November 27, 2000

Mr. John C. Horsley
Executive Director
AASHTO
444 North Capitol Street, N.W.
Suite 225
Washington, DC 20001

Mr. Kenneth R. Wykle
Administrator
Federal Highway Administration
U.S. Dept. of Transportation
400 Seventh Street, S.W.
Room 4218
Washington, DC 20590

Dear Mr. Horsley and Mr. Wykle:

This is the fifth letter report of the Transportation Research Board's Superpave Committee. The Superpave® system of asphalt paving materials selection and mixture design was initially an outcome of the Strategic Highway Research Program (SHRP). The American Association of State Highway and Transportation Officials and the Federal Highway Administration are engaged in a joint effort to further develop and deploy the Superpave system among transportation agencies. Throughout its existence, the SHRP was guided by a tripartite arrangement among the FHWA, AASHTO, and the National Research Council (NRC). By mutual agreement of the three parties, the NRC, through its TRB Superpave Committee, will continue to provide advice and assistance on the conduct of the Superpave deployment and development program.

The fifth meeting of our committee was held on October 30 and 31, 2000. This meeting was principally focused on development of recommendations for research to be included in the FY 2002 programs of the National Cooperative Highway Research Program and the FHWA. We also began a more intensive examination of technology transfer and communications intended to facilitate deployment of the Superpave system. I have enclosed a committee roster (Attachment 1), which indicates those members in attendance. I have also enclosed an agenda for the meeting (Attachment 2). The recommendations and proposed project statements for the FY 2002 contained in this letter report were developed in closed session on October 30.

In preparation for the development of recommendations for projects to be included in the program of research for fiscal year 2002, the committee heard status reports from NCHRP and FHWA staff and contractors. Additionally we heard a report from the chairman of our Expert Task Group on Superpave Mixtures and Aggregates. With respect to technology transfer, training and communications, Mr. Paul Mack reported on how the AASHTO Superpave Lead State Team envisions the transition of Superpave activities from the Lead State Team to the regular AASHTO committee structure. Mr. Douglas Rose informed us of progress in establishing a new AASHTO Technology Steering Committee, which will hold its inaugural meeting in December. Lastly, Mr. Ted Ferragut, a consultant to the committee, and Ms. Anne Stonex of the Northeastern Superpave Center addressed the topic of the use of Superpave technology among municipal and county transportation agencies.

INTEGRATION OF SUPERPAVE WITH PAVEMENT DESIGN MODELS

Dr. Matthew Witczak of Arizona State University described the progress of NCHRP Project 9-19 (Task C) on the development of test methods that show potential for inclusion in the Superpave system as long-sought “simple performance tests.” With the assistance of Dr. Harrigan of the NCHRP staff and Mr. Harman of the FHWA staff, Dr. Witczak also provided a brief summary of recent and current research into predictive models for possible inclusion in the Superpave system. Included in this discussion were mechanistic-empirical models currently under development as part of NCHRP Project 1-37a, “Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II.” The flexible pavement performance models under consideration in Project 1-37a are related to the test methods under study in Project 9-19. The committee also reviewed a letter from Mr. Larry Scofield, Chairman of the NCHRP project panel for Project 9-19 (Attachment 3). In his letter, Mr. Scofield points out that the 2002 guide will mark a major change in the way pavements are designed in the future and suggests that “integration of the pavement design guide and the Superpave mixture design system should be investigated promptly.” The members of the TRB Superpave Committee concur. Without this integration, the successful selection and design of hot-mix asphalt materials that will predictably satisfy the requirements of long-lived, heavy-duty pavement designs will remain problematic.

The goal of integrating flexible pavement structure design and asphalt materials mixture design through common, mechanistically based performance models antedates the Strategic Highway Research Program. With the introduction of Superpave, the achievement of that goal drew closer. Now, the opportunity to accomplish this goal seems to be in reach. With continued progress in project 9-19 toward test methods that can effectively characterize the significant performance-related materials properties of asphalt mixtures and with the progress toward models that can predict long-term performance of flexible pavements in Project 1-37a, new components are in place. However, additional work remains to validate and integrate the findings of these two independent efforts. The TRB Superpave Committee recommends that investigation of this opportunity be undertaken promptly, even if it means delay in the development of the more advanced materials characterization models envisioned in other tasks in Project 9-19. To achieve this, the committee offers the following recommendations.

1. The problem statement entitled <u>Development of a Models Validation Experimental Plan</u>, which we recommended for inclusion in the FY2001 NCHRP Annual Work Plan, should proceed. This problem statement was approved by the AASHTO Standing Committee on Research (SCOR) on a contingent basis. If no funds are available in FY 2001, we reiterate this recommendation for FY 2002 with the amendment that prompt attention be paid to the performance models now under consideration by Project 1-37a. Implicit in this recommendation is the recognition that a future project will actually carry out the plan developed in this project. This future project will likely entail materials sampling and testing that the 1-37a project team could not conduct and will employ LTPP data not yet available.

2. A second project approved by SCOR on a contingent basis for the FY 2001 program should also proceed. This project was entitled Evaluation of IDT Testing and Identification of Future Activities. It is becoming clear that the Indirect Tension Test will be included in the final suite of Superpave asphalt mixture design tests and is under consideration as a test method to support the 2002 pavement design guide. The project approved by SCOR will

complete the development of a practical version of this test method. Again, if funds are not available in FY 2001, we recommend this project for funding in FY 2002.

3. We are also recommending a new project be included in the FY 2002 NCHRP program that will adapt the Superpave Mixture Analysis System to work with the hot mix asphalt materials characterization tests and performance models to be included in the 2002 pavement design guide. A second problem statement defining the work is titled *Adaptation of the Superpave Mix Analysis Method to Function with the Pavement Response and Distress Prediction Models Developed for NCHRP Project 1-37a* and is designated 2002-SUP-01 in Attachment 4.

4. We also recommend that active coordination among these proposed projects and Projects 1-37a and 9-19 be maintained. Coordination should also be maintained with Project 9-20 (Performance-Related Specifications for Hot Mix Asphalt Construction) and with Project 9-22 (Beta Testing and Validation of HMA PRS) and relevant FHWA managed activities. The committee is concerned that without such active coordination and dialogue among the research teams, the final deployment of both Superpave and the 2002 Guide will be unnecessarily delayed.

In offering these recommendations, we are not suggesting that the search for advanced performance models should be abandoned. Rather, we are adding an interim stage that will add substantial value to both the current Superpave system and the new 2002 Guide for the Design of New and Rehabilitated Pavement Structures.

MOISTURE SUSCEPTIBILITY OF ASPHALT AGGREGATE MIXTURES

In previous letters, the committee has expressed concern that research into the susceptibility of asphalt aggregate mixtures to moisture damage was lagging. Moisture damage is a primary cause of asphalt pavement deterioration and the inability to adequately test for moisture susceptibility threatens the progress being made in designing asphalt pavements to resist other failure mechanisms. In our second letter report, we advocated a two-pronged approach to resolution of the problem. On one hand, we called for fundamental examination of moisture damage causes and remedies. On the other, we recommended continued research into developing a physical test to identify the susceptibility of specific mixtures to moisture damage. At our recent meeting, we heard reports from Dr. Ray Robertson and Dr. Kenneth Thomas of the Western Research Institute (WRI) on fundamental research now in progress at their institution. The research, under the auspices of FHWA, is examining the chemistry and physics of five possible mechanisms of moisture damage. If successful, this work may well lead to simple remedies for the control of these mechanisms. The research may also lead to one or more test methods that can quantify propensity for moisture damage. We certainly encourage FHWA and WRI to continue this useful work. At present, however, no timetable for the development of test methods based on these fundamental studies is available. We are concerned that there is no other work in progress for the development of a robust moisture damage susceptibility test.

The “simple performance tests” now being finalized in NCHRP Project 9-19 should be able to discern deteriorating responses of moisture-susceptible materials to repeated loading provided the test samples are properly conditioned. The marriage of these tests to the Environmental

Conditioning System developed as part of SHRP may well provide a cost effective procedure for the quantification of moisture susceptibility. In keeping with our earlier two pronged approach, the committee recommends the attached second stage problem statement entitled Improved Test Procedure for Determining Moisture Damage Susceptibility of Bituminous Pavements with the Superpave Simple Performance Tests (2002-SUP-02).

At out meeting, we were informed by AASHTO staff that a similar problem statement is currently being balloted by the AASHTO Highway Subcommittee on Materials. If both statements reach the Standing Committee on Research, we certainly encourage the Standing Committee to merge the two problem statements.

RECOMMENDATIONS FOR AGGREGATE RESEARCH

As we have reported earlier, the aggregate standards incorporated in the Superpave system are derived from best industry practices and earlier research and were not the product of explicit Superpave research. Because these standards affect the selection of aggregates for asphalt mixtures, they have major economic impact for public works agencies and the aggregates supply industry. Our Expert Task Group on Mixtures and Aggregates has provided a white paper on "Superpave Issues of Concern to the Aggregate Industry" to identify specific concerns amenable to research (Attachment 5). Some of these concerns are currently being considered in active research projects. Others remain to be addressed. We are recommending two projects identified by the ETG for inclusion in the FY 2002 NCHRP work program. These are:

Synthesis of Research on Aggregate Properties and Their Effects on Superpave-Designed Asphalt Aggregate Mixtures (2002-SUP-03)

Our expert task group reports that there is a major body of recent research on the measurement of aggregate properties and their significance to hot-mix asphalt manufacture and performance. However, the lack of a credible synthesis of this research is proving to be a major barrier to effective dialogue regarding the consensus aggregate standards, associated test methods and appropriate criteria. We recognize this synthesis is not a typical NCHRP Synthesis of Highway Practice and, therefore, recommend it as a standalone project. We estimate the cost of this synthesis to be approximately $75,000.

Improved Test Methods for the Determination of Critical Shape Factors for HMA Aggregates (2002-SUP-04)

Aggregate particle shape and surface texture have significant influence on asphalt mixture properties and pavement performance. There is considerable concern, however, that existing standard test methods for aggregate angularity and shape cannot adequately determine the important criteria. Two promising procedures that offer potential for improving the quantification of aggregate shape and texture are multiple ratio shape analysis and x-ray tomographic imaging. We recommend that research be initiated to establish the true potential of these methods to quantify particle shape, angularity and surface texture parameters significant to hot-mix asphalt performance. If the potential of these methods so warrants, the research should also establish standard methods and criteria. We estimate the cost of this work at approximately $300,000.

CONTINUATION OF FHWA-MANAGED SUPERPAVE PROJECTS

The FHWA manages a set of projects that support the effective deployment of the Superpave system by providing laboratory and field testing activities that validate research findings, evaluate newly developed test methods and specifications, and guide refinement of these components of the Superpave system. These projects provide technical information to the AASHTO Highway Subcommittee on Materials for the development or enhancement of Superpave-related standard specifications and test methods. These projects also develop information that is integral to effective Superpave technology transfer activities conducted by the regional Superpave Centers, the AASHTO Superpave Lead State Team and other groups. Our committee is charged with regular review of these projects. For FY 2002, the committee recommends the continuation of the following FHWA-managed projects:

> Project 90-01, Superpave Mix Protocol Refinement and Field Validation (2002-SUP-05)
> The objective of this project is to validate the findings of Superpave-related NCHRP projects quickly and efficiently through the use of the staff and laboratory resources of the FHWA Superpave Mix Team. We estimate that continuation of this project in FY 2002 will cost approximately $750,000. This is a sizable reduction from costs required in past years and reflects a winding-down of activities as tasks are completed. Although we cannot predict the complexity of the deployment of findings of current research, the committee expects this downward trend to continue.
>
> Project 90-02, Superpave Binder Equipment and Test Procedures, Refinement and Field Validation (2002-SUP-06)
> The objective of this project is to further refine and enhance AASHTO MP1 standard for performance-graded binders and to provide field validation of the findings of Superpave binder-related NCHRP projects. We estimate that the cost to continue this project through FY 2002 will be $300,000. This is also a substantial reduction from the funds required for FY 2001.
>
> Project 90-07, Understanding the Performance of Modified Asphalt Binders in Mixes (2002-SUP-07)
> The objective of this project is to evaluate new or modified Superpave test methods and specifications to permit the reliable extension of the Superpave system to modified asphalt binders. We estimate that $500,000 in FY 2002 will be necessary to complete this project. A companion project to 90-07 will evaluate the findings of this project through accelerated pavement testing. Because this companion project will have immediate impact on a selected group of states that rely on modified asphalt binders, we recommend that the accelerated testing be pursued on a pooled-fund basis. Obviously, close coordination must be maintained between these two projects.

TECHNOLOGY TRANSFER

The committee is primarily in a fact-gathering mode with respect to technology transfer needs. In the coming year we will probably be offering a number of recommendations on this topic. One need, however, is already clear. Over the next several years, new elements of great interest to transportation agencies and the hot-mix asphalt paving industry will be added to the Superpave system. Foremost among these will be the “simple performance test(s)” now being finalized in NCHRP Project 9-19. Other likely additions will be amendments to the binder specifications to better accommodate modified asphalts and findings of research now under way on aggregates. We see the need for a national Superpave technology conference or exposition, probably in 2003. This will be another in the series of the National Superpave Conferences that have been held periodically since 1998. We recommend, therefore, that $75,000 be allotted in FY2002 to assist in the planning and conduct of such a conference in partnership with the asphalt paving industry. This recommendation is designated 2002-SUP-08 in Attachment 4.

The anticipated growth of technology transfer and training demands underlies one additional request for the FY 2002 annual program. As you are aware, the funds that support the activities of the TRB Superpave Committee and its associated expert task groups is provided through NCHRP Project 9-21. This project has been funded at $200,000. As you are aware, we are in the process of adding an Expert Task Group on Training and Communications. This ETG is likely to be very busy in FY 2002 in preparation for the heavy technology transfer demand that we foresee in the future. For this reason, we request that Project 9-21 be allocated $250,000 for FY 2002.

