantly higher than for conventional mixes. The cost differential for the mix is higher when binder modification is needed to cover a wide range of temperatures, as would be expected.

States identified a number of concerns they have about Superpave. Many of these are already being researched to identify potential refinements to the existing system. For example, some states had concerns that the aggregate gradation control points required the design of coarse mixtures. Recent research at NCAT concluded that the restricted zone is not necessary. Elimination of the restricted zone is being balloted by AASHTO and it appears this will likely be approved. Other concerns include the appropriate VMA level, testing and specifying modified binders, need for a performance test and a moisture sensitivity test, and proper gyration level for design. These issues are currently being or have recently been researched. Some other issues that appear to need more research include the use of Superpave for low volume roads, durability of Superpave mixes and, for some states, the implementation of standardized wheel rutting tests.

States also identified a wide range of benefits of Superpave implementation, including more accurate tests, improved roadway performance, life cycle cost reduction, faster field testing and more. Some more indirect benefits cited included knowledge sharing across state lines, improved communication between agencies, faster implementation of new technology, better tools for QC/QA and others.

The full report on this assessment will be published by FHWA. In the meantime, Dr. Tandon can provide more information (vivek@utep.edu).

NCHRP 9-9 *Continued from Page 5*

level may be up to 20 gyrations too high for up to 5 million ESAL. However, the current trends for the Troxler compactor suggest that a higher gyration level may be required above 3 million ESAL. However, it should be noted that if 3 million ESAL have been accumulated during the first two years after construction, then with traffic growth, in excess of 30 million ESAL would be expected after 20 years. Therefore, if the "ultimate" pavement density truly has been reached, the predicted Troxler compaction levels may be appropriate.

A separate trend line is plotted on Figure 2 for the one and two-year data for each compactor. The fact that the one and two year trend lines overlap for each compactor suggests that the current data may be extrapolated to higher gyration levels. However, at some point it is expected that the relationship will become asymptotic such that additional increases in traffic will not increase the required design gyrations.

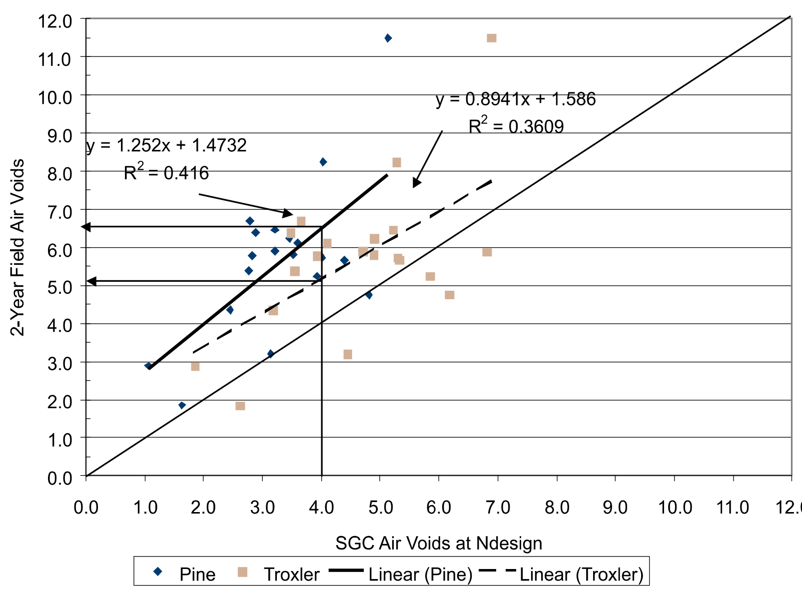

Figure 3. Design versus Field Air Voids after Two Years Traffic

An alternative way to look at the data is shown in Figure 3. This graph shows the air voids of samples compacted in the SGC to the N_{design} gyrations specified by the agency versus the average in-place air voids at a site after two years of traffic loading. In all but one case, the Pine AFG1A produced sample air voids that were equal to or less than the two-year field air voids. Seventy-five percent of the Troxler air voids were greater than the field air voids. Based on regression analysis, for samples compacted to 4 percent laboratory air voids at N_{design} in the Pine AFG1A and Troxler 4141 compactors, 6.5 and 5.2 percent air voids would be expected respectively in the field after two years of traffic.

A distress survey is being conducted as part of the collection of field density data. Rutting is generally non-existent. One project had an average rut depth of 0.25 inches after two years of traffic. Minor loss of surface fines is common among most of the projects. Several overlays of portland cement concrete pavements show reflective cracking after two years, even when the total overlay exceeds 3.5 inches. Longitudinal joints vary from fair to very good condition. Wet spots evidenced some permeability problems.

To date, there is a great deal of variability in the data relating N_{design} to accumulated traffic. The causes of this variability are being investigated. The data from the 40 field projects will be supplemented with data from the NCAT Test Track, where traffic loadings were precisely monitored. The differences in predicted gyration levels between the two compactors used for the entire study emphasize the need to address the bias between SGCs. The dynamic angle verification kit might be a means to address this bias. Though there is some evidence from the data set and from some states' experience that the gyration levels may be too high, reliability must be considered. Until the differences between the two compactors are addressed and the variability in the data is better understood, no changes can or should be recommended and may not be needed.