

SUPERIOR PERFORMING ASPHALT PAVEMENT

# SUPERPAVE

Performance by Design

FINAL REPORT OF THE TRB SUPERPAVE COMMITTEE



TRANSPORTATION RESEARCH BOARD  
OF THE NATIONAL ACADEMIES

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**TRANSPORTATION RESEARCH BOARD**  
OF THE NATIONAL ACADEMIES

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Under the guidance of the TRB Superpave Committee and the Expert Task Group on Communications, the report was drafted by Neil F. Hawks, Director, Special Programs Division, TRB, and by Linda Mason, Communications Manager, who also edited the report and managed its design and production.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

E. Dean Carlson, Carlson Associates, Topeka, Kansas; Raymond K. Moore, University of Nebraska, Lincoln, College of Engineering and Technology, Omaha, Nebraska; and Freddy L. Roberts, Louisiana Technology University, Ruston, Louisiana.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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Administration

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Special Programs Division  
Transportation Research Board

Neil Hawks  
Director  
Special Programs Division  
Transportation Research Board

### CONSULTANT

Ted Ferragut, PE  
TDC Partners, Ltd.



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## PREFACE

Superpave®, a principal product of the Strategic Highway Research Program, is a system of standard specifications, test methods, and engineering practices that enable the appropriate materials selection and mixture design of hot mix asphalt to meet the climatic and traffic conditions of specific roadway paving projects. Through use of this system, highway engineers and constructors can build pavements that last longer, require less maintenance and have a lower life-cycle cost than pavements designed using previous engineering methods.

The origin of Superpave can be traced back to 1984 and the Transportation Research Board's (TRB) publication of Special Report 202, *America's Highways: Accelerating the Search for Innovation*. The committee that authored this report concluded that, despite its dominant position among highway materials, research into asphalt cement or binder had been long neglected and a strategically focused research program could “develop improved asphalt binders.” Building from the recommendations offered by Special Report 202, in 1986, the American Association of State Highway and Transportation Officials (AASHTO) released recommended research plans for a program of strategic research that broadened the focus of asphalt research to include mixture design methods. In 1987, the U.S. Congress funded the Strategic Highway Research Program (SHRP).

In 1993, SHRP was completed with the delivery of 130 research products for implementation among transportation agencies and other segments of the highway industry. The agents of implementation, including innovative partnerships and funding arrangements, teams, training, and research centers, were deployed at various times throughout the process. The timeline in Figure 1 captures the sequence of some major events, but of course, cannot evoke the contributions of those whose commitment brought them about.

This report summarizes the work of the TRB Superpave Committee, which was formed in 1999 to advise AASHTO and the Federal Highway Administration on a research plan that would further the development and deployment of the Superpave system. The committee's work, however, is part of a larger canvas. Implementation efforts that began well before the committee was formed and still continue are the context for its work. For that reason, this report also briefly sketches the story of the campaign to bring the SHRP asphalt research products, organized as the Superpave system, into general use. Because this retelling of the story is

**FIGURE 1: SUPERPAVE IMPLEMENTATION TIMELINE**



necessarily brief, it will only offer highlights from the deployment campaign. This is doubly hazardous. Aspects of the campaign critical to its success will go unmentioned and the contributions of many organizations and hard-working individuals will go unacknowledged. Furthermore, lessons to be learned from the innovative techniques used in this campaign may go untaught and the innovations themselves lost to future technology deployment efforts. For these reasons, the members of the TRB Superpave Committee have recommended that the full “history” of Superpave development and deployment be captured for future study. *(The recommendation is made in the Committee’s 11th letter report to the Federal Highway Administration and the American Association of State Highway and Transportation Officials, which is on the Web at [http://www4.trb.org/trb/dive.nsf/web/superpave\\_final\\_letter\\_reports](http://www4.trb.org/trb/dive.nsf/web/superpave_final_letter_reports))*

Joseph A. Mickes  
Chairman,  
TRB Superpave Committee

## EXECUTIVE SUMMARY

Long-lasting pavement that requires less maintenance, provides a smooth ride, and is a good value for taxpayers were the goals for asphalt research conducted during the Strategic Highway Research Program (SHRP), which ended in 1993. At that time, focus and funding shifted to the task of applying what was learned and implementing the test methods, engineering practices, and standard specifications that together comprise the Superpave system for selecting materials and designing pavement mixtures to meet specific climate and traffic conditions.

Although a prototype system was ready for deployment, its further refinement would require active guidance by experienced hands. This report briefly recounts the actions and outcomes that were the contributions of the Transportation Research Board Superpave Committee to a nationwide implementation effort. A brief sketch of that broader effort is included in chapter 3 to provide context for the committee's work.

Six years after the first full-scale production projects designed in accord with the Superpave system were placed in 1996, the asphalt industry awarded its highest honor to projects built with Superpave. That has remained the case for three consecutive years, illustrating that the system has become a mainstreamed technology. A survey conducted by the TRB Superpave Committee to determine current use of Superpave found that 50 of 52 responding transportation agencies report general use of the Superpave asphalt binder standard specification; the other two agencies are initiating plans to do so. Of the 52 responding agencies, 36 report general application of the Superpave mixture design standard, with 12 others reporting use on high-volume highways. Three other agencies have plans to initiate use. Results of the survey are discussed in chapter 1.

The work of the TRB Superpave Committee was organized by what became known as the 2005 Plan. Designed to meet four specific goals related to integrating Superpave into asphalt pavement engineering practice, the plan matched the four goals with four types of activity related to research, standards development, and technology transfer. Between 1999 and 2005, 25 research projects related to developing and integrating Superpave were carried out through TRB's National Cooperative Highway Research Program (NCHRP). Chapter 2 relates the goals of the 2005 Plan to the current status of efforts to meet them.

Although it is apparent that implementation efforts have succeeded and that Superpave has in fact been mainstreamed, members of the TRB Superpave Committee share concerns in several areas of application. Chapter 4 discusses the committee's recommendations regarding opportunities to improve, extend, or enhance the Superpave system and the performance of hot-mix asphalt. In particular, the committee affirms that maximizing the value of the investment in Superpave will require:

- studying the interactions that result in moisture damage to asphalt,
- developing calibrated, mechanistic HMA performance models,
- continuing research on mechanistic HMA performance models,
- meeting the mixture design needs of local transportation agencies,
- working with the construction industry to achieve well-built pavements, and
- ensuring that the useful lessons from this technology deployment program are available to others.

# 1

## CURRENT STATUS OF SUPERPAVE IMPLEMENTATION

The first Superpave pavement was constructed on July 8, 1992, when the Mathy Construction Company of Onalaska, Wisconsin, and the Wisconsin Department of Transportation placed the first 500 feet of hot mix asphalt conforming to the then-prototypical Superpave asphalt binder and mixture specifications (*Focus*, 9/92). This 3-inch thick overlay was part of a pilot study for a larger pavement performance experiment designed to validate the Superpave system. The first 95 full-scale production projects designed in accord with the Superpave system were placed in 1996.

Six years later, and for three consecutive years, the winner of the asphalt pavement industry's prestigious Sheldon G. Hayes award, as well as both finalists in 2004, used Superpave mixes to build their winning projects. When asked if any conclusions about Superpave could be drawn from these awards, David Newcomb, P.E., Ph.D., Vice President for Research and Technology at the National Asphalt Pavement Association (NAPA), offered that it illustrates how mainstreamed Superpave has become and shows that Superpave is a constructible mix that lends itself to quality pavement.

To determine the extent to which Superpave has entered the mainstream, the TRB Superpave Committee, with the assistance of the Canadian Strategic Highway Research Program, in March of 2005, conducted a survey of the current use of Superpave asphalt binder and mixture standards among American state and Canadian provincial departments of transportation (DOTs). This survey

was a follow-on to similar surveys initially conducted by the American Association of State Highway and Transportation Officials (AASHTO) Lead States Team. The last of these was conducted in 2000 by the New York State DOT and the Federal Highway Administration (FHWA) at the behest of the Superpave Committee (*Mack 2001*).

### ASPHALT BINDER STANDARDS

Responses to the 2005 survey from the DOTs of the 50 states, the District of Columbia, and Puerto Rico, indicate that the application of the Superpave asphalt binder standard specification (AASHTO M 320) is almost universal and will be so by the end of 2006. Currently, 50 of these 52 agencies reported general usage. The two agencies not yet using the Superpave binder standards, the Alaska DOT and Caltrans, reported they are initiating plans for general use. Alaska uses the Superpave binder standards on some projects now and California will deploy the binder standards in 2006. Seven of the 10 provincial DOTs also reported general use of Superpave binder standards.

Several other agencies also responded to the survey. The Central Federal Lands Division and the Western Federal Lands Division of the FHWA reported general use of the binder standards on projects under their jurisdiction, as did the Pennsylvania Turnpike. The Federal Aviation Administration indicated that the binder standards were used on some runway projects.

## ASPHALT-AGGREGATE MIXTURE DESIGN STANDARDS

Although the use of Superpave mixture design standards is predominant among state DOTs, general usage is not universal. Thirty-six of the 52 American DOTs reported general application. Another 12 reported use on some projects, primarily on higher volume roadways. Four agencies do not use the mixture standards at all, although three of the four have formulated plans to do so. The fourth is initiating research regarding the adoption of the Superpave mixture test methods.

In Canada, only three provincial DOTs reported general use of the Superpave standards for mixture design. Only one other provincial DOT reported a plan to adopt the Superpave standards in the future. Among the other American agencies reporting, all four use the mix standards on some projects, at least. Figure 2 summarizes the survey responses.

## USE BY COUNTY AND MUNICIPAL ROADS AGENCIES

The seventh letter report of the committee (November 29, 2001) stated:

Among state DOTs, Superpave is rapidly supplanting other systems of hot mix asphalt materials selection and mixture design. Among local agencies, however,

Superpave deployment is lagging. This situation is not uncommon. New highway technologies are often introduced at the state level and then disseminated among local agencies at a much slower pace. In the case of Superpave, however, this situation may lead to unintended consequences for many local agencies. If the rate of deployment among state departments of transportation (DOTs) continues to outpace deployment among local agencies, the hot mix asphalt paving industry will either have to support dual systems or the Superpave system will be practically imposed on local roads agencies.