Attachment 4 contains all of our recommended second-stage problem statements for fiscal year 2002. Included with the attachment is a table summarizing these recommendations. I hope that this letter conveys the interrelationships that exist among all of these projects and with current research such as NCHRP Projects 9-19, 1-37a and others. We on the committee can see the various threads of research conducted in the last decade drawing together. We are enthused about the power that the potential partnership of Superpave and the 2002 pavement design guide can bring to agency and industry engineering staffs and are pleased that the long-awaited simple performance tests are now coming into view. However, momentum must be maintained in order to meet the goal of merging the Superpave system into everyday highway design and construction practice. I hope that message is remembered as this package of closely related problem statements is reviewed.

In closing, let me state that the members of the committee all felt that this was one of our most productive meetings. Much of that productivity can be traced to the careful preparations made by the AASHTO, NCHRP, and FHWA personnel who make up the Superpave Support Team. Their hard work is greatly appreciated.

Sincerely,

Joseph A. Mickes
TRB Superpave Committee

cc: Robert J. Reilly, NCHRP

TRANSPORTATION RESEARCH BOARD
DIVISION E – SPECIAL PROGRAMS

TRB Superpave Committee

(Names in boldface were present at the meeting of October 31 and November 1, 2000)

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Final Agenda

TRB Superpave Committee
October 30 and 31, 2000

Green Building, Room 118
2001 Wisconsin Ave., NW, Washington DC 20007

Committee Mission: The committee will review the workplans and component tasks of the AASHTO and FHWA to be conducted in support of Superpave implementation and related research. The committee will provide advice on the suitability of overall objectives, missing components (if any), and appropriateness and likelihood of success of the research tasks included in the plan and suggest coordination of activities. In addition, the committee will conduct regular program reviews, provide an accounting of progress, regularly review the financial needs for work remaining to be done and offer advice regarding course corrections, promising opportunities, and significant findings.

Monday, October 30

8:30 a.m. Continental Breakfast

9:00 a.m. Welcome and Introductions — Joe Mickes

Mr. Mickes will welcome members and guests, review the agenda, ask for acceptance of the previous minutes and review the last letter report to FHWA and AASHTO. He will also ask staff to review meeting logistics.

9:15 a.m. Progress on the Superpave Simple Performance Test — Matt Witczak

Dr. Witczak will apprise members of progress made in NCHRP Project 9-19 (Task C) for the finalization of protocols for simple performance tests that can be incorporated into the Superpave volumetric mix design method. This progress report may hold implications for recommendations the committee might make to the AASHTO Standing Committee on Research for future NCHRP research.

10:00 a.m. Break

10:15 a.m. Hot Mix Asphalt Performance Models — Ed Harrigan, Tom Harman, Matt Witczak

Mr. Harman and Drs. Harrigan and Witczak will review the progress of the development of HMA performance models under SHRP, FHWA and NCHRP projects 9-19 and 1-37a. The long-range vision of the SHRP research effort has been the merger of pavement structural and materials design through mechanistically based performance models. In the case of HMA, we have reached the point where decisions must be made on how, or if, the Superpave mixture design system should be integrated with the flexible pavement performance models developed for the AASHTO 2002 Pavement Design Guide. This decision will have implications regarding the pace at which more advanced models can be pursued. Several options developed by staff will be presented to initiate discussion.

11:30 a.m. Update on Asphalt Research at the Western Research Institute, Laramie, Wyoming — Ray Robertson, Ken Thomas

Drs. Robertson and Thomas will report on work underway at WRI with special emphasis on the asphalt moisture sensitivity research that was initiated in response to a previous committee recommendation.

Noon Lunch

1:00 p.m. Mixture ETG Report — Ron Sines

Mr. Sines will report on the outcome of the recent ETG meeting in Indianapolis. Particular attention will be paid to potential research problem statements and the ETG's discussion of needed aggregate research.

1:30 p.m. Project Progress Reports — FHWA and NCHRP Staff

Staff will report on progress of active Superpave related projects and on anticipated projects that have been funded but are not yet under way.

2:15 p.m. Break

2:30 p.m. Review of Potential FY 2002 NCHRP Research Problem Statements — The Committee

With the assistance of staff, Chairman Mickes will lead a discussion of problem statements that the committee may recommend to SCOR for inclusion in the NCHRP Annual Work Program for FY 2002. The committee recommendations will be transmitted to AASHTO in the Committee's next letter report.

4:30 p.m. Adjournment of the Open Session

4:45 p.m. Closed Session — The Committee Only

5:45 p.m. Reception and Dinner for Committee and Invited Guests

Tuesday, October 31

7:45 a.m. Continental Breakfast

8:30 a.m. Superpave Lead State Transition Plan — Paul Mack

The AASHTO Task Force on SHRP Implementation sunsets in December. As part of this sunset, the Task Force asked each of the SHRP Lead State Teams to prepare transition plans to provide an orderly transition of outstanding implementation tasks to other groups. The transition plan for the Superpave Lead State team holds implications for the TRB Superpave Committee as well as the AASHTO Subcommittee on Materials. Mr. Mack, the Superpave Team Leader, will recount the highlights of the Superpave Lead State Team transition plan.

9:00 a.m. AASHTO Technology Deployment Committee — Doug Rose

As an organization, AASHTO regards the SHRP implementation effort as a success and seeks to extend that success to technology deployment in general through the creation of this committee. Mr. Rose, who is a member of the new committee, will briefly explain the committee's purpose and scope and review the committee roster.

9:20 a.m. Organization of the Communication and Training ETG — Neil Hawks

Mr. Hawks will review the composition of the roster of the new Expert Task Group on Communications and Training, which was organized in response to committee recommendations.

9:30 a.m. Superpave and Low Volume Roads — Ted Ferragut, Anne Stonex

At the June meeting, the committee requested staff to gather information on the extent of application of Superpave binders and mixtures on lower volume roads, particularly those administered by counties and municipalities. Mr. Ferragut, consultant to the committee, will brief the committee on the information staff has been able to gather. Ms. Stonex of the Northeastern Superpave Center will provide a view from the working level.

10:00 a.m. Break

10:15 a.m. Superpave Software — Larry Michael, Riaz Ahmad

Distribution of the Superpave Software, through AASHTOWare®, began in January 2000. Mr. Michael of the Maryland State Highway Administration, who has long been active in the development of the software, and Mr. Ahmad, the project contractor, will inform the committee about experiences to date, comments from users and future plans. AASHTOWare is employing an innovative "e-commerce" approach to distribution as the demand for the software exceeds the capability of the "normal" AASHTOWare distribution mode.

11:00 a.m.	Updating the Long-Range Plan	The Committee
	Based upon discussions heard at this meeting, the committee will provide direction to staff for the update of the long-range plan for Superpave development and deployment. The updated plan will form the foundation of the committee's annual report to AASHTO.	
11:30 a.m.	Adjournment of the Open Session	
12: 30 p.m.	Closed Session	The Committee Only
1:30 p.m.	Final Adjournment	

Attachment 3

Neil F. Hawks, Director
Special Programs Division
Transportation Research Board
2101 Constitution Avenue, N.W.
Washington, DC 20418

Dear Mr. Hawks;

Pursuant to our earlier conversation, I would like to comment on the need for coordinated integration of the 2002 design guide flexible pavement mechanistic models (NCHRP Project 1-37A) and the current and future models work from NCHRP Project 9-19. As the upcoming guides will no doubt make one of the landmark changes in how pavements are designed, it is imperative that we keep all the research efforts focused on the same outcome and deployed as early as possible in a systematic manner. Therefore, integration of the new design guide and the Superpave mixture design system should be investigated promptly. If these two advances in flexible pavement design are not made to work together, the full implementation of both will likely be delayed. Without a nationally coordinated effort, individual agencies will either delay adoption of the new design guide or develop their own ad hoc integration schemes, creating duplicate costs and suboptimal solutions. I am not aware that such a systematic approach currently exists and I encourage the development of a national oversight process.

Respectfully,

Larry Scofield,
Chairman,
NCHRP 9-19 Project Panel

Attachment 4

Summary Table

Recommended Superpave Research Projects
FY 2002

Projects approved by SCOR as “Contingent” for FY 2001

2001-SP-22	Development of a Models Validation Experimental Design	$200,000
2001-SP-24	Evaluation of IDT Testing and Identification of Future Activities	$100,000

New Projects Recommended for FY 2002

2002 –SUP-01	Adaptation of the Superpave Mix Analysis Method to Function with the Pavement Response and Distress Prediction Models Developed for NCHRP Project 1-37a	$500,000
2002-SUP-02	Improved Test Procedure for Determining the Moisture Damage Susceptibility of Bituminous Pavements	$400,000
2002-SUP-03	Synthesis of Research on Aggregate Properties and Effects on Superpave Designed Mixes	$75,000
2002-SUP-04	Improved Testing Methods for Determination of Critical Shape/Texture Factors for HMA Aggregates	$300,000
2002-SUP- 08	National Superpave Technology Exposition (2003)	$75,000

Continuation of FHWA-Managed Superpave Projects

2002-SUP-05 (Continuation of 90-01)	Superpave Mix Protocol Refinement and Field Validation	$750,000
2002-SUP-06 (Continuation of 90-02)	Superpave – Binder Equipment and Test Procedures, Refinement, and Field Validation	$300,000
2002-SUP-07	Understanding the Performance of Modified Asphalt Binders in Mixes	$500,000

Continuation of NCHRP-Managed Superpave Projects

Project 9-21	Advisory Structure for Superpave Implementation and Related Research	$250,000

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

PROBLEM NUMBER

2002-SUP-01

PROBLEM TITLE

Adaptation of the Superpave Mix Analysis Method to Function with the Pavement Response and Distress Prediction Models Developed for NCHRP Project 1-37a

RESEARCH PROBLEM STATEMENT

The Superpave mix design system developed by the Strategic Highway Research Program (SHRP) included both a volumetric mix design method (the original Level 1, now an AASHTO Provisional Standard) and a mix analysis method (the original Levels 2 and 3). The mix analysis method used tests conducted with the Superpave shear test device and the indirect tensile test device methods to provide input data to a suite of materials characterization, pavement response, and distress prediction models. The output of the models (in the form of predicted distress for project specific traffic, climate, and pavement structure) was employed in the Level 2 and 3 designs to determine the optimum mix design.

Under FHWA contract DTFH61-95-C-00100, a research team led by the University of Maryland performed an in-depth evaluation of the SHRP Superpave performance model system. Its report concluded that the performance prediction models for load associated distress in the SHRP Superpave system functioned poorly and that "Substantial corrections and enhancements to the load associated rutting and fatigue models are considered mandatory to make these models reliable for general acceptance and use by industry." On this basis, a major, continuing program was undertaken through the FHWA contract and, subsequently, NCHRP Project 9-19 to develop reliable, state-of-the-art performance models for the Superpave mix analysis method.

Work is now underway in Task F of NCHRP Project 9-19 to develop and verify a test method and computational model for accurately characterizing asphalt concrete materials for performance prediction; this effort will extend through 2002. Thereafter, another major research program is planned to develop the actual pavement response and distress prediction models; these are envisioned as purely mechanistic models, probably based on three-dimensional finite element analysis or comparable technology and requiring advanced computing capabilities. Realistically, this next stage of research will extend through 2007 or 2008; its products will be applicable to HMA pavement structural design and performance-related specification (PRS) development as well as HMA mix design.

At present, a comparable suite of materials characterization, pavement response, and distress prediction models for hot-mix asphalt (HMA) is under development in NCHRP Project 1-37A, "Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II." This effort is using the best, state-of-the-practice mechanistic-empirical models; development of new models is not included. Materials characterization employs the dynamic modulus and indirect tensile tests. Delivery of a beta version of the final design software, including HMA performance models calibrated and validated with existing data, is scheduled for late 2001.

The HMA performance model and software development in NCHRP Project 1-37A provides the opportunity to complete a full working version of the Superpave mix analysis method for use by the state highway agencies and industry starting in 2005. The same models can be evaluated for incorporation in the HMA PRS through NCHRP Project 9-22 and future projects, supporting HMA mix design, pavement design, and PRS on a common platform of materials characterization tests and performance models while advanced model development continues.

RESEARCH OBJECTIVE

The objective of this research is to develop a working version of the Superpave mix analysis method based on the HMA materials characterization tests and performance models in the 2002 Pavement Design Guide.

It is anticipated that the research will encompass at least the following tasks:

1. Using the HMA materials characterization and performance modeling software in the 2002 Pavement Design Guide as a basis, develop requisite mix analysis software to complement the AASHTO volumetric mix design and field QC/QA software.

2. Integrate the fully-validated integrated climatic model from NCHRP Project 9-23 with the Superpave mix analysis software.

3. Develop procedures necessary to carry out the Superpave mix analysis in conjunction with the Superpave volumetric mix design method to select a project-specific mix design that is durable and meets performance objectives.

4. Prepare a Superpave mix design and analysis manual and software user's guide.

ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for this project is $500,000. The research will require approximately 36 months to complete.

URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

This research will take advantage of the results of other major NCHRP projects to deliver a fully-functional, comprehensive working version of the Superpave mix design and analysis system to the industry in 2005. The potential payoff is very high. Implementation of the results of this project will be accomplished through the continuing adoption of the Superpave mix design method.

DATE AND SUBMITTED BY

1 December 2000
TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

I. PROBLEM NUMBER

2002-SUP-02

II. PROBLEM TITLE

Improved Test Procedure for Determining the Moisture Damage Susceptibility of Bituminous Pavements

III. RESEARCH PROBLEM STATEMENT

Moisture damage is a primary cause of distress in asphalt pavements. There is good evidence the susceptibility of hot mix asphalt (HMA) to moisture damage is influenced by aggregate mineralogy, aggregate surface texture, asphalt binder chemistry as well as the interaction between asphalt and aggregate. The great number of different aggregate mineralogies and numerous types of unmodified and modified asphalt binders used across the nation, coupled with varied environmental conditions and traffic, make predicting the susceptibility of HMA to moisture damage a difficult task.