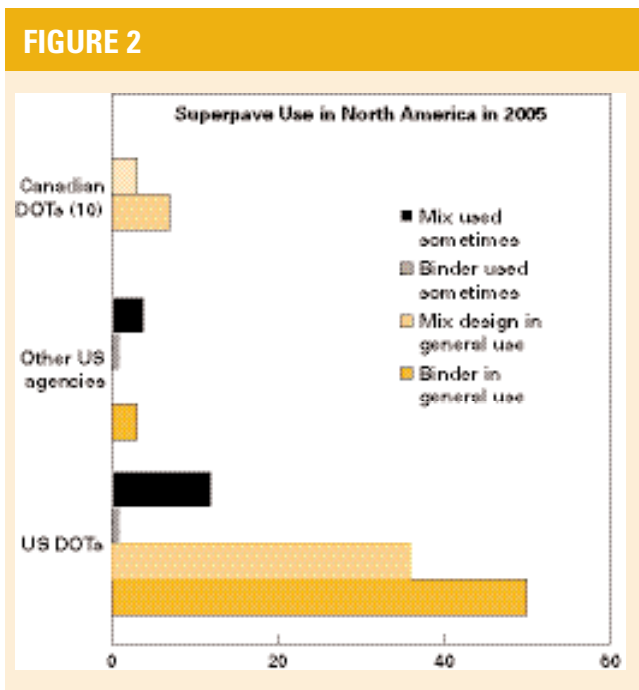
(All letter reports are available on the TRB Web site at [http://www4.trb.org/trb/dive.nsf/web/superpave\\_final\\_letter\\_reports](http://www4.trb.org/trb/dive.nsf/web/superpave_final_letter_reports))

The 2005 survey indicates that the application of Superpave among local agencies continues to lag. The survey was not directly sent to local roads agencies; rather each state and provincial agency was queried about the use of Superpave by local agencies within its jurisdiction. While this approach necessarily introduces some uncertainty to the results, the state and provincial agencies work closely with their municipal counterparts in planning road construction projects, so the degree of uncertainty is judged to be minor.

The 52 American DOTs reported that in 20 states, local agencies used the Superpave system in conformance with state DOT standards. In two states, some local agencies used Superpave standards that did not conform to the state DOT standards. In 33 states, there was no general usage of Superpave by counties and municipalities. That there were 55 responses from 52 states indicates that, in some states, some municipalities specified Superpave and others did not.

The situation in Canada is also uneven. In two provinces, local agencies specify Superpave materials following provincial specifications. In two provinces, other guide specifications are employed, and in six provinces, local agencies do not specify Superpave. C-SHRP also sent the questionnaire to four major cities, all of which specify the Superpave system on at least some projects. Three of those cities are in provinces that do not currently specify Superpave.

There exists a general concern among the TRB Superpave Committee members that in those states where the DOT specifies Superpave binders and mixtures, these same materials are being supplied to local





agencies that are not fully aware of the nature of the products. In the Washington State DOT response to the questionnaire, Tom Baker, the DOT materials engineer, captured the committee's concern perfectly: "Local agencies do not know or test what they are getting." In the Superpave system, binders and aggregates are selected and mixtures are designed to meet specific climatic and traffic conditions. If such mixes are unknowingly used in other situations, unanticipated durability and performance problems may arise. Even the best materials, if used inappropriately, will perform poorly. Materials selected and mixed for heavy duty state highways are likely to be too coarse, too stiff, and too low in asphalt content to perform well on residential streets or farm-to-market roads. Such roads require Superpave mix suitable for lower volume, lighter duty roadways.

## ESTABLISHING BENEFITS AND COSTS

Adoption of the Superpave system is not inexpensive. New test equipment must be purchased, installed and maintained, and staff must be trained in its use. Ultimately, however, the decision to adopt Superpave is driven by the ratio of anticipated performance benefits to construction costs. The denominator of this equation is easily and quickly established. Cost is evident as soon as construction project bids are opened. The numerator, or benefit, is established only over a long period of time as performance gains reveal themselves. In the report *Economic Benefits of SHRP Research*, Little et al. (1997) at the Texas Transportation Institute (TTI) projected that under an adoption scenario that took 10 years for full implementation, the Superpave binder specifications would yield \$482 million in discounted savings to state DOTs in the tenth year alone.

The TTI analysis, based on a handful of necessarily short-term case histories, was highly speculative. Obviously, the authors had to make many assumptions about the extra costs associated with asphalt binders specified with the Superpave system and whether the performance changes indicated by the short-term studies would actually be realized. The TTI study presumed that Superpave PG binder would be 6-7% more expensive than other binders being supplied in 1996. This was based on increases seen in the case studies. In the 2000 study of Superpave needs and assessment, New York State DOT reported a price differential of

2.5% (*Mack and Dunn, 2001*) The 2005 survey could not address the issue of cost, simply because the prevailing use of the Superpave binder specifications now masks any cost differential. In the few instances where respondents did mention price differential, it was only to remark that none existed or were minor.

The 2005 questionnaire did address performance, however. Each DOT was asked: "Has your agency identified performance changes associated with Superpave from your pavement management system, program planning or similar documentary source?" Twenty-two of the 72 respondents replied affirmatively. In some instances, agencies indicated that they are monitoring performance but no significant differences have yet been noted. Others report significant improvements. Reduced rutting is the most commonly cited performance benefit. Thirteen agencies reported that they had conducted studies into the cause of observed performance changes. Ten agencies indicated they had performed benefit/cost studies, but only seven of these are apparently based on locally obtained performance data. Table 1 lists comments offered in response to this question both in the survey and in direct conversation with some state officials.

While it may be disappointing that so few agencies have gathered performance data, nonetheless, there is evidently sufficient data on hand to warrant another examination of the benefits and costs attributable to the Superpave system. A complete tabulation of survey responses is provided in Table 2.

## UNIFORMITY IN IMPLEMENTATION

From the initiation of the Superpave deployment campaign, FHWA, AASHTO, and the TRB SHRP and TRB Superpave Committees have been consistent in urging that the Superpave system be implemented in a uniform fashion. This was not just an appeal to the engineering community's sense of order. There were both technical and economic reasons for this early emphasis on standardization. When first developed, the true precision of the various Superpave test methods was not firmly established and inter-laboratory testing using procedures in common was needed to complete this task. A considerable training effort had to be undertaken and this task would only be made more difficult if each jurisdiction adopted even slightly different standards. Equipment manufacturers had to

**TABLE 1: Benefit Indicators**

<b>Arkansas</b>	Problems that were common with Marshall mixes occurred considerably less often
<b>Connecticut</b>	Noticed reduced rutting on pavement segments prone to rutting
<b>Louisiana</b>	Less rutting observed
<b>Minnesota</b>	Better ride & pavement sufficiency, slightly lower cost
<b>New York City</b>	No cost increase, 1-3 years in extra performance
<b>Ontario</b>	2% lower in cost, 1-2 years increased performance
<b>Pennsylvania</b>	Seems to have resolved the rutting problem
<b>Test Section SPS-9</b>	Reflective cracking retarded 3-4 years
<b>Utah</b>	3-year life increase, 10% LCC savings
<b>Utah DOT Region 2</b>	Crack sealing cost down 70%, patching costs down 20%
<b>Washington State</b>	3% higher in cost, 12-20% longer performance
<b>City of Calgary</b>	Better performance at same cost
<b>City of Ottawa</b>	Marked reduction in cracking

know that their products would be acceptable across jurisdictions. Most importantly, from an economic standpoint, materials suppliers had to know that they would not have to make separate production adjustments to satisfy a wide array of specifications from different jurisdictions.

Conversely, no engineering system can be permanently static. All such systems are, or should be, subject to continuous improvements. As users of any system gain experience, they will note weaknesses that can be

strengthened and deficiencies that should be addressed. In a newly instituted system, early use generally identifies many potential improvements. If that early experience is relatively uniform, guidance can be developed on precisely how to modify the system. This has certainly been true with Superpave. There has been noticeable evolution from the provisional specifications and test methods originally adopted by AASHTO. The progression of standards and test methods from provisional to full standard has been the major work of the Mix and Binder Expert Task Groups. Working with input from the states and industry, the ETGs reshaped uncertain and unreliable provisional tests and methods into well-vetted specifications that dependably produce the expected outcome. Since 1995, research findings have resulted in 21 full standard specifications, six currently provisional standards, and eight future standards that are now being developed.

In the 2005 survey, the TRB Superpave Committee sought to establish just how uniformly, in general terms, Superpave was being applied among the state DOTs. Among the 50 state agencies that responded to the question, 35 indicated general conformance to AASHTO standards and 15 reported that agency standards were modified from AASHTO standards. While this may be the historically highest level of standardization for hot mix asphalt specifications among state DOTs, it is still far from uniform.

The 2005 survey sought to establish the general status of application of the Superpave system and not to identify variations among DOTs. Some information about these variations is available from other sources, however.

In February 2005, Ken Grzybowski of PRI Asphalt Technologies, Inc., reported to the Association of Modified Asphalt Producers on the results of a survey he conducted on Superpave “plus” asphalt binder specifications in use by the state DOTs. (*Grzybowski 2005*). As the name implies, a “plus” specification is one in which the AASHTO standard specification M 320 has been supplemented with additional requirements. According to this survey, 34 state DOTs use the AASHTO standards with additional requirements. The “plus” requirements include specification tests retained from pre-Superpave specifications, prescriptions that limit asphalt modification options either by

specifying or excluding the use of certain materials or techniques, or added tests for properties not considered in the AASHTO standards. The use of “plus” has increased since 2002 when Tandon and Avelar reported that 16 of 47 DOTs used such modified standards.

## **SUMMARY**

In sum, almost all state DOTs are currently using the Superpave system. If the plans of the few state DOTs

that do not use Superpave are carried out, deployment of Superpave will be universal. Universality, however, is not synonymous with uniformity. A significant number of state DOTs do not apply the mixture design procedures on all projects. The number of DOTs that use additional specifications along with the AASHTO Superpave binder standard is large and has grown recently. Nor does the near—universal application among state DOTs extend to county and municipal transportation agencies, where knowledge of the appropriate use of the system is still limited.