AASHTO T 283, *Resistance of Compacted Bituminous Mixture to Moisture Induced Damage*, is the most widely used method for determining HMA moisture susceptibility. However, many DOTs across the U.S. have reported only mixed success with the method over the last 20 years. Several NCHRP and State DOT projects have dealt with its shortcomings. These have resulted in a number of "fixes," but the method remains empirical and liable to give either false positives or false negatives in the prediction of moisture damage.

The SHRP Asphalt Research Program extensively investigated fundamental mechanisms of moisture damage and developed new methods for its prediction. The Environmental Conditioning System (ECS; originally AASHTO TP34, *Determining Moisture Sensitivity of Compacted Bituminous Mixtures Subjected to Hot and Cold Climate Conditions*) was designed to determine the moisture susceptibility of compacted HMA specimens under realistic conditions of temperature, moisture saturation, and dynamic loading found in actual pavements.

The current NCHRP project 9-19, Superpave Support and Performance Models Management, has recommended new simple performance tests for asphalt mixes. The use of the new performance tests with the original ECS may prove to greatly improve the ability to predict the potential for moisture damage in asphalt mixes.

IV. RESEARCH OBJECTIVE

The objective of this research is to develop an improved test method for the moisture sensitivity of compacted HMA from the existing ECS and the simple performance test developed under NCHRP 9-19. The new procedure should be sensitive to the effects of normal variability in material and mix properties expected during laboratory mix design and field construction.

It is anticipated that the research will encompass at least the following tasks:

1. Critically review the literature on basic and applied research conducted on HMA moisture sensitivity. Concentrate the review on work accomplished since 1993 and the recent work done by Western Research Institute under the auspices of the FHWA.

2. Based on the findings of Task 1, prepare a comprehensive report identifying major gaps in current knowledge, probable micro- and macro-scale mechanisms of moisture damage, and promising approaches for modifying the ECS, to improve it's prediction of moisture damage. Present an adequately supported judgment whether further research to modify the ECS is warranted.

3. Prepare a detailed, statistically sound experimental plan to evaluate whether incremental changes to TP34 in combination with the NCHRP simple performance test can significantly improve their accuracy, repeatability, and reproducibility and minimize false positive and negative results. It is envisioned that the laboratory program will judge the effectiveness of modifications to TP34 by comparing their results with those obtained with accelerated laboratory ("torture") tests such as the Hamburg and PurWheel loaded wheel testers for HMA materials exhibiting a wide range of moisture sensitivity.

4. Conduct the Task 3 laboratory work plan, analyze the results, and identify those changes to the test procedures that significantly increase their accuracy, repeatability, and reproducibility.

5. Develop a preliminary test method in AASHTO standard format that incorporates the significant changes and improvements identified in Task 4. Propose a statistically designed work plan for a future field study to validate the preliminary test method.

6. Prepare a final report for the project.

V. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for this project is $400,000. This research will require approximately 30 months to complete.

VI. URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

Moisture damage to HMA pavements is widespread, difficult to detect in its initial stages, and causes major collateral distress and loss of service life. An improved test method to accurately identify moisture susceptible HMA during mix design and field quality control will result in improved pavement performance and significant savings in maintenance and rehabilitation costs. The potential payoff is expected to be high. After field validation is completed in a second project, implementation will require adoption of the new or revised method by the AASHTO Subcommittee on Materials and should be rapid.

VII. DATE AND SUBMITTED BY

1 December 2000

TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

PROBLEM NUMBER
2002-SUP-03

PROBLEM TITLE
Synthesis of Research on Aggregate Properties and Effects on Superpave Designed Mixes

RESEARCH PROBLEM STATEMENT

The performance of the hot mix asphalt (HMA) is influenced by the characteristics of its two main constituents, asphalt binder and aggregate. While under SHRP considerable emphasis was placed on developing new binder tests, only limited efforts were dedicated to aggregate tests and criteria. During the last ten years, considerable efforts have been conducted, and continue, to study the measurement of aggregate properties and most importantly the effects on asphalt mixture performance. In particular, since the end of SHRP, research has been performed on various aggregate tests under NCHRP Project 4-19, and the current Project 4-19(2) is investigating "Validation of Performance-Related Test of Aggregate for Use in HMA".

RESEARCH OBJECTIVE
The objective of this effort is to conduct a critical review of the literature on aggregate properties and in particular effects on Superpave designed mixes. The focus of this work should be to include current research and in particular that conducted over the last ten years that has centered on aggregates used in Superpave designs and recommended changes to existing consensus properties.

ESTIMATE of PROBLEM FUNDING AND RESEARCH PERIOD
The estimated funding for this project is $75,000. This research will require approximately 12 months to complete.

URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION
Current Superpave tests/criteria on aggregate need to reflect those properties that influence performance. Since development of Superpave, there has been increased emphasis on determining critical aggregate characteristics. Representatives of the aggregate industry and the Superpave Mixture/Aggregate ETG have identified the need for improved aggregate tests and criteria as one of the most needed aspects left to complete in the Superpave system.

DATE AND SUBMITTED BY

1 December 2000 / TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

PROBLEM NUMBER

2002-SUP-04

PROBLEM TITLE

Improved Testing Methods for Determination of Critical Shape/Texture Factors for HMA Aggregates

RESEARCH PROBLEM STATEMENT

The performance of the hot mix asphalt (HMA) is influenced by the asphalt binder and aggregate. While under SHRP considerable emphasis was placed on developing new binder tests, only limited efforts were dedicated to aggregate tests and criteria. Aggregate shape and surface texture can have a major influence on mixture properties and pavement performance. These properties can vary widely with type and location of aggregate sources, as well as processing techniques.

Two promising procedures for aggregate evaluation that offer potential improvements are the multiple ratio shape analysis and use of imaging technology (x-ray tomography) to model and quantify aggregate shape and texture. Information on these procedures has been recently presented at the Superpave Mixture/Aggregate Expert Task Group meetings.

The current Superpave procedure for determining and describing an aggregate sample's particle shape (one number for a given ratio of maximum compared to minimum particle dimensions) provides very limited detail about the variety of particle shapes found within the sample. An improved procedure for determining an aggregate samples particle shape is needed. Multiple ratio analysis gives an accurate picture of an aggregate sample's particle shapes by evaluating the sample on five different ratios instead of one (<2:1, 2:1 to 3:1, 3:1 to 4:1, 4:1 to 5:1, >5:1). This procedure can be conducted with a relatively simple piece of equipment/caliper device.

Current technology advance in imaging technology (x-ray tomography) offers another, albeit complex tool that can be used to characterize aggregate properties and their potential influence. This approach offers the potential to model and enhance our understanding of the influence of aggregate properties on asphalt mixtures

RESEARCH OBJECTIVE

The objective of this research is to develop tests/criteria to better define measurement of aggregate shape and texture and the relation to mixture performance.

It is anticipated that the research will encompass at least the following tasks:

1. Conduct a critical review of the literature on current tests to analyze aggregate shape and texture. In particular efforts should include activities being conducted under NCHRP Project 4-19. Emphasis should be given to examining current developments with the multiple ratio shape analysis and imaging technology (x-ray tomography).

2. Develop a work plan for examining these promising tests (and others) and for establishing criteria applicable to desirable characteristics for HMA performance.

3. Perform laboratory testing, analyze the results, and make changes to the test procedures that significantly increase the accuracy, repeatability, and reproducibility of the results.

4. Design and conduct a preliminary validation effort of tests and criteria.

5. Develop preliminary test methods in AASHTO standard format for testing aggregates utilizing newly developed methods.

6. Propose a statistically designed work plan for a future field study to validate the preliminary test method(s).

7. Prepare a final report for the project.

ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for this project is $300,000. This research will require approximately 18 months to complete.

URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

Current Superpave tests/criteria on aggregate need to reflect those properties that influence performance. Since development of Superpave, there has been increased emphasis on measuring critical aggregate shape and texture characteristics. Representatives of the aggregate industry and the Superpave Mixture/Aggregate ETG have identified the need for improved aggregate tests and criteria as one of the most needed aspects left to complete in the Superpave system.

DATE AND SUBMITTED BY

1 December 2000 /TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Transportation Research Board, National Research Council

Second Stage Problem Statement

I. PROBLEM NUMBER

2002-SUP-05 (Continuation of NCHRP Project 90-01)

II. PROBLEM TITLE

Superpave Mix Protocol Refinement and Field Validation

III. RESEARCH PROBLEM STATEMENT

To take NCHRP research to full field implementation requires an extensive effort in refinement and validation. Project 90-01 "Superpave Mix Protocol Refinement and Field Validation," is intended to fill this function. Under this project, the Federal Highway Administration (FHWA) has refined and validated over 15 new and modified pieces of SHRP mix test equipment and procedures since the research was formally concluded. As NCHRP research continues to fill the gaps in the Superpave system, parallel and follow-up work is required for refinement and validation. The newly-designated NCHRP 90-01 Mix Team is fully trained and equipped to perform a complete Superpave mix design, specializing in aggregate testing, binder testing, gyratory compaction, and mix moisture sensitivity testing.

The NCHRP 90-01 Mix Team takes this foundational expertise to evaluate, validate, refine and conduct final development efforts on all new, modified, or alternate equipment and test procedures, as recommended by AASHTO, NCHRP or the TRB Mix ETG. What is unique about this effort is that data is collected at hot mix plants on active construction projects selected by the State DOTs in cooperation with the hot mix industry. The NCHRP 90-01 Mix Team, with the unique capability of a mobile laboratory, is able to joint venture with both State DOT and industry engineers and technicians on understanding and evaluating NCHRP protocols in quality control and quality assurance.

The NCHRP 90-01 Mix Team can rapidly validate and uniformly transfer data to the States and industry. With the AASHTO-certified laboratory and over 10 years of experience, the Mix Team can quickly evaluate whether new ideas and concepts are viable for further implementation.

IV. RESEARCH OBJECTIVE

The objective of this research is to validate the results of selected NCHRP projects quickly and efficiently through the use of the staff and resources of the FHWA (NCHRP 90-01) Mix Team.

It is anticipated that the research will encompass at least the following tasks:

Task 1. (NCHRP 9-19) Field test the Simple Performance Test in simulations on actual construction projects to develop final test procedure and equipment spec.

Task 2. (NCHRP 9-16) Gyratory & Permanent Deformation field validation studies, procedure refinement and specification development.

Task 3. (NCHRP 4-19(2)) Evaluation of aggregate tests, field validation studies and test procedure refinement and final test development.

Task 4. (NCHRP 9-20) PRS Shadow Studies at plant sites and final procedure development.

Task 5. (NCHRP 9-07) QC/QA Field simulation studies and final tolerance development.

Task 6. Development and ruggedness testing of the Gyratory Compactor angle validation kit.

V. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for a 1-year continuation of Project 90-01 is $750,000.

VI. URGENCY, PAYOFF POTENTIAL AND IMPLEMENTATION

This project will continue the field testing, validation, and AASHTO standardization of products from a variety of NHRP projects using the staff and resources of the FHWA Mix Team. Without such coordinated efforts, the products may have limited practical value. The potential payoff is expected to be high. Implementation of the results will be accomplished through the continuing adoption of the Superpave mix design method.

VII. DATE AND SUBMITTED BY

1 December 2000

TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

II. PROBLEM NUMBER

2002-SUP-90-02

II. PROBLEM TITLE

Superpave -- Binder Equipment and Test Procedures, Refinement, and Field Validation

III. RESEARCH PROBLEM STATEMENT

The dynamic shear rheometer (DSR) is still evolving. The NCHRP 90-02 binder Team is testing and evaluating the device and assessing potential changes to the current AASHTO procedures as well as equipment changes and their impact on the industry as a whole. This work is being done at the request of the TRB Binder ETG and the AASHTO Subcommittee on Materials.

The NCHRP 90-02 Binder Team is developing a new specification for determining the high temperature properties of asphalt binders that will reflect the performance characteristics of modified binders. It is intended that the new high temperature specification will be blind to modifiers.

Preliminary results from NCHRP Project 9-10, which will be completed in approximately 1 year, indicate many more changes are in store for the binder specification. These include changes to the DSR and the addition of some new tests – the Laboratory Asphalt Stability Test (LAST) and the Particle Additive Test (PAT). NCHRP 90-07 will initiate equipment commercialization; NCHRP 90-02 will proceed to procure multiple sets for evaluation, ruggedness, precision-bias, and test protocol completion.

The Direct Tension Tester (DTT) will be the next major equipment added to the AASHTO binder specification. It is almost ready for ruggedness testing. The NCHRP 90-02 Binder Team crew will take the lead in the testing program, working with AASHTO's Asphalt Materials Reference Laboratory (AMRL). Once the device is ready for production testing, state and industry personnel will begin widespread evaluation and testing. The NCHRP 90-02 Binder Team will manage and report on the evaluation and propose necessary changes to the equipment and/or test protocols, if required.

Additionally with the DTT, the NCHRP 90-02 Binder Team will complete a new specification for determining the Critical Cracking Temperature of asphalt binders. It is intended that the new low temperature specification will be blind to modifiers.

The NCHRP 90-02 Binder Team will continue to provide State DOTs independent and unbiased access to technical training and advice on equipment; the Team will continue to be responsive to technical issues generated by the TRB Binder ETG.

IV. RESEARCH OBJECTIVE

The objective of this research is to use the staff and resources of the NCHRP 90-02 Binder Team to further refine and enhance the AASHTO MP1 specification and validate the results of selected NCHRP projects.

It is anticipated that the research will encompass at least the following tasks:

Task 1. Develop a new high temperature binder specification, which better reflects performance of modified binder in the field and validate the specification.

Task 2. (NCHRP 9-10) Conduct further field validation of results and initiate ruggedness and precision and bias studies for new test methods.

Task 3. Evaluate proposed changes to the dynamic shear rheometer at the direction of the AASHTO Subcommittee on Materials and the TRB Binder ETG.

Task 4. Provide the state highway agencies with independent and unbiased access to technical training and advice on equipment procurement.

V. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for this18 month project is $300,000

VI. URGENCY, PAYOFF POTENTIAL AND IMPLEMENTATION

This project will continue the deployment of the staff and resources of the FHWA Binder Team to assist in the field testing, validation, and AASHTO standardization of products from a variety of NCHRP projects and to respond to requests from the AASHTO Subcommittee on Materials and the TRB Binder Expert Task Group for quick-response technical studies. Without such coordinated efforts, new products may have limited practical value. The potential payoff is expected to be high. Implementation of the results will be accomplished through the continuing adoption of the Superpave mix design method.

VII. DATE AND SUBMITTED BY

1 December 2000

TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

PROBLEM NUMBER

2002-SUP-07 (Continuation of NCHRP Project 90-07)

PROBLEM TITLE

Understanding the Performance of Modified Asphalt Binders in Mixes

RESEARCH PROBLEM STATEMENT

Performance data for the validation of proposed changes and refinements to the Superpave system are essential for AASHTO acceptance and adoption. Previous work conducted by FHWA demonstrated the effectiveness of laboratory and full-scale accelerated performance testing (APT) in the assessment of the Superpave system.

Previous work conducted by FHWA has shown the inability of the current Superpave binder specification to capture the performance of modified asphalt binders. In addition, relationships between laboratory and full-scale APT were developed.

The pavement performances of conventional (unmodified) asphalt binders tested by FHWA accelerated load facility (ALF) were found to agree with the Superpave rutting index (G*/sin ä). The performance data also validated the current criterion for the rutting index (2.20-kPa). However, the rutting index, and various other asphalt binder properties, for the two modified binders did <u>not</u> correlate with performance.

NCHRP 9-10, entitled, “Protocols for Modified Asphalt Binders,” reported that some modified asphalt binders could not be graded using the current Superpave specification. NCHRP 9-10 is developing and refining existing tests to be incorporated in to the Superpave binder specification.

NCHRP 9-19, entitled, “Superpave Support and Performance Models Management,” is developing a simple performance test(s) (SPT) for inclusion in the Superpave system. Preliminary screening of candidate tests was performed using material from the previous FHWA full-scale APT, WesTrack, and MnRoad. Any proposed SPT will require additional validation. In addition, NCHRP 9-19 will be developing advanced material characterization tests for use in performance prediction models.

This project is for the laboratory evaluation only. Full-scale testing conducted under the FHWA accelerated load facility will be conducted and funded as part of a pooled fund study.

RESEARCH OBJECTIVE

A comprehensive suite of modified binders, blended to the same performance grade, are being evaluated using the NCHRP 9-10 proposed binder protocols, NCHRP 9-19 simple performance test(s), and laboratory accelerated performance tests. The performance data obtain will be used to validate the proposed changes and refinements to the Superpave system.

The objective of this research is to validate the Superpave binder, mixture, and performance models through the use of laboratory accelerated performance testing. In the process, the project will refine or develop new Superpave asphalt binder tests and specifications and Superpave mixture tests and performance prediction models. These will be used to more accurately predict or estimate the rutting and cracking resistances of modified asphalt binders and mixtures. The following tasks are included in this effort:

(1) Validate or refine current Superpave tests and specifications for modified binders, including those provided by NCHRP 09-10,
(2) If necessary, develop new tests for modified asphalt binders, mastics, and mixtures,
(3) Provide reasons for the behaviors of the various polymer-modified asphalts used in asphalt pavements and why standard asphalt binder tests do not grade complex modified binders correctly, and
(4) Determine if polymers undergo degradation with time.

Under this project, the research team will also provide technical support to the Transportation Research Board Superpave Binder, Mix-Aggregate Expert Task Groups. Additionally, the team will validate the asphalt mixture tests provided by NCHRP Study 09-19, and asphalt mastic tests developed under NCHRP Study 90-09. Both laboratory accelerated mixture tests and an Accelerated Loading Facility (ALF) will be used this study.

Funding for the ALF will be provided under a separate effort.

ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for this project is $500,000. This research will require approximately 18 additional months to complete. Previous funding was provided to FHWA for this project under NCHRP: FY 1999 ($500,000), FY 2000 ($300,000). No additional funding is anticipated to complete this project at this time.

URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

Validation is required for any of the proposed or future changes to be included in the Superpave system. Currently, the Superpave system does not adequately address the benefits of modified asphalt binders. Refinements to the binder specification are needed today. In addition, the inclusion of a simple performance test in the mix design system of Superpave is rated as the number one user need. Validation data, again, is required prior to full acceptance and adoption.

DATE AND SUBMITTED BY

1 December 2000

TRB Superpave Committee

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Transportation Research Board, National Research Council

Second Stage Problem Statement

I. PROBLEM NUMBER

2002-SUP-08

II. PROBLEM TITLE

National Superpave Technology Exposition (2003)

III. RESEARCH PROBLEM STATEMENT

In 1998, the “Superpave: Today and Tomorrow” forum was held in St Louis. It was acclaimed as an important and necessary activity, and one that should be repeated periodically to aid in Superpave implementation. Over 500 people attended the 1998 forum, from nearly every segment of the highway industry as well as 11 foreign countries. The forum provided an opportunity for the asphalt pavement community to see where we have been with Superpave and where we need to go to achieve the maximum benefits of Superpave.

The Forum 2000, held in Denver, was also attended by over 500 people, representing industry and as well as various government agencies. It focused on the next stage of Superpave adoption. The emphasis of presentations centered on the user perspective.

The planned 2003 Conference will take us to the final level of Superpave adoption. It is anticipated that in 2003 most of the States will have completely adopted the Superpave system. The final elements of the material characterization and modeling will be well underway. This conference will focus on performance experiences as well as how the system is meeting the State agencies and industry needs and, in particular, focus on the refinements that have been made to the Superpave system.

IV. RESEARCH OBJECTIVE

The objective of this effort is to conduct in 2003 a nation level forum on the effects of adoption of the Superpave system.

V. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

The estimated funding for this project is $75,000.

VI. URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

Currently over 50% of the State asphalt construction is accomplished using the Superpave system. This conference will share experiences and provide information on user experience and impact of the system on pavement performance. These lessons and experience if properly applied will benefit all the highway agencies and allow them to continue enhance their design of asphalt pavements.

VII. DATE AND SUBMITTED BY

1 December 2000

TRB Superpave Committee

WHITE PAPER ON SUPERPAVE ISSUES OF CONCERN TO THE AGGREGATES INDUSTRY

Prepared by Charles R. Marek
Vulcan Materials Company

July 14, 2000

INTRODUCTORY COMMENTS

This White Paper was prepared at the request of the TRB ETG on Superpave Mixtures and Aggregates. Its intent is to frame aggregate-related issues that currently present challenges to the implementation and use of the Superpave mix design system. There are a number of issues with certain criteria and test methods adopted for use in the Superpave system. Research that has been performed subsequent to The Strategic Highway Research Program (SHRP)is showing that many of the concerns that have been expressed by the aggregate industry are valid. This research shows that changes are necessary to aggregate specifications, acceptance criteria, and test methods. The changes are needed 1) to improve the Superpave system, 2) to allow use of quality aggregates from sources that may not meet the original criteria adopted for use, 3) to match aggregate quality requirements with the application, and 4) to provide high performing, long-lasting hot-mix asphalt pavements.

The Superpave mixture design system is a product of the five years of research developed during the Strategic Highway Research Program that was completed in 1993. New concepts emerged from the research to ensure mixture performance. However, very little work/research was performed on aggregates, which comprise approximately 95 percent by mass of an asphalt concrete mixture.

Departments of Transportation (DOTs) throughout the United States are now implementing the Superpave mixture design system and constructing Superpave projects. Many projects have successfully met all Superpave requirements. However, significant problems have been encountered on some projects, and this has caused considerable concern for materials suppliers, paving contractors, and even personnel of the state DOTs.

The aggregate supplier is concerned because problems have been encountered meeting the specified consensus properties or the source properties or both with certain types of aggregates, including aggregates that are 100 percent crushed. Some aggregate sources are producing a product having particles that are “too cubical” in shape. This results in low fine aggregate angularity (FAA). It may also adversely impact the voids in the mineral aggregate (VMA) for the asphalt mixture. However, the profession determined years ago that cubically shaped particles are desired to produce high performing hot mix asphalt (HMA) mixtures.

A wide variety of mineral aggregate is used to produce HMA. Sand and gravel from river or glacial deposits is processed and used. Crushed stone is also used, and is produced by crushing, sizing, and washing into distinct size fractions or products. All aggregates are not alike, but most can be used to produce high quality, long lasting HMA pavements. Regardless of the aggregate source, processing method, or mineralogy, the aggregate must provide enough shear resistance to resist repeated load applications, and must result in pavements that are resistant to rutting and cracking.

Results of current research, and engineering judgment applied to local conditions, must be considered and permitted, to modify current Superpave criteria and test methods as necessary. Use of an aggregate that has a history of good performance should not be prohibited because the aggregate does not meet all currently specified Superpave criteria.

The proliferation of test procedures is one of the most contentious issues facing the aggregate and contracting industries. Proliferation, and also modification of standard test methods, by state DOTs needs to end. ASTM/AASHTO test methods should be adopted by state DOTs without modification whenever possible.

The aggregate and contracting industries believe that Superpave is a step forward for the hot mix asphalt (HMA) industry. The aggregate industry continues to work on methods and plant modifications, when necessary, to permit production of the specified/ needed products. Large capital investments for hardware, and time, are required to implement a change once it is determined that the change is necessary. The industry cannot make changes overnight. Industry personnel are active at the national and regional level in various associations, with asphalt user/producer groups, with researchers, and with expert task groups (ETGs) and state DOTs to focus on pertinent issues and to develop rational approaches to implementing Superpave.

At the September, 1999 meeting of the Transportation Research Board (TRB) ETG on Mixtures and Aggregates, the aggregate industry was asked to develop a "white paper" that would 1) identify on-going aggregate research, 2) identify areas where additional aggregate research is needed, and 3) identify activities the ETG could undertake to address areas of concern.

The aggregate industry has been given an opportunity to identify their concerns relative to the Superpave design system and Superpave aggregate test methods and acceptance criteria. They have been asked to identify and to recommend activities to be undertaken by the Superpave ETG or by the main TRB Superpave Committee, or both, and to identify/recommend research projects that should be developed for approval and funding through AASHTO and others.

PERTINENT INFORMATION FROM MINUTES OF ETG MEETING (SEPTEMBER ‘99)

The minutes of the Superpave Mixture and Aggregate ETG for the first meeting of the newly formed ETG that was held on September 21-22 contain the following:

"Chuck Marek, a member of the TRB Superpave Committee, was asked to frame the issues currently facing the aggregate industry relative to Superpave which need to be resolved. The following areas of concern were identified by Marek in a presentation given to the ETG at this meeting:

1) Aggregate test procedures, standards and definitions are not being applied uniformly by state agencies throughout the U.S. For example, differences exist in how states measure and implement flat and elongated (F&E) and fine aggregate angularity (FAA) test procedures. Use of the restricted zone varies. Where to draw the maximum density line and control points is different in some states. The concept of promoting the use of variable criteria among states, while still utilizing the same definitions and procedures, needs to be explored.

2) The aggregate industry is concerned with potential problems with the Superpave criteria regarding the restricted zone, FAA, dust-to-binder ratio, VMA (specific gravity values are critical to VMA), tighter grading control (variability in grading). Aggregate producers need to continue to develop test data for each aggregate product. Also of concern is the need to increase the level of competence and understanding of the technicians running these tests.

3) Improvements in the test procedure used to determine FAA are needed. There is significant variability in test results.

4) Excess crusher fine material is being generated at many quarries, and there is less demand to use these materials in coarse graded Superpave mixtures.

5) Some aggregate production operations have experienced difficulty making aggregate to the specific sizes needed in Superpave. Operational and equipment changes in aggregate production at many facilities have resulted in fractionalization of coarse aggregate sizes to meet grading requirements, production of more aggregate fines, more wear on plants, reduced production rates, and increased quality control efforts.

6) Available local materials should be used to the greatest possible extent to minimize transportation costs. The aggregate industry wants to ensure that good materials are used and bad materials are rejected. Valid performance measures need to be developed, the economic impacts of Superpave requirements fully understood, and aggregate research continued.

7) The aggregate industry questions whether or not the equipment changes that have been necessary for production of Superpave aggregates are truly needed, that the aggregate criteria may not be related to HMA performance, and that the requirements are not going to change dramatically again. The industry does not want to incur significant cost to meet current aggregate criteria, and then learn that the acceptance criteria are not valid nor related to mixture performance.

Based on Marek's presentation and subsequent discussion, ETG members associated with the aggregate industry, and "friends" of the ETG in attendance at the

September meeting, summarized several key aggregate issues that need to be addressed as:

1) Recommend test procedure standardization among states (allow variable criteria).

2) Evaluate the VMA criteria (need different requirements for fine and coarse mixture gradings).

3) Eliminate the restricted zone.

4) Conduct ruggedness testing of consensus aggregate test procedures and criteria, and develop precision statements to identify inherent testing variability.

5) Design and use fine-graded aggregate mixtures that meet criteria for Superpave mixture volumetrics, and perform well.

6) Evaluate current fine aggregate angularity (FAA) test procedures (bulk specific gravity, sample grading, and other) and resolve problems being experienced with this test method. Recommend testing of blends, and development and use of acceptance criteria based on relation to mixture application and desired performance.