**TABLE 2: 2005 SUPERPAVE SURVEY RESULTS**

AASHTO Subcommittee on Materials -- Questionnaire on Use of Superpave Standards — Final Summary — April 6, 2005													
Agency	Use Binder Standards Now?			Use Mix Standards Now?			Plans to Use Binder?		Plans to Use Mix?		General Conformance with AASHTO Standards		
	Yes, Generally	On Some Projects	No	Yes, Generally	On Some Projects	No	Yes	No	Yes	No	AASHTO	Modified AASHTO	Other
<b>Sum of DOT Responses</b>	50	1	1	36	12	4	2	0	5	0	35	15	0
Alabama	X			X							X		
Alaska*		X*			X*		X*		X*				
Arizona*	X				X							X	
Arkansas*	X			X							X		
California*			X*			X*	X*		X*				
Colorado	X			X								X	
Connecticut*	X			X							X		
Delaware*	X			X							X		
DC	X			X							X		
Florida	X			X							X		
Georgia*	X			X*								X	
Hawaii	X				X						X		
Idaho	X					X			X		X		
Illinois*	X			X								X	
Indiana	X			X							X		
Iowa*	X			X								X	
Kansas	X			X							X		
Kentucky	X			X							X		
Louisiana*	X			X								X	
Maine*	X			X							X*		
Maryland	X			X							X		
Massachusetts	X				X						X		
Michigan*	X			X							X		
Minnesota	X			X							X		
Mississippi	X			X							X		
Missouri	X			X							X		
Montana	X			X							X	X	
Nebraska	X			X							X		
Nevada*	X					X			X*				

Performance Changes Documented?									
Performance Changes Documented?		Cause of Changes Investigated?		Cost/Benefit Analysis?		Used by Counties and Municipalities?			Contact
Yes	No	Yes	No	Yes	No	State Spec's	Other Spec's	No	E-mail address of respondent
13	39	8	10	4	48	20	2	33	
X			X		X	X	X	X	mountcastler@dot.state.al.us
	X				X			X	scott_gartin@dot.state.ak.us
	X				X		X*		jnodes@azdot.gov
	X*		X		X	X			jerry.westerman@arkansashighways.com
	X				X			X	phil.stolarski@dot.ca.gov
	X				X	X			tim.aschenbrener@dot.state.co.us
	X*				X	X			keith.lane@po.state.ct.us
X		X			X*	X			james.pappas@state.de.us
	X			X					wasi.khan@dc.gov.
X		X			X	X		X*	jim.musselman@dot.state.fl.us
	X				X	X			georgene.geary@dot.state.ga.us
	X				X			X	joanne.nakamura@hawaii.gov.
	X				X			X	mike.santi@itd.idaho.gov
X*			X		X	X			trepanierjs@dot.il.gov
X		X		X				X	dandrewski@indot.state.in.us
	X*		X		X	X			michael.heitzman@dot.state.ia.us
	X				X			X	lingram@ksdot.org
X			X		X	X			allen.myers@ky.gov
X*			X		X	X*		X*	scooper@dotd.louisiana.gov
	X				X	X			bruce.yeaton@maine.gov
X		X			X	X			lmichael@sha.state.md.us
	X				X			X	clement.fung@mhd.state.ma.us
	X*				X*			X	bleeche@michigan.gov
	X				X			X	john.garrity@dot.state.mn.us
X			X		X	X			sheffield@mdot.state.ms.us
	X				X	X			jason.ewalt@modot.mo.gov
	X		X		X			X	sbarnes@state.mt.us
X		X		X		X			lweishah@dor.state.ne.us
	X				X			X	dweitzel@dot.state.nv.us

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Agency	Use Binder Standards Now?			Use Mix Standards Now?			Plans to Use Binder?		Plans to Use Mix?		General Conformance with AASHTO Standards		
	Yes, Generally	On Some Projects	No	Yes, Generally	On Some Projects	No	Yes	No	Yes	No	AASHTO	Modified ASSHTO	Other
New Jersey	X			X							X		
New Hampshire*	X			X								X	
New Mexico	X			X							X		
New York	X			X							X		
North Carolina	X			X							X		
North Dakota	X				X						X		
Ohio	X				X							X	
Oklahoma*	X*			X							X		
Oregon	X			X							X		
Pennsylvania*	X			X							X		
Puerto Rico	X				X						X		
Rhode Island	X				X							X	
South Carolina	X				X							X	
South Dakota	X				X						X		
Tennessee*	X					X			X*			X	
Texas	X				X							X	
Utah*	X			X								X	
Vermont	X			X							X		
Virginia	X			X								X	
Washington	X			X							X		
West Virginia*	X*			X							X		
Wisconsin	X			X							X		
Wyoming	X				X						X		
<b>Sum of US Other responses _</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>0</b>
Cent. Fed. Lands	X			X							X		
West. Fed. Lands	X			X							X		
Penna. Turnpike	X				X							X	
Fed Aviation Admin.		X			X		X		X			X	

Performance Changes Documented?									
Performance Changes Documented?		Cause of Changes Investigated?		Cost/Benefit Analysis?		Used by Counties and Municipalities?			Contact
Yes	No	Yes	No	Yes	No	State Spec's	Other Spec's	No	E-mail address of respondent
	X				X			X*	eileen.sheehy@dot.state.nj.us
	X*		X*		X			X	arawson@dot.state.nh.us
	X				X			X	john.tenison@nmshtd.state.nm.us
	X				X			X	rthielke@dot.state.ny.us
	X				X	X			cljones@dot.state.nc.us
	X				X			X	rhorner@state.nd.us
	X				X			X	david.powers@dot.state.oh.us
	X				X	X			dgierhart@odot.org
	X				X			X	bruce.m.patterson@odot.state.or.us
	X*				X			X*	rapple@state.pa.us
	X				X			X	aalvarez@act.dtop.gov.pr
	X				X			X	mpbyrne@dot.state.ri.us
	X				X			X	hawkinscw@scdot.org
	X				X			X	rick.rowen@state.sd.us
	X				X			X	brian.egan@state.tn.us
X		X			X			X	rizzo@dot.state.tx.us
	X*				X			X*	tbiel@utah.gov
	X				X			X	ted.domey@state.vt.us
	X		X		X	X			bill.bailey@vdot.virginia.gov
X		X			X			X*	bakert@wsdot.wa.gov
	X				X			X	lbarker@dot.state.wv.us
X		X		X		X			judith.ryan@dot.state.wi.us
	X				X			X	rick.harvey@dot.state.wy.us
1	3	0	1	0	4	0	0	0	
	X				X				michael.peabody@fhwa.dot.gov
	X				X				brad.nietzke@fhwa.dot.gov
X			X		X				mwagner@paturnpike.com
	X				X				jeffrey.rapol@faa.gov

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Agency	Use Binder Standards Now?			Use Mix Standards Now?			Plans to Use Binder?		Plans to Use Mix?		General Conformance with AASHTO Standards		
	Yes, Generally	On Some Projects	No	Yes, Generally	On Some Projects	No	Yes	No	Yes	No	AASHTO	Modified ASSHTO	Other
Sum of Canadian Responses	9	3	3	4	4	7	0	3	1	4	11	2	0
Alberta*		X*				X				X*	X		
Calgary, Alb.*		X			X						X		
Edmonton, Alb.		X			X							X	
British Columbia			X		X			X	X		X		
Vancouver, BC*	X*			X							X		
Manitoba	X					X				X	X		
New Brunswick	X			X							X		
Newfoundland	X					X		X			X		
Northern Terr's			X			X							
Nova Scotia	X					X				X	X		
Ontario	X			X							X		
Ottawa, Ont.*	X				X						X		
Pr.Edward Is.*	X					X*					X		
Quebec*	X			X*								X	
Saskatchewan*			X			X*		X		X			



Performance Changes Documented?									
Performance Changes Documented?		Cause of Changes Investigated?		Cost/Benefit Analysis?		Used by Counties and Municipalities?			Contact
Yes	No	Yes	No	Yes	No	State Spec's	Other Spec's	No	E-mail address of respondent
8	5	5	3	6	8	2	2	7	
X*		X*		X				X*	chuck.mcmillan@gov.ab.ca
X*			X		X*				ken.yeung@calgary.ca
X		X		X					hugh.donovan@edmonton.ca
X			X		X	X			mike.oliver@gov.bc.ca
X			X		X				
	X				X			X	terry.hughes@gnb.ca
	X				X			X	brennand@gov.nl.ca
								X	larry_purcka@gov.nt.ca
	X				X			X	gouthrto@gov.ns.ca
	X			X		X			kai.tam@mto.gov.on.ca
X*		X			X*				steve.goodman@ottawa.ca
	X				X			X	jtkelly@gov.pe.ca
X		X		X			X*		miparadis@mtq.gouv.qc.ca
				X*			X		mbeshara@highways.gov.sk.ca

# 2

## MEETING THE R&D GOALS OF SUPERPAVE DEVELOPMENT AND DEPLOYMENT

The program of research and development to accomplish the general deployment of the Superpave system began in 1993 and continues to this day. The effort can be divided into two distinct time periods. The first period was largely coincident with the span of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. This act provided substantial funding to encourage the implementation of the research results of the Strategic Highway Research Program (SHRP) including the Superpave system. For the most part, research and technology transfer during this period was guided by the Federal Highway Administration (FHWA). Associated standards development was guided by AASHTO, and TRB maintained the TRB SHRP committee of stakeholders and experts to advise FHWA and AASHTO on the overall SHRP implementation campaign.

The second phase has coincided with the Transportation Equity Act for the 21st Century (TEA-21) enacted in 1998. This legislation did not continue funding to support the deployment of Superpave and threatened to leave the effort half completed. In response, the state departments of transportation, acting through AASHTO, agreed to continue the R&D aspects of the deployment effort via the National Cooperative Highway Research Program (NCHRP). AASHTO and the FHWA asked TRB to organize the TRB Superpave Committee to advise on the content of this R&D effort, monitor progress, and coordinate the activities of the various research and technology transfer agencies. The TRB Superpave Committee was organized in early 1999.

Any discussion of Superpave deployment and its associated R&D activities must begin with the understanding that hot mix asphalt paving is an engineering system with many interrelated components. Any change to one or more components of this system requires adjustment among the remaining components. If the changes are large and revolutionary, as is the case with Superpave, many adjustments within this HMA engineering system, either to Superpave or to other components, must be accommodated within a very short time. Much of the R&D that occurred during the deployment phase was occasioned by the need for system accommodation.