7) Reexamine F&E criteria, and recommend that acceptance criteria be related to mixture performance.

SUMMARY OF RESEARCH

The **National Center for Asphalt Technology** (NCAT) periodically compiles information on research projects that are currently in progress pertaining to hot mix asphalt pavements. The listing of projects as of April, 2000 is contained in Appendix A of this White Paper. Projects that include aggregate research are denoted by a "bullet" in the left-hand margin. This listing by NCAT is probably the most complete listing of research projects that is available. Input is obtained from many sources, including TRB, ICAR, NAPA, and others. The most current listing can be obtained by visiting the NCAT website at the following address: **www.eng.auburn.edu/center/ncat** and clicking on *Information*, and then clicking on *Research in Progress*.

Research has been performed on various aggregate tests since the conclusion of the Strategic Highway Research Program (SHRP). One recent project was **NCHRP Project 4-19**, *Aggregate Tests Related to Asphalt Concrete performance in Pavements.* This research project evaluated many aggregate tests, and identified a set of nine aggregate tests that the researchers believe relate to performance of HMA. The project did not assess the validity of the identified tests by in-service performance or accelerated load tests. **Validation** is needed, **and adoption and use** of valid tests and acceptance criteria for each test in the Superpave system is critical to the success of Superpave.

NCHRP Project 4-19(2), FY'99 entitled *Validation of Performance-Related Tests of Aggregates for Use in Hot mix Asphalt Pavements* has recently been defined and awarded. The objective of this research project is to evaluate the validity of the aggregate tests identified in NCHRP project 4-19. The Research Project Statement developed by TRB for this project contains the following statements.“The properties of coarse and fine aggregates used in hot mix asphalt (HMA) mixtures are very important to the performance of the asphalt concrete pavements in which used. Many currently used aggregate tests were developed empirically (in Project 4-19) to characterize an aggregate without, necessarily, understanding the direct relationship to the performance of the final product.”

Although Project 4-19(2) will provide information on specific tests to evaluate aggregates, it will not address all of the issues of concern to the aggregate producers and contractors pertaining to the current Superpave mix design system. Additional research is needed, and a recommendation by the TRB ETG for inclusion of some of the needed research in future FHWA and TRB research programs has been made. Recommendations for additional research should be reinforced by the ETG on Superpave Mixtures and Aggregates.

Some states use mathematically combined aggregate properties for aggregate blends because Superpave criteria are based on the total blend of the aggregates. If a given aggregate fails a particular requirement, its use is permitted in the mixture as long as the entire blend does not fail the requirement. In reality, an individual aggregate component that fails to meet the criteria is typically rejected from use. Research recently performed by **Carter and Prowell** in Virginia shows that significant differences exist between the physically and mathematically combined aggregate properties. Tests were performed to determine: bulk specific gravity of coarse and fine aggregate, flat and elongated, fine aggregate angularity, sand equivalent, and sieve analysis. This research showed that the fine aggregate properties are affected most significantly. The authors concluded:“agencies may need to reevaluate the manner in which they calculate aggregate properties for Superpave design”.

Additional studies have been performed by several researchers on issues of concern and importance to the Aggregates Industry. Four pertinent presentations were made at the Transportation Research Board (TRB) 79th Annual Meeting held in January, 2000.

Fernandes and Roque, et. al. (Paper No.1397) reported that although fine aggregate angularity (FAA) contributes to shear strength, other factors such as toughness, grading, and packing characteristics of the fine aggregate overshadow FAA. The FAA criteria rejected some aggregates with high shear strength and accepted aggregates with low shear strength. Aggregate toughness and grading have a dominant effect on shear strength that overwhelms the effect of FAA.
These researchers concluded: “continued use of FAA as a tool for screening or accepting fine aggregates for use in asphalt mixtures must be seriously questioned”.

In a study by **Khosla and Kawaguchi** (Paper No.1061), asphalt concrete mixtures prepared with aggregate gradings that pass through and above the restricted zone met all of the current Superpave system requirements. The authors concluded “that these gradings with crushed and angular aggregates can be expected to perform adequately in the field”.

A study reported by **Epps and Hand** (Paper No.1269) stressed the need for a performance-related test to prevent catastrophic rutting failures in asphalt pavements. They concluded that based on "their study and the observed performance of Superpave mixtures at WesTrack, experimentation with fine graded, rather than coarse graded, Superpave mixtures should be considered and performed".

Mallick, et.al. (Paper No.1105) reported that the researchers observed that substantial differences in VMA exist among different permissible gradings of mix made with aggregate of the same nominal maximum size. The average difference in VMA for a five percent increase in percent passing the 2.36mm sieve was found to be 0.4 percent. The authors concluded "a more rational way of specifying the minimum design VMA will be to specify VMA on the basis of percent passing the 2.36mm sieve rather than the nominal maximum size".

Additional research has been conducted and is contained in the literature. This author did not attempt to conduct an exhaustive review of all of the research that has been performed and as a result, this White Paper does not include reference to all of the research that may have been conducted. However, some of this additional research is summarized below.

McRae has reported that the currently used Superpave criteria of fixed compaction at 0.6 M Pa and fixed air voids at 4 percent will result in serious problems with some Superpave mixtures. This conclusion is based on work performed at the U.S. Army Engineer Waterways Experiment Station (WES), and subsequent WES investigations pertaining to adoption and use of empirical voids criteria. McRae stated that the optimum asphalt content and density is a function of aggregate grading and stress related compaction effort. "The air voids content of a mixture at optimum asphalt content will vary with aggregate grading and porosity as well as with the required amount of compaction". McRae concluded that the current Superpave mixture criteria fail to take this into account. Some, but not all, aggregate industry engineers believe that McRae's position has merit. Additional research of the Superpave mixture criteria should be supported and recommended by the Superpave Mixtures and Aggregates ETG.

Jahn recently reported the results of a research effort at Martin Marietta pertaining to measurement of aggregate particle shape. He believes that Multiple Ratio Analysis (MRA) of the aggregate is an improved method for categorizing the various particle shapes present in an aggregate sample. He reports that "the current Superpave procedure for determining and describing a sample's particle shape provides very limited detail about the variety of particle shapes present in a given sample. Further, the currently accepted measurement method does not give a true representation of a three dimensional particle. Describing the flat and elongated particles present using the percent of particles found at one ratio (e.g. 5 to 1) does not give a true representation of the various ratios in the sample. Jahn believes that Multiple Ratio Analysis may give a more accurate representation of an aggregate sample's particle shape by evaluating the sample on five different ratios instead of just one. Further, Jahn reports that MRA appears to be a sensitive analysis technique that can provide information to allow Superpave mix designers to optimize the combined aggregate grading that best fits the particle shapes present in the aggregate. Rather than force uniform particle shapes across all geologic aggregate types, MRA analysis may identify the particle shapes and the appropriate combined grading suitable for each aggregate material. Further research on this analysis technique (MRA) appears to be warranted, and should be supported by and recommended by the Superpave Mixtures and Aggregates ETG. Also, research to characterize particle shape by three dimensional analysis techniques should be continued.

Dukatz reported on practical factors influencing Superpave performance at an 6th Annual Symposium of ICAR in 1998. He expressed concern for both the FAA and the flat and elongated test methods and current specification requirements, and also reported on *squirrelly mixes* that may occur due to the grading of some mixtures, based on his field experience in producing Superpave mixtures. **Dukatz** stated that "Superpave is still a design method in development. There will be, must be, changes as more is learned from the performance of pavements built and being built. The Superpave mix design procedure must be allowed to grow. The philosophy is sound."

Weingart reported that the mid-Atlantic states have more difficulty than other areas of the country with the Superpave F&E specification "due to the nature of and the greater use of igneous stone and use of older compression cone crushers to manufacture the stone products. He also stated that current work to date with video imaging systems to analyze aggregate shape and grading changes has demonstrated the capacity to readily distinguish shape and grading changes in a reasonably fast time frame. One imaging system that was recently evaluated "provided output that is more discrete and precise than either the current F&E test or a Gilson grading test." **Weingart** believes that a good optical system for measurement of these aggregate properties may be the best bet for the long term, and recommends that additional research be defined and conducted in this direction.

At the 8th Annual International Center for Aggregate Research (ICAR) Symposium in April, 2000 **Hanf** reported his concern and the difficulty that sand and gravel producers are having in meeting Fine Aggregate Angularity (FAA) and Coarse Aggregate Angularity (CAA) consensus requirements for aggregates for asphalt mixtures designed for high traffic volume pavements. He stated that the coarse aggregate crush count of most gravels can be as high as 98 percent, but that a 100 percent two-faced crushed gravel is very difficult (if not impossible) to achieve. Aggregate industry representatives from Indiana, and elsewhere, have reported similar issues in their state. (**Yzenas** commented that the Coarse Aggregate Angularity issue is on the horizon.) Sand and gravel producers are challenged to produce higher quality aggregates and to remain competitive in supplying aggregates for HMA. **Hanf** concludes by stating that "industry is spending millions of dollars to achieve a 100 percent crushed gravel as opposed to a 98 percent crushed gravel." He recommends that research be performed to evaluate the significance of a 2 or 3 percent difference in coarse aggregate crush count (change from 97% to 100%) on the performance of Superpave mixtures designed for high traffic levels.

Hanf also reported that another potential concern of aggregate producers is the moisture sensitivity test, AASHTO T 283. Many producers believe this test is inaccurate, experience different results when the test is performed on 4 in. versus 6 in. specimens, and believe that some anti-strip agents reduce the tensile strength of dry specimens (rather than increase the tensile strength of the moisture conditioned specimens).

Lastly, **Hanf** reported that the bulk specific gravity of the fine aggregate that is used to calculate the FAA can significantly change the uncompacted void content (and consequently, the FAA). A change in bulk gravity of $\pm$ 0.100 can result in a change in FAA of 2 or more points, i.e., from 44 to 46.

Discussion of Some Current Issues/ Problems

Differences exist in the definitions used by various state DOTs relative to the Superpave mixture being specified. For example, 12.5mm Superpave mixtures defined by the MsDOT, by the LaDOTD, and by the AlDOT are all different. This leads to confusion, and potential problems for contractors performing work in multiple states.

In Mississippi, the maximum density line is a straight line on the FHWA 0.45 power grading chart which extends from the zero origin point of the chart through **the plotted point of the combined aggregate grading curve on the nominal maximum sieve size.**

In Louisiana, the maximum density line is a straight line plot on the FHWA 0.45 power grading chart which extends from the zero origin point of the chart through **the nominal maximum sieve size.**

In Alabama, the maximum density line is a straight line on the FHWA 0.45 power grading chart which extends from the zero origin point through the **maximum particle size**. The maximum particle size is defined as the sieve size that is two sizes larger than the first sieve to retain more than 10 percent of the material. Alabama designates the mix by maximum particle size rather than nominal maximum size. Therefore, a 12.5mm mix in Alabama is a 9.5mm mix elsewhere.

Some aggregate sources have problems with the criteria that have been established for aggregate consensus standards. A simple performance test is needed to properly evaluate acceptance criteria for each consensus property. This will help ensure that the criteria are not arbitrary, but rather are related to mixture performance.

Development and implementation of a aggregate testing plan to provide current test data for each aggregate source is recommended. Frequent testing of aggregates for specific gravity is necessary for valid volumetric analysis of Superpave mixtures. Testing each aggregate product on an annual basis is not adequate to properly characterize the aggregate. Since the contractor normally gets paid on compacted mixture volumetrics, more frequent data, and control of aggregate specific gravity, are essential.

Most aggregate production plants are not currently designed to produce fractionated aggregate sizes. Others do not currently have the types of crushers and screens that may be necessary to permit production of the specified aggregate products. Consequently, some producers can not adequately produce the specific sizes currently needed in Superpave. Major plant changes, at substantial cost to the producer, and new permits will be required to change crushers, add screens and conveyors, etc. to enable production of individual sizes necessary for specified aggregate blends. The industry wants to improve the quality of hot mixed asphalt concrete, but may not be able to make all needed changes. The industry is moving towards fractionalization, but slowly, and not at all production facilities. Fractionalization also requires an increase in the number of bins at asphalt plants to handle the greater number of aggregate products used in a given mixture.

The aggregate and contracting industry continues to review what can be done operationally to increase production of aggregate products that meet Superpave requirements and to produce Superpave designed mixtures. Significant upgrades may be required at many aggregate production plants and at some older asphalt plants.

There must be better recognition of appropriate use of available materials that accounts for both performance and economics. Engineers should utilize locally available materials whenever possible to minimize transportation costs, and should utilize these materials to their best technical advantage in each application. This will also maximize the benefit to the taxpayer and to the driving public. Economics must be considered in the design of the pavement, particularly in this time of limited funds available for construction and maintenance and increasing fuel costs.

The industry has placed asphalt concrete mixtures for years that have performed well in both low and high traffic volume situations. This can continue within the Superpave mix design system. However, the same Superpave mix should not be required or used on a rural two-lane road with 50 vehicles per day and on an Interstate highway carrying thousands of vehicles per day. This is a major missing link with implementation of the current Superpave design system. It is causing a great deal of concern within the industry. Different materials and mixture design requirements should be required based on traffic volumes. The highest quality aggregates and Superpave mixtures should be required and used only on some high volume roads of strategic importance.