Immediately upon its organization, the Superpave Committee began work on a strategic plan to guide Superpave deployment activities. After compiling the plan, the committee judged that deployment of Superpave would be largely complete by late 2005 and the plan became known as the “2005 Long Range Plan” or simply the “2005 Plan.” This plan was designed to meet four goals.

1. The Superpave system will recommend asphalt binder type and mixture proportions based on environmental conditions, anticipated traffic loads and layer location.
2. The Superpave System will predict the ability of a mix to withstand rutting, fatigue, thermal cracking and moisture damage through a series of laboratory tests.

3. The Superpave system will integrate the binder and mix requirements into performance-based specifications for HMA pavement construction.
4. Superpave will be fully comprehended by the SDOTs and the HMA industry.

These four goals succinctly codified the objectives of the original SHRP asphalt research, the nature of the adjustments needed to integrate Superpave into HMA engineering practice, the accommodation of Superpave to other evolving HMA research, and the necessary reliance on technology transfer to complete the program. To meet these goals, the 2005 Plan recommended substantial efforts involving four types of activities:

1. Research and development to integrate Superpave into the HMA engineering system.
2. New research to address essential questions not completely answered by the SHRP asphalt research program.
3. Continuation of the aggressive program of engineering standards development initiated by AASHTO.
4. A multi-faceted program of technology transfer, training, and facilitation to inform and enable the proper application of Superpave by agency and industry personnel or alert them how the introduction of Superpave will impact related activities such as construction.

Matching the four goals and the four types of activities that comprise the 2005 Plan can be confusing because there is not a one-to-one correspondence between a particular goal and a specific activity. Even specific projects might address more than one goal. Table 3 tabulates the R&D projects related to Superpave deployment. The table illustrates how many projects address more than one goal. Indeed, NCHRP Project 9-33, currently in progress, is addressing all four goals. The following discussion of Superpave Deployment R&D is organized by activity type and correlation to goals is related in the text. Because of the overarching nature of the technology transfer efforts, these activities are discussed separately in chapter 3.

### ACTIVITY TYPE 1: INTEGRATION R&D

Of the 25 Superpave-related NCHRP projects undertaken in accord with the 2005 plan, 14 directly enabled

the integration of Superpave into overall HMA paving practice. While discussion of all 14 would be too lengthy to include here, several examples will illustrate the nature of these projects and why their completion was essential to the deployment program.

### Superpave and Recycled Asphalt Pavement

The SHRP research did not consider the inclusion of recycled asphalt pavement (RAP) in Superpave mixtures. The growth of pavement recycling in recent years showed this to be a major gap. The Superpave system did not quantify how, or even if, the inclusion of RAP with aged asphalt would affect the properties of Superpave performance-graded binders. It was not even certain if RAP functioned as “black rock” with little or no mixing of the older and new asphalt binders or if the aged binder was mixed with the new asphalt binder in the mixing and paving process. NCHRP Project 9-12 was undertaken to answer these questions and to provide more definitive guidelines on the use of RAP in Superpave mixes.

The final product of NCHRP project 9–12 consists of a technical report supported by seven appendices, which was published as:

- NCHRP CD-ROM CRP-CD-44, “Recommended Use of Reclaimed Asphalt Pavement in the Superpave Mix Design Method,” contains a 12-minute video presentation on the incorporation of RAP into hot mix asphalt designed with the Superpave method.
- The appendix titled “Summary: Guidelines for Incorporating Reclaimed Asphalt Pavement in the Superpave System” has been published as Research Results Digest 253.
- The appendix titled “Use of RAP in Superpave: Technicians’ Manual” has been published as NCHRP Report 452 .
- The main report and the remaining appendices have been published as NCHRP Web Document 30.

NCHRP Report 452 provides comprehensive guidelines on the sampling, testing, mixture handling, and mixing of RAP with new binders and aggregates to ensure a reliable HMA is produced. Without this research, although it does not directly address the Superpave system, the general deployment of Superpave would have been significantly delayed.

*This research addressed goals 1, 3 and 4.*

**TABLE 3 R&D PROJECTS RELATED TO SUPERPAVE DEPLOYMENT**

Title	Objective (if active) or Product	Goals Superpave 2005 Plan	Start	Due	Report of Reference
<p><b>GOALS</b></p> <ol style="list-style-type: none"> <li><b>1. Recommend binder type and mixture proportions based on environment, load, and layer location.</b></li> <li><b>2. Predict the ability of a mix to withstand rutting, fatigue, thermal cracking, and moisture damage through a series of laboratory tests.</b></li> <li><b>2/3. Integrate products derived from the Mechanistic-Empirical Pavement Design Guide into the 2005 mix design method and the HMA performance related specification (PRS).</b></li> <li><b>3. Integrate the binder and mix requirements into PRS for HMA construction.</b></li> <li><b>4. Be fully comprehended by the states and industry through initial and continuing educational programs.</b></li> </ol>					
<p>NCHRP 4-30, Improved Testing Methods for Determination of Critical Shape/Texture Factors for Aggregates</p>	<p>Test procedures for measuring aggregate shape, texture, and angularity characteristics that are likely to influence performance of hot-mix asphalt.</p>	<p>2,3</p>	<p>2002</p>	<p>Complete</p>	<p>None available</p>
<p>NCHRP 4-30A, Test Methods for Characterizing Aggregate Shape, Texture, and Angularity (Active)</p>	<p>The objective of this research is to identify or develop, for use in central and field laboratories, suitable test methods for measuring shape, texture, and angularity characteristics of aggregates used in hot-mix asphalt. Follows on 4-30.</p>	<p>2,3</p>	<p>2003</p>	<p>2005</p>	<p>NCHRP Report 409</p>
<p>NCHRP 9-07, Field Procedures and Equipment to Implement SHRP Asphalt Specifications</p>	<p>Developed a quality control/quality acceptance (QC/QA) plan in AASHTO standard format for hot mix asphalt (HMA) paving projects incorporating Superpave mix designs.</p>	<p>3</p>	<p>1993</p>	<p>Complete</p>	<p>NCHRP RRD 237</p>
<p>NCHRP 9-09, Refinement of the Superpave Gyration Compaction Procedure</p>	<p>The key product of the project was a recommendation to reduce the number of possible design gyration values in AASHTO PP28 (now AASHTO M 323) to 4 from the original 28; it has been incorporated in the standard.</p>	<p>2</p>	<p>1996</p>	<p>Complete</p>	<p>NCHRP Report 459</p>
<p>NCHRP 9-9(I) Verification of Gyration Level in the Ndesign Table (Active)</p>	<p>Verify through a series of field project evaluations that the gyration levels in the <math>N_{design}</math> table in AASHTO PP28 (now M 323) are correct for the stated project traffic levels and to modify the levels as necessary.</p>	<p>2</p>	<p>2000</p>	<p>2005</p>	<p>NCHRP Report 452</p>
<p>NCHRP 9-10, Superpave Protocols for Modified Asphalt Binders</p>	<p>Potential new or revised protocols for testing modified binders</p>	<p>1</p>	<p>1996</p>	<p>Complete</p>	<p>NCHRP Report 464</p>
<p>NCHRP 9-12, Incorporation of Reclaimed Asphalt Pavement in the Superpave System</p>	<p>Guidelines for incorporating RAP in the Superpave system and a manual for use by laboratory and field technicians.</p>	<p>2,3</p>	<p>1997</p>	<p>Complete</p>	<p>NCHRP Report 452</p>
<p>NCHRP 9-14, Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification</p>	<p>Found that the restricted zone requirement is not necessary to ensure satisfactory performance when all other relevant Superpave design requirements are met. Led to spec. change.</p>	<p>2</p>	<p>1998</p>	<p>Complete</p>	<p>NCHRP Report 464</p>

Title	Objective (if active) or Product	Goals Superpave 2005 Plan	Start	Due	Report of Reference
NCHRP 9-16, Relationship Between Superpave Gyration Compaction Properties and Permanent Deformation of Pavement in Service	Results suggested that N-SRmax provides a rapid means of identifying gross HMA mix instability or rutting potential during volumetric mix design. but it is not a fundamental material property for predicting the development of permanent deformation.	2	1999	Complete	NCHRP Report 478
NCHRP 9-19, Superpave Support and Performance Models Management	The dynamic modulus test recommended as the primary simple performance test for rutting. The flow number (repeated load permanent deformation) test provides an optional, complementary procedure for evaluating the resistance of an HMA mix design to tertiary flow.	2	1999	Complete	NCHRP Report 465
NCHRP 9-20, Performance-Related Specifications for Hot-Mix Asphalt Construction	Develop a performance related specification for HMA construction	3	1998	Complete	NCHRP Report 455
NCHRP 9-22, PRS – Beta Testing and Validation of HMA (Active)	Evaluate and define HMA PRS, incorporate 2002 models	3	2000	2007	
NCHRP 9-23, Integrated Climatic Model (ICM) Validate with LTPP Seasonal Monitoring Program (Active)	Validate Integrated Climatic Model (ICM) developed in NCHRP Project 1-37A with LTPP data; (2) develop practical guidelines for selecting ICM input data sets; (3) verify the estimated period or rate of aging simulated by the current Superpave binder and hot mix asphalt conditioning procedures -- AASHTO provisional practices PP1 and PP2 – with LTPP data; and (4) revise the current conditioning procedures as necessary for use in Superpave system.	2	2001	2005	
NCHRP 9-25, Requirements for Voids in Mineral Aggregate for Superpave Mixes (Active)	The objective of this research is to develop recommended mix design criteria for VMA, VFA, or calculated binder film thickness, as appropriate, to ensure adequate HMA durability and resistance to permanent deformation and fatigue cracking in the context of the Superpave mix design method.	3	2001	2005	
NCHRP 9-27, HMA in-place Air Voids, Lift Thickness and Permeability	Guidelines on compaction and controlling permeability HMA.	3,4	2001	2003	NCHRP Report 531
NCHRP 9-29 Simple Performance Tester (SPT) for Superpave Mix Design	Designed, procured, and evaluated simple performance testers for use in Superpave mix design and in HMA materials characterization for pavement structural design. Wider procurement planned.	2,3	2001	2006	NCHRP Report 513 & NCHRP Report 530
NCHRP 9-30, Experimental Plan for Calibration and Validation of HMA Performance Models for Mix and Structural Design	Developed a practical experimental plan to refine the calibration and validation of the performance models of the NCHRP 1-37a design guide with laboratory-measured hot mix asphalt (HMA) material properties for use in future mix and structural design methods.	2	2001	2004	NCHRP RRD 283

NCHRP 9-31, Air Void Requirements for Superpave Mix Design (Active)	Recommend air void contents required for durability and resistance to permanent deformation.	3	2001	2005	NCHRP Report 539
NCHRP 9-33, A Mix Design Manual for Hot Mix Asphalt (Active)	Develop a new mix design manual for HMA. Capstone product of Superpave deployment.	1,2,3,4	2004	2005	
NCHRP 9-34 Improved Conditioning Procedure for Predicting the Moisture Susceptibility of HMA Pavements (Active)	Develop an improved conditioning procedure based on the environmental conditioning system (ECS) for evaluating the moisture susceptibility of compacted HMA in combination with the simple performance test (SPT).	1,2	2002	2005	
NCHRP 9-35 Aggregate Properties and Their Relationship to the Performance of Superpave-Designed HMA: A Critical Review	Review of the technical literature to identify consensus, source, and other aggregate properties that significantly impact HMA performance.	3,4	2002	2004	
FHWA 90-01, Superpave Mix - Protocol Refinement and Field Validation	Mobile laboratory that validates NCHRP output, including PRS, gyratory advancements, and volumetric requirements	1,2,4		2005	
FHWA 90-02 Superpave - Binder Equipment & Test Procedures – Refinement and Field Validation	Laboratory validation of all binder advancements, including aging, modifier tests, and direct tension tests.	1,4		2004	
FHWA 90-03, Superpave Mix Tenderness	Research reasons behind mix tenderness issues	2,3		Complete	
FHWA 90-04, Investigation of Modified Asphalt Systems	Research to evaluate modified binder mix properties in the laboratory	1		2004	
FHWA 90-05, Fine Aggregate Specific Gravity Test	Research to evaluate new fine aggregate specific gravity tests	2,3		Complete	
FHWA 90-06 Ruggedness Testing of Superpave Shear Tester and Indirect Tensile Tester	Conduct ruggedness testing of two separate SHRP developed devices - the Superpave Shear Tester (SST) and the Indirect Tensile Tester.	2		Complete	
FHWA 90-07 & 09, Understanding the Performance of Mixtures with Modified Asphalt Binders and Asphalt Mastics	Research that will lead to final binder table that clearly identifies relationship of binder to mixture performance.	1		2004	
TPF-5 (019) ALF Pooled Fund Study	Research to validate laboratory tests conducted on modified binder mixes and to validate 2002 models predictive capabilities.	1,2		2004	<a href="http://www.eng.auburn.edu/center/necat/reports/rep02-11.pdf">http://www.eng.auburn.edu/center/necat/reports/rep02-11.pdf</a>
SPR 2/211 Evaluation of Corelok Device		2		2002	<a href="http://www.pooled-fund.org/projectdetails.asp?id=11&amp;status=6">http://www.pooled-fund.org/projectdetails.asp?id=11&amp;status=6</a>

## Superpave and Mineral Aggregate Standards

The consensus aggregate standards incorporated in the Superpave system, initially developed by a SHRP panel, were derived from industry practices and earlier research and were not the product of explicit Superpave research. While generally providing improved performance, these standards greatly affected the selection of aggregates for asphalt mixtures and had major economic impact on public works agencies and the aggregates supply industry. Particularly disturbing for both groups were instances, few in number but large in consequence, where aggregate supplies known to yield asphalt mixtures with superior performance could not meet the new standards.

Discussion on amending the consensus standards began as soon as the Superpave research was completed in 1993 and some project-by-project research to guide such amendments was initiated during the ISTEA period. For example, in May 1998, NCHRP Project 9-14 (Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification), began to investigate one of the more contentious of the consensus standards.

The Superpave Committee's Expert Task Group on Mixtures and Aggregates developed a white paper on "Superpave Issues of Concern to the Aggregate Industry" to identify specific concerns amenable to research. This white paper led to the inclusion of a number of aggregate research projects in the 2005 Long-Range Plan. Over time these recommendations resulted in NCHRP Projects 4-30 (Test Methods for Characterizing Aggregate Shape, Texture, and Angularity), 9-14 (Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification), and 9-35 (Aggregate Properties and Their Relationship to the Performance of Superpave-Designed HMA: A Critical Review). Other research already under way, such as 9-14, was subsumed into the plan.

These projects are reducing reliance on the consensus standards, improving the understanding of aggregate properties critical to performance, and eliminating the arbitrary exclusion of sources of aggregate supply. Issues regarding aggregate standards had stalled the deployment of the Superpave mixture design standards in certain locales. Had this research not been undertaken, that situation would have continued.

*This research addressed Goals 3 and 4*

## Superpave and Quality Control and Acceptance

NCHRP Project 9-07 (Field Procedures and Equipment to Implement SHRP Asphalt Specifications) initiated the integration of Superpave with construction quality control procedures. This project developed a quality control/quality acceptance (QC/QA) plan in AASHTO standard format for hot mix asphalt paving projects incorporating Superpave mix designs. The objectives of this research were to (1) establish comprehensive procedures and, if required, develop equipment for at the asphalt plant and lay-down site to ensure that asphalt pavements meet the SHRP performance-related specifications and (2) develop a framework for a training program for qualifying technicians to accomplish the QC/QA field procedures developed.

The final report was published as NCHRP Report 409, "Quality Control and Acceptance of Superpave-Designed Hot Mix Asphalt, and formed the basis for development of PP52-05, *Developing a Quality Assurance Plan for Hot Mix Asphalt (HMA)*."

*This research also addressed Goals 3 and 4.*

## Calibration of Superpave Test Equipment

The last example of integration research is the dynamic angle validation (DAV) device, which facilitates the calibration and comparison of Superpave gyratory compactors. This device was developed by the FHWA through the NCHRP-supported project 90-01: Superpave Mix-Protocol Refinement and Field Validation. The widespread availability and use of Superpave gyratory compaction devices was a mark of the success of Superpave deployment. Increasingly, these devices were being used for quality control and quality assurance purposes in asphalt pavement construction. Occasionally a dispute arose between an agency and a construction contractor as to whose device was "right" if the bulk specific gravity of specimens prepared with different devices varied unacceptably. Often the difference was attributed to mechanical problems with one of the devices or to incorrect calibration of the internal angle of gyration. Use of the DAV now provides a way to directly compare the compactors involved in such disputes. When coupled with a sound maintenance regimen, the DAV can also be used to keep compaction devices properly calibrated, preventing future disputes. The dynamic angle validation device is now available commercially. By provid-

ing a reliable approach to dispute resolution and gyratory compactor calibration, the DAV facilitated the deployment of Superpave. (Al-Khateeb 2002)

*The DAV research addressed goals 2 and 3.*

## **ACTIVITY TYPE 2: NEW RESEARCH**

The SHRP research met its principal goal of delivering a prototype system of materials selection and mixture design for hot mix asphalt that improved on procedures in use at the time. Between the time that this goal was first articulated in TRB Special Report 202 in 1984 and the completion of the research in 1993, the world of HMA pavement engineering had evolved. The two most significant changes were the rapid increase in asphalt modification and the introduction of mechanistic principles into the structural design of pavements. In today's world, if Superpave is to be widely used and deployed, it must work as well with the new array of modified asphalt as it does with conventional asphalt binders. Also, the introduction of mechanistic principles made it possible to explicitly relate certain characteristics of asphalt mixtures, currently considered in the Superpave system, to pavement performance. This should permit the development of relationships between long-term performance mixture properties.

The SHRP program and other research revealed glimpses of how the Superpave system could be strengthened and extended by new research not originally contemplated as part of SHRP or not completed when SHRP closed its doors. New research initiated by the FHWA under ISTEA and continued in the Superpave 2005 plan under TEA-21 seeks to turn these glimpses into a vision. Fifteen of the 29 projects included in the 2005 plan include "new" research elements directed at strengthening and extending the application of the superpave system.

### **Superpave and Environmental Effects Models**

For example, the original Superpave performance model system developed through SHRP incorporated an environmental effects model as an integral component. This model provided the capability to predict temperature and moisture conditions in the structure of the pavement, thus accounting for specific, long-term effects of climate on material properties and pavement performance. In 1996, a University of Maryland research team reviewed the original SHRP

Superpave environmental effects model as a part of the FHWA Superpave Support and Performance Models Management project and suggested that the predictive capabilities of Superpave could be strengthened by replacing the original model with an adaptation of a newer Integrated Climatic Model (ICM) developed for FHWA by (Dempsey, et al. 1985) The committee and others incorporated this recommendation into the 2005 plan. NCHRP project 9-23 (Environmental Effects in Pavement Mix and Structural Design Systems), scheduled for completion in 2005, seeks to complete this enhancement of the Superpave system.

*Project 9-23 addresses Goals 2 and 3.*

Other projects included in the plan are designed to strengthen or extend Superpave in other areas.

### **Superpave and Asphalt Modification**

Two research projects were conducted to extend the Superpave binder specification to modified asphalt. These projects, the NCHRP-managed 9-10 (Superpave Protocols for Modified Asphalt Binders) and the FHWA-managed Project 90-7 (Understanding the Performance of Modified Asphalt Binders in Mixes) were both initiated in the ISTEA period, but the Superpave Committee recognized the research was essential if the Superpave system was to be extended to the testing of binders that include the ever-growing array of asphalt modifiers and additives. The objectives of 9-10 were (1) to recommend modifications to the Superpave asphalt binder tests for modified asphalt binders and (2) to identify problems with the Superpave mixture performance tests in relation to mixtures made using modified asphalt binders. Project 90-7 sought to establish the validity of test methods developed as part of 9-10 through laboratory testing and to develop new procedures to overcome the problems identified in the 9-10 research. Project 9-10 was completed in 2001 and 90-7 is continuing. A state DOT supported pooled funds study is using results from accelerated pavement testing to complement the laboratory testing conducted in project 90-7.