The restricted zone is intended to eliminate poor performing humped gradings that contain too much round natural sand in relation to total sand. Unfortunately, the restricted zone also eliminates many successful heavy duty, rut resistant mixtures produced with 100 percent crushed aggregate from sources that have been used successfully for many years. Many states prohibit gradings that pass through the restricted zone. At least ten states (Co, Cn, Ga, Ms, NH, Tn, Ut, Vt, Wi, and Va) do not have a restricted zone requirement in their Superpave specifications. States (e.g. Ga) that have granite sources typically have very high performance mixtures that pass through the restricted zone. Best economy is also achieved with these mixes due to the balanced aggregate skeleton that these blends create. Use of all particle sizes produced at an aggregate source is important to keeping extra production and inventory costs at a minimum. Research currently being performed at NCAT, and elsewhere, suggests that asphalt mixtures made with aggregate gradings that pass through the restricted zone exhibit performance qualities equal to and even better than mixtures made with other gradings of aggregate. The restricted zone is not needed, and its use in Superpave specifications should be eliminated.

Differences often exist for certain geologic types of aggregates between the grading of aggregate used in laboratory design and the grading of the same aggregate products and proportions used in the field mixture. As a consequence, aggregates obtained from the aggregate production plant may need to be 5 to 10 percent coarser (to account for grading changes that occur during transport, handling, and mixing) in order to meet mixture design volumetric requirements in the field. However, an aggregate product that is 5 to 10 percent coarser at the aggregate production facility may not meet Superpave grading requirements (and may be rejected from consideration). Mixture designers, specifiers, and field plant personnel should become knowledgeable in the properties of aggregates obtained from specific sources, and should permit adjustment of aggregate gradings during laboratory mixture design to be representative of the aggregate gradings that will be received and used at the asphalt plant.

RECOMMENDED ACTIONS TO BE TAKEN BY THE ETG

The issues set-forth and discussed herein are Superpave issues, and not issues currently facing only the aggregate industry. Some elements of the Superpave system are not correct, and should be changed or corrected. Aggregate producers, paving contractors, and government agency personnel must all do a better job than what we have done in the past. Efforts to partner and to learn together, and to improve the Superpave System must continue in order to achieve the greatest benefit. The Mixtures and Aggregates ETG should take appropriate actions to address and correct significant issues that have been identified herein.

The recommended actions identified below have been grouped, per request of the Superpave Mixtures and Aggregates ETG Chairman Ron Sines, into one of four categories. These categories include: Informational, Regional Issues, Standards Changes, and Needed Research. The Recommended Actions have also been prioritized within each category.

INFORMATIONAL

1) The ETG should request an immediate, fast track effort by TRB to synthesize all published and currently on-going research on aggregate properties and aggregate acceptance criteria for use in Superpave. This review and compilation should be performed by an *independent* source.
2) Aggregate producers must perform more frequent tests on aggregate products produced for Superpave mixtures. Properties such as fine aggregate and coarse aggregate specific gravity must correctly reflect the properties actually used in the mixture. The ETG should encourage aggregate producers to develop appropriate testing and quality control plans to provide accurate information for use in Superpave mixture design.

REGIONAL ISSUES

3) Some source properties, such as L.A. degradation, have not been related to the performance of a Superpave mixture, and therefore, the validity of state DOT acceptance criteria is questioned. Research on source properties for various geologic aggregate types used in HMA should be supported and recommended by the ETG. In

particular, the influence of L.A degradation loss on asphalt mixture performance should be evaluated, and current guidelines and/or acceptance criteria should be validated, or revised.

4) The use of locally available aggregates should be encouraged if they will not adversely impact the performance of the Superpave mixture. Engineering judgment should be permitted in Superpave mixture design to avoid excessive transportation costs for materials that will be incurred when the local materials are not within the acceptance criteria.

STANDARDS CHANGES

5) The ETG should recommend to AASHTO SOM that the basic definitions used by all state DOTs in the Superpave mix design system be standardized. (For example, a 12.5 mm design should have the same maximum density line and control points in each state). In addition, the proliferation of aggregate test procedures by state DOTs should be discouraged. The ETG should support and recommend that the *best test methods* (ASTM or AASHTO methods if good, or some other method if better than ASTM/AASHTO) for aggregate properties be adopted and used by all state DOTs without modification and without tweaking.
6) The ETG should recommend consideration and acceptance of aggregate blends that meet Superpave requirements that are anywhere within the grading control points. The Restricted Zone should be eliminated. The ETG should encourage State DOTs to consider blends that are on the fine side as well as on the coarse side of the band. Experience with fine-graded Superpave mixtures at WesTrack supports this recommendation. Forcing the use of gradings that only go below the maximum density line should be eliminated. Consideration and use of fine-graded Superpave mixtures and mixtures having gradings that pass through the restricted zone should be encouraged.
7) The ETG should encourage development of proper corrections and adjustments to aggregate gradings used in the laboratory design process (to account for changes that may occur during handling, transport, and mixing), and encourage state DOTs to permit use of the adjusted gradings in the design process.
8) The significance of test method precision should be recognized, and the inherent variability of each test should be properly reflected in Superpave mixture acceptance criteria. The ETG should recommend that state DOTs incorporate test method precision into their specifications and acceptance criteria.
9) Differences will be experienced between the grading of the aggregate components used in the laboratory design of Superpave mixtures and the grading of each aggregate in stockpiles at the asphalt plant. These differences should may be significant. Specifying agencies should allow the contractor to modify the mixture design (adjustment to the aggregate blends) in the field to account for these differences. The ETG should encourage field verification of a mix and adjustment as necessary, and without penalty, to ensure that the mix will perform as designed.

NEEDED RESEARCH

10) The ETG should recommend and promote development of valid performance measures and related tests. A performance measure and test will allow the mix designer to use available aggregates to their best technical advantage to achieve cost-effective HMA pavements for each application.
11) The use of the fine aggregate angularity (FAA) test and current FAA acceptance criteria should be reexamined. Many aggregate suppliers question the validity of the test method. The ETG should recommend that research be performed on the test method a) to establish the validity and applicability of the method, b) to establish the sensitivity of the method and the results to specific test parameters (size of sample, size of orifice, height of free fall, size of collection cylinder, etc.), and c) to validate current acceptance criteria. Since 100 percent crushed sands perform well in asphalt mixtures, the ETG should support and recommend acceptance of use of 100 percent crushed, angular, sharp edged aggregate products in Superpave mixtures **without** a FAA requirement.
12) The ETG should recommend that the minimum VMA required for a given Superpave design should be a function of aggregate grading, not just the nominal maximum size of the aggregate. The need for a maximum (or upper) VMA limit should also be thoroughly researched. Further, the influence of variability of aggregate grading on mixture volumetrics has not been adequately researched. Mixture volumetrics may change dramatically with a small change in grading for some geologic types of aggregate. The ETG should recommend that research be performed to determine the amount of variation that may be experienced in aggregate grading at the HMA plant, and to evaluate the significance of this variability on the volumetric properties of a Superpave mixture. Acceptable and realistic tolerance limits for grading should then be established and recommended.
13) Proposed limits for flat and elongated particles at 3 to 1 should be thoroughly researched, and the impact of F&E on mixture performance should be determined, prior to a change of Superpave acceptance criteria. Research by NCAT, and more recently by the Asphalt Institute, shows that the percent F&E in the mix has little to no adverse impact on mixture performance in the laboratory.
14) The significance of a 2 or 3 percent difference in coarse aggregate crush count (change from 97% to 100%) on the performance of Superpave mixtures designed for high traffic levels using a crushed gravel aggregate should be researched. This research will determine the effect that this change may have on the performance of Superpave mixtures. The ETG should support and recommend that this research be performed.
15) The use of the Superpave criteria of fixed air voids at 4 percent should be carefully reexamined. The ETG should recommend that research be performed on the validity of use of the empirical voids criteria, and that future Superpave criteria should consider the influence of aggregate grading and porosity and compaction.
16) The tests for aggregates identified in NCHRP 4-19 should be validated, and the ETG should support and recommend adoption and use of those tests that are valid and relate to pavement performance.
17) The validity of the moisture sensitivity test, AASHTO T 283, is of concern to aggregate producers and others. The ETG should continue its efforts to support

research of this test, or to develop an alternate test that more accurately relates to mixture performance.

18) The ETG should recommend research pertaining to Multiple Ratio Analysis for characterizing aggregate shape. It should also encourage determination of particle shape and then optimum grading, rather than vice versa, to minimize the requirement of a uniform particle shape for all geologic aggregate types. Further, video imaging systems have demonstrated a capacity to readily distinguish aggregate shape and grading changes quickly and accurately. These systems permit separation of an aggregate into separate individual sizes, and then classification as desired for shape or size distribution or both. The ETG should support and recommend continuing research in this area.

Disclaimer

This White Paper was written and reviewed by a limited number of individuals from the aggregate industry, and consensus was achieved amongst this group. The ideas and thoughts expressed in the White Paper have not received review by the entire industry. Additional review should be performed, and comments and input from others within the aggregate industry should be solicited. Therefore, this White Paper should be considered by the Superpave Mixtures and Aggregates ETG members as a document in progress, subject to change as additional information becomes available.

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3) Carter, Chester B., and Prowell, Brian D., *Comparison of Mathematically and Physically Blended Aggregate Properties*, Paper submitted to TRB Committee A2J03 for consideration for presentation at the Transportation Research Board (TRB) 79th Annual Meeting, January 9-13, 2000 in Washington, D.C.

4) Fernandes and Roque, et. al., *Paper No.1397* presented at the Transportation Research Board (TRB) 79th Annual Meeting, January 9-13, 2000 in Washington, D.C.

5) Khosla and Kawaguchi, *Paper No.1061* presented at the Transportation Research Board (TRB) 79th Annual Meeting, January 9-13, 2000 in Washington, D.C.

6) Epps and Hand, *Paper No.1269* presented at the Transportation Research Board (TRB) 79th Annual Meeting, January 9-13, 2000 in Washington, D.C.

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Randy **Weingart** (Luck Stone),
Randy **West** (APAC),
Sam **Woolwine** (W.W Boxley), and
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RESEARCH IN PROGRESS

(as of November, 2000)

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

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Alabama	Collection and Analysis of QC/QA Data for Superpave Mixes	NCAT	103,100	2000	Title self-explanatory.
Alaska	High Temperature for Alaskan Asphalt Pavements	Saboundjian, Alaska DOT	10,000	October 2000	Develop high air and pavement temperature relationships for Alaskan climatic zones.
Alaska	Implementation of Successful Asphalt Mix Designs	Saboundjian, Alaska DOT	20,000	October 2000	Compile historical asphalt mix designs data and correlate to existing pavement performance data in order to implement the most effect9ive aggregate gradation for a given location.
Arkansas	Loaded Wheel Tester (LWT) Based SHRP Mix Design	Hardison, Arkansas DOT	150,000	March 2001	Determine how LWT correlates with field performance in Arkansas using the Asphalt Pavement Analyzer (Georgia Loaded Wheel Tester).
Arkansas	Wheel Track Testing for Rutting and Stripping	Hall, Univ. of Arkansas	129,000	September 1999	Same as above with a Hamburg Type machine.
Arkansas	Review of Flexible Overlays on the Interstate System	Black, Arkansas DOT	N/A	N/A	Monitor the performance of HMA overlays on PCC pavements.
Arkansas	Asphalt Additives Exp. Proj. #3	Austin, Arkansas DOT	N/A	N/A	Monitor a rubber modified asphalt pavement on PCCP.
Arkansas	Effectiveness of Pot Hole Patching Materials	Hardison, Arkansas DOT	N/A	N/A	Evaluate different products and methods for repairing pot holes in asphalt pavements.
Arkansas	Permeability of Superpave	Hall, Univ. of Arkansas	225,000	July 2000	Develop strategies for considering permeability during design and construction.
Arkansas	ERSA LWT Testing for Rutting and Stripping	Hall, Univ. of Arkansas	158,000	January 2000	Screen mixes and develop proof testing for Superpave mixes as related to rutting and stripping.

Arkansas	Quality Control for Superpave	Gazin, Arkansas DOT	78,000	June 2002	Compare current Arkansas procedures with procedures outlined by NCHRP.
Arkansas	Stone vs. Asphalt Treated Bases	Bennett, Arkansas DOT, Dennis, Univ. of Arkansas	60,000	June 2001	Develop design guidance that will aid the designed regarding the proper selection of base material for pavement design.
Colorado	In-Place Void Monitoring	Aschenbrener, Colorado DOT	50,000	1999	Validate the air voids in field pavements with the Superpave gyratory compactor. 22 field projects have been constructed.
Connecticut	Demonstration and Evaluation of Superpave Technologies	Lane and Larsen, Connecticut DOT	250,000	December 2002	Assess QC/QA procedures set forth in NCHRP Project 9-7, and evaluate the performance of Superpave mixes using both virgin and recycled aggregate.
Florida	Implementation of SHRP Indirect Tension Tester to Mitigate Cracking in Asphalt Pavements & Overlays	Roque, University of Florida	330,000	1999	Provide FDOT with a practical & effective system to obtain & specify relevant asphalt mixture properties needed to design crack resistant pavements & overlays.
Florida	Development of a Suitable Procedure for Simulating Aging Effects of Hot Mixing on Modified Asphalts for Use in Superpave Binder Specifications	Tia, University of Florida	190,000	1999	Investigate the feasibility of a modified Rotavapor for simulating the aging effects of hot mixing on modified asphalts, & develop an effective & convenient test set-up & procedure for this purpose.
Florida	Evaluation of an Alternative Solvent for Extraction of Asphalt to Reduce Health Hazards	Roque, University of Florida	150,000	N/A	Title self-explanatory.
Florida	Evaluation of Superpave Criteria for VMA and FAA.	Roque, University of Florida	200,000	N/A	Title self-explanatory. Study started in 1998.
Florida	Investigation of the Suitability of the Asphalt Pavement Analyzer for Predicting Pavement Rutting	Choubane, Page, Musselman, Florida DOT	N/A	N/A	Title self-explanatory.