*Both 9-10 and 90-7 addressed Goal 1.*

### **A Simple Performance Test for Superpave**

In concept, the Superpave system is a stepwise materials selection and design process. The performance of



the resulting asphalt pavement is evaluated using results from mechanistically based tests and design procedures applied at each step. No final “strength” test was included in the system. Many state DOTs and HMA suppliers saw the absence of such a test as a barrier to deployment. A survey of state DOT materials engineers conducted by the Superpave Mixture and Aggregate Expert Task Group assigned the highest priority to the development of simple performance tests for evaluating the resistance of Superpave-designed HMA to permanent deformation and fatigue cracking.

Work to define a new Superpave strength test was initiated by FHWA and was absorbed into the 2005 plan where it was restarted as part of NCHRP project 9-19. This work has been completed and a summary of the work to identify the simple performance tests selected for field validation has been published as NCHRP Report 465: *Simple Performance Test for Superpave Mix Design*.

NCHRP Report 465 identified several candidate test methods that either alone or in combination might serve as a ‘simple performance test’ for the Superpave system. The objectives of the subsequent NCHRP Project 9-29 were to design, procure, and evaluate test equipment to perform these tests for use in Superpave mix design and in HMA materials characterization for pavement structural design. The project also required the construction of a sufficient number of test devices from independent manufacturers to conduct round-robin ruggedness tests to demonstrate the validity of the test method and test equipment. This work was completed in 2005 and the results have been published as NCHRP Report 513: *Simple Performance Tester for Superpave Mix Design: First-Article Development and Evaluation*.

Adoption of the simple performance test for routine use in the Superpave mix design method will require the production of commercial test equipment. The 2005 plan recognized the need to develop equipment specifications, conduct equipment evaluations, test method ruggedness evaluations, and final procedure verification — all leading toward a national procurement for the state DOTs and eventual widespread adoption and use in the HMA industry. These steps were successfully pioneered by the Federal Highway Administration throughout the Superpave implementation process to bring many new test devices into routine use.

*The work conducted under NCHRP 9-19 and 9-29 was primarily directed at Goal 2.*

### ACTIVITY TYPE 3: STANDARDS DEVELOPMENT

Engineering systems are defined by engineering standards. Standards provide the common language for highway engineers, materials suppliers, and construction contractors to share requirements and expectations for construction projects. They also provide the benchmarks by which the quality of the design, the materials, and the construction is measured. Unfortunately, the introduction of new technology or methods can be delayed because no engineering standards have been developed. This potential was recognized early in the Superpave deployment effort (and in corollary efforts for other SHRP derived technologies) and AASHTO, through the Highway Subcommittee on Materials, published a set of “provisional” standard test methods, materials specifications, and practices for Superpave in 1994.

Because of recent trends toward improved quality control of highway materials and the use of performance related properties, the Superpave implementation effort has been subjected to scrutiny not applied to earlier HMA design procedures. Such intense scrutiny could have delayed general deployment. The use of provisional standards, however, turned a potential barrier into a mechanism to accelerate deployment and initiate training. As state DOTs, equipment manufacturers, material producers, contractors, researchers and other users of the provisional standards gained experience, they were able to relate that experience to the Superpave expert task groups who, in turn, could offer advice on keeping the R&D focused on resolving issues of standard practice, fostering deployment still further. The AASHTO provisional standard significantly accelerated Superpave deployment.

Table 4 lists all of the provisional Superpave standards published by AASHTO. As laboratories gained experience with the standards and provided data to complete the standards development process and as R&D resolved concerns, the provisional standards were formally adopted as full standards, combined with other standards, or dropped because they were not needed or were not being used on a regular basis. The current disposition of each provisional Superpave standard is also shown on the table.

**TABLE 4: Superpave-Related AASHTO Provisional Standards, 1994-2005  
Summary and Current Status**

Provisional Designation*	Brief Title	First Published	Current Status	Current Designation*	Remarks
MP 1	Performance Graded Asphalt Binders	Jan-94	Full Standard	M 320	Combines MP1 and MP 1a
MP 1a	PG Binder (including modified)	Apr-01	Full Standard	M 320	
MP 2	Spec. for Superpave Mix	Jun-97	Full Standard	M 323	
PP 1	PAV Accelerated Aging	Jan-94	Full Standard	R 28	
PP 2	Long/Short Term Mixture Conditioning	Jan-95	Full Standard	R 30	
PP 3	Rolling Wheel Compactor	Jan-95	Dropped	–	
PP 5	Eval. Modf. Asph. System	Jan-94	Dropped	–	
PP 6	PG Binders Verification	Jan-94	Full Standard	R 29	
PP 19	Vol. Design HMA	Jan-94	Dropped	–	
PP 26	Certif. Binder Suppliers	Jun-97	Full Standard	R 26	
PP 28	Superpave Volumetric Mix Design	Jun-98	Full Standard	R 35	
PP 42	Low Temp Props-Binders	Apr-01	Provisional	PP 42	Prov. Status Extended 2 Yrs.
PP 47	Comparing 2 Gyratories	May-02	Provisional	PP 47	Prov. Status Extended 2 Yrs.
PP 48	Gyratory Internal Angle	Jul-03	Provisional	PP 48	
PP 52	Develop QA Plan for HMA	Jul-05	Provisional	PP 52	
TP 1	Flexural Creep Stiffness with BBR	Jan-94	Full Standard	T 313	

**TABLE 4: Superpave-Related AASHTO Provisional Standards, 1994-2005  
Summary and Current Status**

*Continued*

Provisional Designation*	Brief Title	First Published	Current Status	Current Designation*	Remarks
TP 2	Quantitative Asphalt Extraction	Jan-95	Full Standard	T 319	
TP 3	Fracture Properties of Binder in Dir. Ten	Jan-94	Full Standard	T 314	
TP 4	Density of HMA Specimens w/ SGC	Jan-94	Full Standard	T 312	
TP 5	Rheologic Properties w/ DSR	Jan-94	Full Standard	T 315	
TP 6	Absorb. & Desorb. Bind.	Jan-94	Dropped	–	
TP 7	Shear Strain and Stiffness w/ SST	Jan-95	Full Standard	T 320	
TP 8	HMA Fatigue w/ Repeat Bending	Jan-95	Full Standard	T 321	
TP 9	Creep Compliance w/ IDT	Jan-95	Full Standard	T 322	
TP 10	Therm. Stress Restrtn.	Jan-94	Dropped	–	
TP 31	Resilient Modulus of HMA	Jan-95	Dropped	–	
TP 33	Voids in Fine Aggregate	Jan-94	Full Standard	T 304	
TP 34	Moisture Sensitivity of HMA	Jan-94	Dropped	–	
TP 39	Modified Rice SG	Jan-95	Full Standard	T 209	
TP 40	% Asphalt HMA	Jan-95	Dropped	–	
TP 48	Viscosity with Rotational Viscometer	Jan-95	Full Standard	T 316	
TP 53	Asphalt Content by Ignition Method	Jun-97	Full Standard	T 308	
TP 61	% Fract. Coarse Agg.	May-02	Provisional	TP 61	Prov. Status Extended 2 Yrs.
TP 62	Dynamic Modulus of HMA	Jul-03	Provisional	TP 62	

● MP= Provisional Materials Specification  
 PP = Provisional Practice  
 TP = Provisional Test Method  
 M = Materials Specification  
 R = Recommended Practice  
 T = Standard Test Method

# 3

## FROM EXOTIC TO EVERYDAY

### Looking Back at the Technology Transfer Challenge

Could targeted research discover the way to provide America's highway users with a smooth ride on a long-lasting pavement? From such a simple scenario grew a program of increasingly complex technical challenges. In addition to studying individual properties and characteristics of materials in varying combinations, researchers tested for effects of load and temperature, compaction and construction, developing, over a few years, a system by which smooth-riding pavements could be designed for specific climate and load conditions. With the passage of The Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, Congress funded a campaign to implement the results of this research, and Superpave, along with other SHRP products, was about to meet its public.

Implementation, however, encompasses a far broader scope of activities than the word itself can conjure. In the case of Superpave, effecting change on a national scale would require gaining the attention, cooperation, active support, and financial commitment of people in leadership and technical roles in government; transportation agencies; industry, including manufacturers, suppliers, consulting firms, and associations; and academia.

An array of techniques supported these efforts: convening expert task groups and technical working groups; supporting lead states as mentors; establishing regional centers to provide training and conduct continuing research; encouraging partnerships with industry and academia; pooling funds to buy equipment; developing provisional standards; implementing

round-robin testing; and developing certification procedures for technicians. Some of these techniques were being tried for the first time in the highway community, but each reflected a responsive and flexible approach to technology deployment. An overview of the major implementation methods is provided here to give dimension to the readers' understanding of how Superpave came to be synonymous with hot mix asphalt. The timeline in Figure 1 (p. xii) shows the progression of deployment activities.

#### IMPLEMENTATION DRIVERS

##### Lead State Program

The Lead State team, established by AASHTO in 1996 as a means of developing and sharing practical expertise in the Superpave system, continued to serve as the principal champion of Superpave and to inform the work of the Superpave Committee until the program ended in 2000. The Lead State team included Florida, Indiana, Maryland, New York, Texas, and Utah, as well as members from the FHWA, the asphalt industry, the research community, and the Superpave Centers.

The Lead State team was very active in drafting provisional standards, explaining the underlying rationale for change, and guiding the revised standards through the review and approval process. The team's effectiveness, especially in this area, was due in large part to the synergy created by cross-membership in key committees. For example, team members were also members

of the ETGs, the AASHTO Standing Committee on Research and the Subcommittee on Materials, NCHRP research panels, national and regional forum steering committees, and many others. Importantly, these activities received extensive support from the FHWA.

Annual national surveys conducted by the Lead State team to determine where and how Superpave was being implemented served the TRB Superpave Committee both as an implementation tool and literally as a developing roadmap. Results of the surveys were sent to the Chief Engineer and the Materials Engineer in each state so that both management and operating levels of state transportation agencies were informed of and challenged by the growing national acceptance of the technology. The surveys supplied reason for undecided states to decide in favor of implementation. As the implementation picture began to develop from the survey, the committee could use the information to gauge its efforts and to better understand where there were barriers to implementation.

Additionally, members of the Lead State team developed reports that became the basis for presentations at stakeholder meetings and journal articles that reached many audiences. These efforts resulted in confirmation and support for states that had adopted the technology and encouragement to those not yet committed.