Florida	Comprehensive Monitoring of Field Performance of Superpave Projects	Roque, Tia and Birgisson, University of Florida	1,500,000	July 2004	Long term evaluation of 13 Superpave projects to examine effects of mix properties, traffic level, etc.
Florida	Field Conditioning of Superpave Asphalt Mixes	Musselman, Sholar, and Page, Florida DOT	N/A	August 1999	Examine the effects of conditioning/aging on field produced mixes.
Florida	Follow-Up Evaluation of the Asphalt Pavement Analyzer	Sholar, Musselman, and Page, Florida DOT	N/A	August 1999	Examine the variability of the APA and evaluate the new automated acquisition system.
Florida	Evaluation of CoreLok for Gmm Determination	FDOT Staff	N/A	September 2000	Determine if the CoreLok can be used as a substitute or alternative to the conventional flask method used in Florida.
Florida	Precision of Ignition Oven Using Plant Produced Mix	FDOT Staff	N/A	October 2000	Current precision statements for the ignition oven are based on lab fabricated mixtures which may result in precision values too strict to use in QC/QA.
Georgia	Development of a Computer-Based Pavement Condition Evaluation System	Lai, Tsai, Georgia Tech; Santha, Georgia DOT	238,400	March 2000	To develop a computer-based pavement condition evaluation system for integration into the GDOT Pavement Management System.
Georgia	Implementation of Condition Protocols in the GDOT Pavement Management System	Harris, Texas R&D; Santha, Georgia DOT	39,000	March 1999	To develop a method of demonstrating the implementation of FHWA condition protocols to GDOT and compare existing GDOT data with that of the protocols.
Georgia	Evaluation of Indirect Tension Fatigue Test	Jared, Johnson, Georgia DOT	9,400	January 1999	Evaluate a new asphalt fatigue test which utilizes indirect tension.
Indiana	Second Phase Study of Changes In Service Asphalts	Galal, Indiana DOT	193,000	1999	Validate Superpave binder aging procedure.
Indiana	Ability of Asphalt Additives, Modifiers, and Fillers to Resist Rutting	White, Purdue University	165,000	1999	Determine the ability of various modified asphalt to reduce rutting.

Indiana	Development of a Procedure to Identify Aggregates for Bituminous Surfaces in Indiana	West, Purdue University	82,000	February 2000	Investigate sources for better aggregate quality.
Indiana	Validation of SHRP Asphalt Mixture Specifications Using Accelerated Testing (National Pooled Fund Study No. 176)	Noureldin, Indiana DOT; White, Purdue University	507,000	August 1999	Investigate fine aggregate angularity, VMA requirements, and mixture gradation specified by Superpave.
Indiana	Use of Reclaimed Asphalt Pavement Under Superpave Specifications	McDaniel, Olek, Purdue University	15,000	August 2000	Investigate the applicability of Superpave specifications on recycled pavement.
Indiana	Fine Aggregate Angularity Testing and Performance	McDaniel, Purdue University	15,000	November 2000	Identify better tests that measure fine aggregate angularity.
Indiana	Validation of Superpave Mix Design and Analysis Procedures Using NCAT Test Track	White, Purdue University	909,000	May 2002	Correlate the NCAT Test Track results with those of the APT and PurWheel.
Indiana	Advancing of Superpave System Technology at Indiana Universities	White, Purdue Univesity	62,000	October 1998	Designing a Superpave Technology Course for Indiana Universities.
Indiana	Development of Indiana's SPS-9A Site	Olek, Purdue University	100,000	June 2000	Instrument and monitor pavement for long-term validation of Superpave relationships.
Indiana	Fine Aggregate Angularity	White, Purdue University	81,000	March 1999	Investigate fine aggregate angularity and effect it has on HMA mixtures.
Indiana	Laboratory Verification of Significant Asphalt Mixtures Properties Determined from INDOT Accelerated Pavement Testing Facility	Galal, Indiana DOT	170,000	2000	Title self-explanatory.
Iowa	Determine Critical VMA for HMA Mixes	Coree, Iowa State University	150,000	June 2000	Evaluate VMA criteria as it impacts Iowa aggregates.
Iowa	Measuring Specific Gravity of Fine Aggregate	Coree, Iowa State University; Heitzman, Iowa DOT	N/A	2000	Develop a more objective test method for measuring SSD condition.
Iowa	Effect of Crusher Type on Mixture Properties	Hinrichsen, Seward, Iowa DOT	N/A	2000	Determine which crushers generate better aggregate particle shape.
Iowa	Laboratory Techniques to Optimize Friction	TBA	TBA	2002	

Kansas	Full Depth Bituminous Recycling of I-70	Fager, Kansas DOT	75,000	December 1999	Evaluate various asphalt additives in hot and cold recycled mixes.
Kansas	Aggregate Specifications for Stone Mastic Asphalt (SMA)	Cross, University of Kansas	45,000	May 1999	Evaluate aggregate properties, mixes, aggregate resistance to abrasion and moisture sensitivity.
Kansas	Effect of Segregation on Hot Mix Asphalt Using the Asphalt Pavement Analyzer	Cross, University of Kansas	$10,000	April 2000	Evaluate segregation by using the APA on two Kansas mixes.
Kentucky	Development of ESAL Forecasting Procedures for Superpave Pavement Design	Kentucky Transportation Center (University of Kentucky)	45,000	March 1999	Develop ESAL forecasting procedures for resurfacing projects which will be consistent with Superpave design procedures.
Kentucky	Development of ESAL Forecasting Procedures for Superpave Pavement Design	Kentucky Transportation Center (University of Kentucky)	45,000	March 1999	Develop ESAL forecasting procedures for resurfacing projects which will be consistent with Superpave design procedures.
Kentucky	Determination of Remaining Life for Pavements	Kentucky Transportation Center (University of Kentucky)	202,500	July 2001	Conduct an evaluation of the long-term pavement performance sites in Kentucky; and evaluate the mechanisms of deterioration and failure of each LTPP site.
Kentucky	Evaluation of Experimental Hot-Mix Asphalt Superpave Projects	Myers, Kentucky Transportation Center (University of Kentucky)	112,500	July 1999	Develop a database and performance prediction models for Superpave. Evaluate construction practices involving Superpave projects. Attempt to perform life-cycle cost analyses for Superpave projects.

Kentucky	Evaluation of Compaction at Longitudinal Joint in Asphalt Pavements	Kentucky Transportation Center (University of Kentucky)	135,000	July 2001	Evaluate level of compaction at construction joints in asphalt pavements; determine level of water infiltration and segregation at joint; review other states' specifications and construction practices for joint construction; and develop specifications and construction methods to ensure proper joint density.
Kentucky	Development of Field Permeability Test for Asphalt Pavements and Aggregate Bases	Kentucky Transportation Center (University of Kentucky)	225,000	July 2001	Develop rapid and repeatable field test for measuring permeability of asphalt mixtures and aggregates bases, and develop QC/QA specification for permeability.
Louisiana	Evaluation of Superpave Mix Design for Louisiana Implementation	Abadie, Louisiana Transportation Research Center	240,000	June 2000	Title self-explanatory.
Louisiana	Evaluation of Fatigue Properties of Modified Asphalts	Mohammad, Louisiana Transportation Research Center	75,000	December 2000	Title self-explanatory.
Louisiana	Evaluation of a Loaded Wheel Tester for Asphaltic Concrete Mixtures	Mohammad, Louisiana Transportation Research Center	163,000	December 1998	Title self-explanatory.
Louisiana	Performance Evaluation of Louisiana's Superpave Implementation Projects Utilizing the Superpave Shear Tester	Mohammad, Louisiana Transportation Research Center	78,500	December 1998	Title self-explanatory.
Maine	Utilization of Rubber Modified HMA	Pilsbury, Maine DOT	N/A	December 1999	Evaluate the performance of rubber modified HMA.
Maine	Experimental Use of Pavement Reinforcement Mesh/Fabric to Control Reflective Cracking	Colson, Maine DOT	N/A	June 2000	Determine if the use of either of the two products delay and reduce the amount of reflective cracking.
Maine	Experimental Use of Saw and Sealed Joints to Minimize Thermal Cracking	Colson, Maine DOT	N/A	June 2001	Determine if the saw and sealing process can control thermal cracking.

Maine	Longitudinal Joint Study	Marquis, Maine DOT	N/A	June 2001	Develop a standard paving technique to reduce joint separation.
Maine	Evaluate of "Superpave" Gradation and Performance Graded Asphalt Binders	McClay, Maine DOT	N/A	June 2001	Monitor performance of the "Superpave" pavement and develop cost estimates and life cycle cost analysis.
Maine	Experimental Utilization of Permeable Base	Smith	N/A	June 2001	Monitor performance of permeable base course, establish costs and life cycle cost analysis.
Maine	Treated and Untreated Permeable Subbase on Route 139 in Fairfield	Breskin, Maine DOT	N/A	December 2003	Evaluate the effectiveness of permeable subbase gravel with and without asphalt treatment.
Maine	Evaluation of Permeability of Superpave Mixes in Maine	Mallick, WPI	N/A	November 1999	Evaluate the permeability of Maine's Superpave mixes.
Maine	Quality Assurance Specification Review	Hughes, Fugro-BRE	N/A	May 2000	Evaluate the effectiveness/statistical validity of Maine DOT's quality assurance program.
Michigan	Detecting and Quantifying Segregation in Bituminous Pavements and Relating its Effects to Conditions	Michigan State University	150,000	October 1999	Develop specification based on quantification of segregate.
Mississippi	Polymer Modified Hot Mix Asphalt Field Trial	Albritton and Crawley, Mississippi DOT	127,300	September 1999	Evaluate the engineering properties and performance, especially rut resistance, of dense graded HMA containing specific polymer modifiers.
Montana	Crack Sealing Cost Effectiveness	Freeman, Montana State University	93,000	February 2002	To determine most cost effective materials and methods for asphalt crack sealing.
Montana	Methods for Remediation of Stripped Asphalt Pavement	Freeman, Montana State University	110,000	May 2000	Title self-explanaory.
New Jersey	Evaluation of Rutting of Asphalt Mixes Using the Georgia Loaded Wheel Tester	Center for Advanced Infrastructure and Transportation (CAIT), Rutgers Univ.	95,000	August 2000	Develop improved pavement performance and design life of HMA.
New Jersey	Polymer Modified Asphalt Binders for Superpave Mixes	CAIT, Rutgers Univ.	213,500	January 2003	Develop improved HMA mix design for rutting resistance.

New Jersey	Characteristics of New Jersey Hot Asphalt Materials	CAIT, Rutgers Univ.	200,000	January 2002	Develop HMA characteristics for mechanistic pavement design.
New Jersey	Correlation of Surface Texture, Air Voids, and Segregation	New Jersey Institute of Technology	80,000	January 2003	Develop improved HMA mix design for the reduction of segregation andimproved surface texture.
Ohio	Polishing and Friction Characteristics of Aggregates Produced in Ohio	Liang, University of Akron	214,178	December 1999	To investigate the specific causes of rapid polishing behavior and the attendant loss of skid resistance of limestone aggregates used on some ODOT districts.
Ohio	Comparison Between Various Laboratory Mixture Permanent Deformation (Rutting) Test Equipment Using Ohio Mixes	Abdulshafi, Ohio State University	157,923	June 1999	To determine if other type(s) of laboratory equipment can be used to produce results consistent and similar to those produced by the SHRP shear device using Ohio materials and mixes.
Ohio	Durability and Performance Characteristics of Hot Mix Asphalt Containing Polymer Additives, Phase I: Laboratory Study	Liang, University of Akron	212,071	May 2001	To evaluate the durability and performance characteristics of two types of polymer modifiers: Styrene Butadiene Rubber (SBR) and Styrene-Butadiene-Styrene (SBS).
Ohio	Pavement Performance Testing	Sargand, Kim, Ohio University	224,916	May 2000	To determine the effect of aggregate characteristics and gradation and polymer modifier on pavement rutting performance.
Ohio	Evaluation of Ohio Superpave Projects	Abdulshafi, Ohio State University	36,116	November 1999	Title self-explanatory.
Ohio	Determination of RAP Content in Asphalt Mixes Based on Expected Mix Durability	Abdulshafi, Ohio State University	159,000	30 months	Determine a rational use of RAP in northern climates based on mix durability.
Oklahoma	Experimental Evaluation of Asphalt Binders	Williams, Oklahoma DOT	200,000	June 2000	Compare performance of HMA with different asphalt binders.

Oklahoma	Permeameter Testing of HMA	Oklahoma DOT	N/A	September 2000	Collect permeability data on roadway cores and correlate to SGC compacted specimens at same density.
Oklahoma	APA Testing	Oklahoma DOT	N/A	October 2000	Develop a specification for using the APA and collect data on existing mixes.
Oklahoma	Stripping Problems in Bituminous Mixtures	Oklahoma DOT	150,000	August 2000	Determine variability in Oklahoma DOT test method and AASHTO T 283.
Oklahoma	Fatigue Round Robin Study Using APA	Oklahoma DOT	N/A	December 2000	Conduct round robin study in cooperation with other states.
Oklahoma	Evaluation of Rutting and Fatigue in Gravel Mixes Using APA	Oklahoma DOT and Oklahoma University	150,000	August 2001	Title self-explanatory.
Oklahoma	Alternative Specific Gravity Measurements by Use of the Corelok	Oklahoma DOT	75,000	October 2000	Evaluate Corelok method of measuring specific gravity of HMA.
Oregon	Crumb Rubber Modifiers in AC Pavement	Hunt, Oregon DOT	150,000	July 1999	Evaluate all CRM mixes constructed in Oregon.
Oregon	Preservation Strategies for ODOT Open-Graded F-Mixes	Rogge, Oregon State University	94,000	May 2001	Title self-explanatory.
Oregon	Using Superpave Technology for Quality Management of HMA	Leahy, Oregon State University	91,000	June 1999	Determine the suitability and cost effectiveness of the Superpave mix design concepts and equipment for ODOT; assess the effectiveness of gyratory compaction for voids management in the field.
Oregon	Development of Open-Graded Compaction Specifications	Rogge, Oregon State University	96,000	June 2000	Title self-explanatory.
Pennsylvania	Stone Matrix Asphalt (SMA)	Ramirez, Pennsylvania DOT	60,000	December 1998	Field evaluation of SMA mix containing a polymer modified binder.