The Lead State concept was an effective driver of technology transfer. Early adopters of the technology could model the implementation process and share what they had learned with those who came later. This was possible because the Lead States received support, collaborated with each other and with industry partners and the FHWA, developed champions with authority to commit resources, and received recognition for their efforts. Many Lead State team members continued to contribute to the work of the TRB Superpave Committee throughout its lifetime, providing a rare continuity over a long-term project.

### **Expert Task Groups**

Because Superpave technology involved a broad spectrum of scientific and engineering disciplines (from basic chemistry to construction management and facilities maintenance), the TRB Superpave Committee enlisted task groups with more focused expertise. The Mixture/Aggregate and Binder Expert Task Groups provided input essential to designing

both the long-range research plan and the annual research programs.

The ETGs were organized in 1999 to provide technical advice on mixture and aggregate issues; monitor the FHWA Superpave technical activities related to mixture and aggregate; identify potential improvements to mixture and aggregate specifications and standard test methods; identify needed standards; and discuss emerging issues.

Since that time, the Binder ETG has advised the Superpave committee on specifications that relate binder selection to pavement performance, including nearly all unmodified binders and an increasing number of modified binders. The intent to include in the specification as many binders as possible without reference to modification type, chemistry, or brand name has made this task one of the most complex elements of Superpave and has been the primary focus of the Binder ETG.

Perhaps the most important role of the ETGs was facilitating the transition from research findings to standard specifications. Working with the AASHTO Subcommittee on Materials, the ETGs kept research and development focused on resolving issues of standard practice. More than 30 Superpave related standards were issued by AASHTO and most were later converted to permanent status when states accumulated enough experience.

At a time when state DOTs are experiencing a contraction of technical staff, the ETGs have filled a void in the process of converting research into standard practice. A frequently voiced concern expressed by technical professionals among both agencies and industry groups is that completion of Superpave development will lead to renewal of the void.

### **User/Producer Groups**

The five regional asphalt user-producer groups also played a key role in the Superpave implementation effort. Representing the materials-producing industry, asphalt refineries, paving contractors, and highway agencies, the user-producer groups outlined strategies for adopting the Superpave system on a regional basis. They worked to encourage standardized specifications, binder grade selection processes, and acceptance plans. Additionally, the groups provided a forum for dis-

cussing common concerns and arriving at workable solutions. Local user-producer groups were encouraged as focal points for training and materials testing.

A lead states format was developed within the user-producer groups so that expertise could be shared among the partners. For example, binder equipment on loan from FHWA was installed in Indiana, where DOT staff were trained in its use and later held training sessions for other members of the user-producer groups. Indiana's laboratory was also made available for materials testing. Minnesota was a lead state in developing an implementation plan encompassing volumetric principles, field verification, process control, compaction, and National Quality Initiative principles. The Rocky Mountain UPG purchased a trailer so that loaned binder equipment could be taken to each state for six weeks. Four binders were tested at each location to establish a basis for comparison among states.

This collaborative approach helped to spread expertise and address practical issues more uniformly than might have been possible without user/producer groups.

## TRAINING AND TECHNOLOGY TRANSFER

Transferring technology from research labs to job sites across North America is an enormous undertaking that is itself benefiting from innovative techniques. Opportunities to learn about the Superpave mix design system have been offered by a range of providers in a variety of settings to students with an equally diverse range of backgrounds. Training and technology transfer techniques have included traditional class room and laboratory training, on-site training, mobile laboratories, distance learning and electronic information exchange, certification programs and traditional outreach activities such as conferences and publications. Most of these activities began during the early days of implementation and have continued during the tenure of the Superpave Committee, while others are currently in development.

### Traditional Classroom and Laboratory Training

The five Superpave Centers (see sidebar) established in 1995 have been an essential means of transferring

## SUPERPAVE CENTERS

### North Central Superpave Center

Indiana Department of Transportation Building  
1205 Montgomery Street, Box 2382  
West Lafayette, Indiana 47906  
(765) 463-2317  
<http://bridge.ecn.purdue.edu/~spave/>

### Northeast Superpave Center

Northeast Center of Excellence for  
Pavement Technology  
The Pennsylvania State University  
201 Transportation Research Building  
University Park, PA 16802  
(814) 863-1903  
<http://www.superpave.psu.edu>

### South Central Superpave Center

Texas A&M University  
TTI/CE Building, Suite 508  
College Station, TX 77843-3135  
(409) 845-9965  
<http://tti.tamu.edu/inside/centers/scsc.stm>

### Southeastern Superpave Center

Auburn University  
277 Technology Parkway  
Auburn, AL 36830  
(334) 844-6228  
<http://www.eng.auburn.edu/center/ncat/ssc/ssc.html>

### Western Regional Superpave Center

University of Nevada at Reno  
Reno, NV 89557-0179  
(775) 784-6565  
<http://www.wrsc.unr.edu/>

technology. Each center represents a partnership between the FHWA, the host state, and an engineering university in that state to establish regional centers of expertise that would facilitate Superpave implementation. Start-up funding and mixture testing equipment were provided by FHWA. The remainder of required funding had to be generated by each center, with the intention of eventually becoming self-supporting. The

funding mechanisms pursued by the individual centers varied somewhat but typically included some support from participating states, research funding, and training income.

Thousands of engineers, managers, technicians, both agency and industry personnel, have received training from the Superpave Centers over the last 10 years. The number continues to increase as new people join the workforce and as research results in further refinements to processes. Courses range from 2-hour management overviews, through half-day sessions on the gyratory compactor, to two-week hands-on binder testing and mix design training programs. Similar classroom and lab training is also available at the National Asphalt Training Center operated by the Asphalt Institute in Lexington, Kentucky. At the National Center for Asphalt Technology (NCAT) at Auburn, Alabama, nearly 300 instructors have taken the Professor Training Program in Asphalt Technology and many more students have completed HMA courses for undergraduates.

Both the Superpave Centers and the FHWA's training arm, the National Highway Institute, provide instructors for training courses at the client's site. The NHI has also developed course materials that can be made available for other organizations to conduct training.

Industry associations such as NAPA, the Asphalt Institute, and the state asphalt paving associations all have been sources of training sessions and resource materials from the early days of implementation. A sample survey conducted by the Expert Task Group for Communications and Training in 2002 found as many as 10 different sources for training and certification materials.

### **Job-Site Training**

The FHWA equipped mobile trailers as asphalt pavement mixture labs to provide on-site field testing to validate equipment and evaluate mixes while providing state DOT and construction personnel with hands-on training. The mobile laboratories are studies in multi-tasking. In addition to providing on-the-job training to agency and contractor personnel, quality control data valuable to the specific construction project were collected and, as the labs were moved from project to project, data were collected

about the normal variation in Superpave test methods. These data proved valuable as AASHTO test methods were refined.

The mobile laboratories were also made available to industry conferences, technology showcases, universities, and DOT offices. The mobile labs, updated with the latest performance-testing equipment, still deliver new technologies to the states.

### **Distance Learning and Electronic Information Exchange**

The National Highway Institute has supported superpave deployment from its early days, offering courses throughout the country. More recently NHI began to offer hot mix asphalt classes through Web conferences and on-line sites as a complement to its more traditional course offerings.

Other sophisticated instructional options are being developed by researchers at NCAT and the University of Washington with support from NAPA. Interactive training materials on CD will help the current generation of asphalt technicians and pavement engineers design for performance. One CD provides a complete overview of HMA technology using movie clips, animation, topic search capability, and glossary links. Another product, the Virtual Superpave Laboratory, uses computer-based learning tools to teach laboratory procedures and data analysis. A third product, HMAView, is supported through a pooled fund effort. It is a Web-enabled application that allows for real-time acquisition of mix design, field construction, and performance data. The data can be shared across divisions to inform decision making at various organizational levels. (More information about these products is available from the contacts listed in the box.)

### **Certification**

Certification of asphalt laboratory technicians is sometimes required by DOTs as a device to ensure that agency and contractor staff engaged in materials selection and mixture design have a proper understanding of the specifications and test methods involved in hot-mix asphalt materials selection and mixture design, including the Superpave system and the associated test

## SUPERPAVE RESOURCES

### Hot Mix Asphalt for the Undergraduate Professor Training Course

Information about these courses is available from NCAT at [www.eng.auburn.edu/center/ncat](http://www.eng.auburn.edu/center/ncat)

### HMAView

For information about HMAView contact George White, University of Washington at 206-685-7198 or Gloria Burke, Asphalt Team Leader, Maryland State Highway Administration at 800-477-7453. To view HMAView live, visit the Web site at <http://hotmix.ce.washington.edu/MD>

**A Guide for Hot Mix Asphalt Pavement and the Virtual Superpave Laboratory** are available from NAPA.

**National Asphalt Pavement Association**  
5100 Forbes Blvd.  
Lanham, MD 20706  
888-HOT-MIXX (468-6499)

methods. It also serves as a driver to agencies, contractors, and the technicians themselves to provide or seek training. A 2005 survey by the AASHTO Subcommittee on Materials found that 16 of 41 responding DOTs require certification for asphalt binder quality control technicians. Survey responses indicate that certification training and testing is provided by the DOT in 4 of the 41 responding states, by the AASHTO Materials Reference Laboratory in 5 states, and through regional certification programs such as the Northeastern Technician Training and Certification Program, which provides training at Penn State University and the University of Connecticut, in 7 states.

Variation in training materials is an important factor in discussions about certifying technicians and whether certification could be reciprocal among states. The FHWA's Transportation Curriculum Coordinating Council (TCCC) seeks to identify the various technician certification programs offered across the country and provide curriculum guidance. In recent years, TCCC leaders have met periodically to review

Superpave research findings so that appropriate training materials could be cited in this curriculum advice.

### Outreach

Traditional outreach activities such as conferences, workshops and publications have been often and effectively used to convey information about Superpave to various audiences. Superpave has figured prominently in regular conferences such as the TRB Annual Meeting and the Association of Asphalt Pavement Technologists. Special presentations on the development and deployment of Superpave were regularly included in meetings and conferences organized by AASHTO, the National Asphalt Pavement Association, the Asphalt Institute, and the National Stone, Sand, and Gravel Association. Periodically, The FHWA, TRB, AASHTO and industry organizations collaborated in sponsoring special Superpave Conferences. The first of these was held in Reno, Nevada, in October of 1994. The most recent was held in Nashville, Tennessee, in 2003, in conjunction with the World of Asphalt Exposition.