Pennsylvania	Superpave Mix Design Pilot Projects	Ramirez, Pennsylvania DOT	69,800	December 2001	Evaluate the mix design process, production, quality control, quality assurance of Superpave mix designed projects and revise and implement any required specification changes to move to full implementation by 2000.
South Carolina	Investigation of SCDOT Asphalt Mixtures Using the Pavement Analyzer	Hawkins, South Carolina DOT	35,000	June 2000	Use the Asphalt Pavement Analyzer with the GaDOT test procedure and specifications to evaluate the rutting characteristics of SCDOT high performance asphalt mix types (including Superpave).
South Carolina	Development of a Gyratory Design System for Conventional SCDOT HMA Mixtures	Amirkhanian, Clemson Univ.	77,000	June 2001	Develop a gyratory mix dcesign system for the SCDOT's conventional mixes.
South Carolina	Development of a Quality Assurance Program for Asphalt Paving Mixtures (Phase II)	Burati, Clemson Univ.	151,000	October 2000	Develop a quality assurance program for asphalt mixtures based on: (1) quality control (or process control) in South Carolina by the contractor, (2) end result quality acceptance testing by the SCDOT, and (3) independent assurance testing by the SCDOT.
South Carolina	A Laboratory and Field Evaluation of the Use of Waste Materials in Highway Construction	Amirkhanian, Clemson Univ.	205,000	December 1999	Investigate the feasibility of the use of crumb rubber modifiers (CRM), excluding rubberized asphalt, shingles, plastics, glass, and clearing and grubbing debris in highway construction in SC.
Tennessee	Evaluation of the Relative Permeability of Superpave Mixes - Phase I	Jackson, University of Tennessee at Knoxville	90,000	August 2000	Evaluate the relative permeability of Superpave mixes and conventional mixes.

Tennessee	Bulk Specific Gravity of Compacted Bituminous Mixtures	Crouch and Sauter, Tennessee Tech University at Cookeville	87,000	September 2000	Develop a new method, or adapt a current method, for determining bulk specific gravity of compacted bituminous mixtures with wide applicability.
Texas	Evaluation of Repeatability of AASHTO T283	Solaimian, University of Texas	70,000	2000	Title self-explanatory.
Texas	Relationships Between Aggregate Properties and Hamburg Test Results	Solaimian, University of Texas	100,000	2000	Title self-explanatory.
Texas	Evaluation of Superpave Aggregate Specifications	Button, Estakhri, Little, TTI, Texas A&M	300,000	June 2000	Evaluate effects of fine aggregate angularity, restricted zone, VMA on HMA characteristics & performance.
Texas	Evaluation of Shear Strength Properties of HMA for Predicting Performance	Button, Estakhri, TTI, Texas A&M	300,000	August 2001	Determine which of the six SST protocols relate most closely to rutting in a HMA pavement.
Texas	Evaluation of Superpave Shear Tester	Button, TTI, Texas A&M	150,000	2001	Title self-explanatory.
Texas	Model Mobile Load Simulator (MMLS)	Epps, TTI, Texas A&M	100,000	2000	Evaluate performance of MMLS in WesTrack test sections.
Texas	Geotextiles in Flexible Pavements to Reduce Reflective Cracking	Button, Lytton, TTI, Texas A&M	160,000	August 2001	Evaluate geotextiles placed under or within a HMA overlay to reduce or delay reflection cracking.
Texas	Evaluate Non-Specification Properties for Performance Graded Asphalts Which May Affect Performance	Glover, Davison, TTI, CHEN, Texas A&M	385,000	August 2001	Evaluate tests for non-specification properties that impact performance, such as binder fatigue.
Texas	Improved HMA Plant Binder Aging Simulation	Glover, Davison, TTI, CHEN, Texas A&M	206,000	August 2001	Develop an Improved HMA Plant Binder aging procedure that will apply to both modified and unmodified materials.
Texas	Research Support for the Addition of Tire Rubber in Asphalt	Glover, Davison, TTI, CHEN, Texas A&M	500,000	September 1999	Develop methods for improving asphalt binder performance through the use of ground tire rubber.
Texas	Superpave Binder Tests for Surface	Epps, Estakhri, Glover,	222,000	August 2001	Develop a grade selection

	Treatment Binders	TTI, Texas A&M			algorithm for selection of PG surface treatment binders and an associated specification.
Texas	Evaluation of Densities of HMA Pavements Along Longitudinal Construction Joints	Estakhri, Freeman, TTI, Texas A&M	79,000	August 2000	Assess the density along the longitudinal construction joint of 48 Texas pavements and modify current HMA specs to require joint density measurements if justification is verified.
Texas	Long-Term Research on Bituminous Coarse Aggregate	Little, Button, TTI; Jayawickrama, Texas Tech; Solaimanian, University of Texas	750,000	August 2004	Conduct a process review of testing and monitoring protocols in TxDOT's Aggregate Quality Monitoring Program and develop system improvements.
Texas	Hot Mix Performance from Measured Properties	Fernando, Scullion, TTI, Texas A&M	1,000,000	August 2004	Develop nondestructive test procedures for evaluating the quality of the finished pavement during construction on the basis of its predicted performance.
Utah	Evaluation of Trinidad Lake Asphalt to Enhance Pavement Performance	Anderson, Utah DOT	N/A	2004	Evaluate the effect of 25% Trinidad Lake Asphalt on mix properties and pavement performance.
Vermont	Pavement Performance and Annualized Cost Survey	Graham, Gilman, Vermont DOT	45,000	September 2001	To determine the life cycle cost of pavements in Vermont.
Vermont	Permeability of Superpave Mixes	Pockette, Vermont DOT	80,000	2005	Evaluate the relationship of in-place air voids with permeability of Superpave mixtures.
Vermont	RAP in Superpave	Pockette, Vermont DOT	55,000	2001	Evaluate the effect of RAP in Superpave mixtures and binders.
Vermont	Longitudinal Joint Compaction	Ross, Vermont DOT	N/A	N/A	Investigate compaction levels of tapered longitudinal joints in HMA pavements.

Virginia	Superpave Implementation	Prowell, VTRC	290,000	2000	Investigate criteria for base mixtures and low volume roads. Support operations during implementation through testing, training, and field support.
Virginia	RAP in Superpave	Prowell, VTRC	89,000	2000	Evaluate methods of characterizing RAP for use in Superpave.
Virginia	Flat/Elongated Aggregate Shape Measurements	Prowell, VTRC	N/A	N/A	Evaluate precision of ASTM D4791 and ability of VDG-40 videograder to measure aggregate shape.
Virginia	Asphalt Permeability	Maupin, VTRC	85,000	2000	Investigate test methods and measure permeability of typical mixes.
Virginia	Stripping Investigation	Maupin, VTRC	147,000	2001	Determine damage associated with visual stripping and investigate Asphalt Pavement Analyzer as a prediction tool.
Virginia	Alternative Primes	Maupin, Payne, VTRC	N/A	N/A	Perform field trials of primes as replacements for cutbacks.
Virginia	Mechanized Pothole Patcher	Maupin, Payne, VTRC	N/A	N/A	Evaluate truck mounted pothole patcher.
Washington	Cyclic Segregation	Mahoney, Univ. of Washington	88,000	December 2000	Investigate the extent of segregation caused by temperature differentials.
Washington	Quality Assurance Specifications	Mahoney, Univ. of Washington	120,000	October 2000	Assess and modify current QA specifications for asphalt concrete.
Washington	EVERFE II	Mahoney, Turkiyyah, Univ. of Washington, Davids, Univ. of Maine	127,000	February 2000	Develop finite element software to model asphalt pavements.
Wisconsin	Reflective Cracking & Tenting in Asphalt Overlays	Busche, Wisconsin DOT	N/A	December 1998	Evaluate the effects of open-graded base on reflective cracking & tenting of HMA overlays.

Wisconsin	Superpave Validation and Implementation	Rita Leahy, Oregon State University	144,092	January 1999	Determine if SHRP/Superpave concepts yield mix designs that perform comparable to or better than those based on Hveem technology and to determine if the Superpave Shear Tester is an effective tool for predicting performance.
Wisconsin	Cyclic Segregation	Joe Mahoney, University of Washington	76,000	March 1999	Determine if cyclic segregation is the result of temperature differentials from cooling of the mix during transport from the plant to the paver.
Wisconsin	Investigation of Modified Asphalt Concrete Performance Using SHRP Binder Specifications	Russell, University of Wisconsin	N/A	December 1999	Title self- explanatory.
Wisconsin	Evaluation & Correlation of Lab & Field Tensile Strength Ratio (TSR) Procedures	Bahia, University of Wisconsin	N/A	To be determined	Determine if Wisconsin pavements have moisture damage problem based on laboratory & field TSR values. If so, establish the testing procedures & criteria.
Ontario, Canada	Pavement Smoothness by Profilograph	Tam, Blair, Ontario Ministry of Transportation	40,000	April 2000	To investigate how the smoothness specification will impact on single lifts, night paving, cold-in-place and hot-in-place mixes.
Ontario, Canada	SP-9A Superpave Trial, Petawawa, Ontario	Tam, Virani, Ontario Ministry of Transportation	50,000	February 2003	Monitor trial sections completed in 1997 using Superpave and conventional mix designs.
Ontario, Canada	Evaluation of the Performance of Enhanced (Polymer-Modified - PMA) and Engineered Asphalt	Tam, Erb, Ontario Ministry of Transportation	10,000	N/A, on-going	Compare the relative performance of enhanced and conventional asphalt in hot mix.

Ontario, Canada	Superpave PGAC Monitoring and Evaluation	Ontario Ministry of Transportation and Industry	10,000	March 2002	Test samples of various mix types for evaluation of attributes which can replace recovered penetration used for QA of regular and recycled mixes.
Ontario, Canada	Specification and Construction of Stone mastic Asphalt Trials in Southern Ontario	Ontario Ministry of Transportation	700,000	March 2002	Evaluate the cost benefits of SMA and Modified Open Friction Course (OFC) and develop more durable premium mixes.
Ontario, Canada	Ignition Oven	Ontario Ministry of Transportation and Industry	20,000	October 2001	Assess the effect of the ignition furnace on ERS payments when carbonate aggregates are used.
FHWA	Evaluation of Crumb Rubber Modifier (CRM) in Asphalt Pavements, Phase II	Oregon State University	2,500,000	September 1999	Develop guidelines for the use of CRM in HMA pavements.
FHWA	Recycling of Asphalt Pavements (Training Course)	Kandhal, Mallick, NCAT	166,400	May 1999	Develop a training course for recycling of asphalt pavements and conduct 9 workshops.
FHWA	Critical Cracking Temperature of Binder	Dongre, FHWA; Bouldin, Koch Materials; Anderson, Penn State; Reinke, Mathy Construction; and Klutz, Shell	N/A	December 1999	Develop a new test procedure and specification for determining the critical cracking temperature of asphalt binders.
FHWA	Effect of Hydrated Lime on the Ignition Oven Calibration	D'Angelo, FHWA	N/A	June 2000	Title self-explanatory.
NCHRP	Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures (NCHRP 1-37)	Hallin (ERES), Nichols, Consulting Engineers	400,000	December 2001	Title self-explanatory.
NCHRP	Superpave Protocols for Modified Asphalt Binders (NCHRP 9-10)	Bahia, Asphalt Institute	845,800	October 1999	Recommend modifications to the Superpave asphalt binder tests for modified asphalt binders.
NCHRP	Segregation in Hot-Mix Asphalt Pavements (NCHRP 9-11)	Stroup-Gardiner, NCAT	300,000	June 1999	Develop procedures for defining, locating, and measuring segregation and evaluate its effect on HMA pavement properties.

NCHRP	Incorporation of Reclaimed Asphalt Pavements in the Superpave System (NCHRP 9-12)	McDaniel, Purdue University	400,000	March 1999	Develop guidelines for incorporating RAP in the Superpave system.
NCHRP	Evaluation of Water Sensitivity Tests (NCHRP 9-13)	Epps, University of Nevada	150,000	March 1999	Evaluate AASHTO T-283 and recommend changes to make it compatible with the Superpave system.
NCHRP	Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification (NCHRP 9-14)	Kandhal, NCAT	400,000	April 2000	Title self-explanatory.
NCHRP	Quality Characteristics and Test Methods for Use in Performance-Related Specification of HMA Pavements (NCHRP 9-15)	Killingsworth, Brent-Rauhut Engineering	450,000	December 2001	Title self-explanatory.
NCHRP	Relationship Between Superpave Gyratory Properties and Permanent Deformation of Pavements in Service (NCHRP 9-16)	Anderson, Asphalt Institute	250,000	24 months	Using Superpave gyratory compactor to predict rutting.
NCHRP	Accelerated Laboratory Rutting Tests: Asphalt Pavement Analyzer (NCHRP 9-17)	Kandhal, NCAT	27 months		Evaluate APA test for predicting rutting potential of HMA.
NCHRP	Field Shear Test for Hot Mix Asphalt (NCHRP 9-18)	Christensen, Pennsylvania State University	200,000	20 months	Enhance and refine the field shear test device for QC/QA of HMA production.
NCHRP	Superpave Support and Performance Models Management (NCHRP 9-19)	Witczak, University of MD	1,700,000	26 months	Develop and validate an advanced material characterization model for HMA.
NCHRP	Performance-Related Specifications for HMA Construction (NCHRP 9-20)	Epps, Nevada Automotive Test Center	1,500,000	January 2000	Develop performance related specifications for HMA construction and provide early field verification of the Superpave mix design method.

N/A = not available