Workshops incorporating training elements were also a common technique to introduce the Superpave concept to users and to track the evolution of the system as improvements were made. Workshops were frequent additions to meetings sponsored by the regional asphalt/user producers groups or the Superpave Centers.

Conferences and workshops provide the human interaction that fosters learning and leads to evolutionary improvements to engineering systems such as Superpave. Publications, however, whether print or electronic, provide the system with a documentary foundation. In the past 10 years, hundreds of reports, syntheses, manuals, and guides documenting the use and evolution of Superpave have been published. A small sample of significant references published in support of Superpave deployment includes:

Asphalt Institute SP-1 *Superpave Performance Graded Asphalt Binder Specification & Testing*, 3rd ed. 2003.

Asphalt Institute SP-2 *Superpave Mix Design*, 3rd ed. 2001.

FHWA-RD-01-052 *Mixture Design Guide, Westrack Forensic Team Consensus Report*. 2001.



FHWA—RD-02074 *Understanding the Performance of Modified Asphalt Binders in Mixtures: Low Temperature Properties*. 2002. On the Web at: [http://www.fhwa.dot.gov/pavement/pub\\_details.cfm?id=291](http://www.fhwa.dot.gov/pavement/pub_details.cfm?id=291)

NCHRP 452: *Recommended Use of Reclaimed Asphalt Pavement in the Superpave Mix Design Method: Technician's Manual*. 2001.

NCHRP 455: *Recommended Performance Related Specification for Hot-Mix Asphalt Construction*. 2002.

NCHRP 459: *Characterization of Modified Asphalt Binders in Superpave Mix Design*. 2001.

NCHRP 464: *The Restricted Zone in the Superpave Aggregate Gradation Specification*. 2001.

NCHRP 465: *Simple Performance Test for Superpave Mix Design*. 2002.

NCHRP 478: *Relationship of Superpave Gyrotory Compaction Properties to HMA Rutting Behavior*. 2002.

NCHRP 513: *Simple Performance Tester for Superpave Mix Design: First Article Development and Evaluation*. 2004.

NCHRP 530: *Evaluation of Indirect Tensile Test (IDT) Procedures for Low-Temperature Performance of Hot Mix Asphalt*. 2004.

NCHRP 531: *Relationship of Air Voids, Lift Thickness, and Permeability in Hot-Mix Asphalt Pavements*. 2004.

### **Audience Diversity: An Additional Challenge**

Most technology transfer and training efforts are crafted to reach audiences that share common backgrounds and levels of relevant expertise. The deployment of Superpave, however, demanded technology transfer to multiple audiences whose members had widely varying technical backgrounds.

As Superpave became the standard hot mix asphalt design method for state DOTs, more local transportation agencies needed to develop expertise in its use. This precipitated new outreach and training efforts. Case studies and other materials were prepared under the direction of the Communications and Training ETG that could be the focus of workshops specifically for local agencies. The first workshop was held during the 8th International Low-Volume Roads Conference in Reno in 2003.

The Communications and Training ETG has suggested that such collaborations should be continued and expanded in the future. For example, communication with the FHWA's Transportation Curriculum Coordinating Council can ensure that research findings are included in new training materials. The second recommendation is participation in the FHWA's Community of Practice. This Web-based tool could become a dynamic center for learning best practices and moving HMA technology forward through shared interests. Participation in the Community of Practice would require commitment of funds and staff, as well as active means of engaging participants. An e-mailed bulletin or newsletter would be one approach to this.

### **SUMMARY**

Innovation is often an effective teacher and valuable lessons were learned from evaluating the techniques used to implement Superpave. A principal lesson was to take a measured approach to widespread implementation of what was essentially a prototype product. Resolving early challenges with test methods, equipment design, and aggregate issues in the lab or on test tracks would undoubtedly have bolstered early acceptance of Superpave. Not all problems will arise under test conditions, of course, but refining procedures where possible before deployment eliminates some barriers. This is a corollary to another lesson, which had to do with including potential product users in early discussions and decision making. Although including stakeholders was a guiding principle of the entire SHRP research and implementation effort, it was difficult to identify all affected groups and to ensure balanced influence among group members.

Ultimately, implementation efforts succeeded where barriers were eliminated. Congress funded implementation at nearly the same level as the initial research, risk-averse public agencies responded when mentors stepped forward, decision makers believed in the potential payoff and were willing to contribute support. These actions created a cultural shift that encouraged individuals at the operating level in all states to take implementation risks they might not otherwise have taken.

# 4

## UNANSWERED QUESTIONS

### A Need for Continuous Improvement

No engineering system can remain static for long. Situations will arise where reliability is compromised or opportunities may surface where reach and effectiveness can be extended or enhanced. The Superpave Committee recognized this eventuality and, as it developed and prosecuted the 2005 long-range plan, offered periodic recommendations regarding deficiencies or opportunities.

An example of such a recommendation can be found in the sixth letter report (August 10, 2001), of the TRB Superpave Committee. The committee recommended that the FHWA pursue the research that led to the development of the Dynamic Angle Validation Device that is now used to calibrate the internal angle of gyration of Superpave gyratory compactors (SGCs). When the SGC was first included in the Superpave system, it was not anticipated that the HMA suppliers and paving contractors would be using these compactors for construction quality control purposes and no technique to compare agency and contractor SGCs was provided. Over time it became evident that such a technique was needed if the deployment of the system was to continue. Similarly, when research conducted under NCHRP Project 9-14 (Investigation of the Restricted Zone in the Superpave Aggregate Gradation Specification) concluded that the “restricted zone” that controlled the proportion of fine aggregate included in an HMA materials design was redundant if all other Superpave aggregate standards were met, the committee recommended that the restriction be deleted from the AASHTO Superpave Standards (Letter Report 7, November 29, 2001).

The committee also offered recommendations for other research to enhance the Superpave System or to improve the performance of HMA pavements that is still incomplete or was never initiated because of funding or time constraints. These recommendations are summarized below as a reference for designers of future hot mix asphalt research programs. Although the Superpave system has obviously been deployed with great success, all of the original research objectives have not been completely met. Reliability of aspects of the system can still be enhanced and the progress of pavement research has opened new opportunities to further improve the design and construction of hot mix asphalt pavement.

#### MOISTURE DAMAGE

Moisture damage, also known as asphalt stripping or moisture susceptibility, refers to the loss of bond between asphalt binder and aggregate in the presence of moisture and traffic loading. Moisture damage is a complex phenomenon resulting from multiple physical and chemical interactions among asphalt cements, mineral aggregates, imposed loads, and environmental conditions. The fundamental mechanisms involved in these interactions are still not well understood and stripping continues to be a major cause of distress in asphalt pavements. In its third letter report (December 13, 1999) the TRB Superpave Committee recommended a two-pronged approach for future research.

1. Additional research on developing a physical test should recognize that any testing regime must sim-

ulate the conditions of service, in an accelerated manner, of specific asphalt-aggregate mixtures to accurately quantify the overall potential for moisture damage.

2. Because the fundamental mechanisms that lead to moisture damage are still not well understood, it would be prudent to support research into the underlying chemistry and physics of the problem. Any advance in basic understanding of this complex phenomenon would lead to improvements in physical tests used to quantify moisture damage potential of a mixture and would improve screening of the constituent materials.

Subsequently, the FHWA and the Western Research Institute of Laramie, Wyoming, agreed to pursue chemical and physical research into possible mechanisms of moisture damage. NCHRP Project 9-34 (Improved Conditioning Procedure for Predicting the Moisture Susceptibility of HMA Pavements), recommended by the committee, was initiated in 2002 to develop an improved conditioning procedure based on the SHRP-developed Environmental Conditioning System for evaluating the moisture susceptibility of compacted HMA in combination with the Superpave Performance Test validated in NCHRP Project 9-19 (Superpave Support and Performance Models Management). As yet this research is incomplete. While neither effort may prove to be the final answer, they represent a significant start in finding that answer.

## **INTEGRATION WITH PAVEMENT DESIGN MODELS**

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. The progress in NCHRP Project 9-19 toward test methods that can effectively characterize significant performance-related materials properties of asphalt mixtures and the progress toward models that can predict long-term performance of flexible pavements in Project 1-37a (Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II)

put new components in place. Even before these two projects were completed, the Superpave Committee saw an opportunity to validate and integrate the findings of these two independent efforts. In its fifth letter report (11/27/2000) the committee recommended that the investigation of this opportunity be undertaken promptly, even if it meant delay in the development of the more advanced materials characterization models. From this recommendation, the AASHTO Standing Committee on Research approved NCHRP Project 9-30 (Experimental Plan for Calibration and Validation of HMA Performance Models for Mix and Structural Design). This project has been completed and a follow-on project (9-30A) on calibration of rutting models for HMA is pending. The coordination of these research projects is an intimation of the coordination of pavement structural design and materials design that will be possible in the future.

In the same letter report, the committee recommended coordinating this research with NCHRP Projects 9-20 (now completed) and 9-22 (still active), which are investigating performance-related specifications for hot mix asphalt. If factors significant to performance can be specified in pavement design and/or mixture selection and design and then controlled during construction, a major step toward enhanced performance becomes possible.

The development of new, more sophisticated, mechanistic performance models was not crucial to the deployment of the Superpave system in its current form. Therefore the committee did not recommend additional model development as part of the Superpave deployment effort. However, the committee does see benefit in the development of calibrated, valid, fully mechanistic HMA performance models. Except in special cases, models of such complexity will probably not be used directly in pavement design. However, information derived from these models will lead to improved design procedures. This work will also lead to the identification of critical factors that can be controlled or influenced by materials suppliers and construction forces and so result in improved construction quality control and dependable long-term performance warranties. The pavement performance modules incorporated into asset management systems will also be influenced. Asphalt pavement performance models in use today still contain many empirically based components. Such models cannot adjust to new materials or conditions. When applied outside

their inference space, these models can yield undependable or even nonsensical predictions.

For these reasons, the committee's ninth letter report (January 7, 2003) recommended that the FHWA pursue development of fully mechanistic performance prediction models as an element of its long-range infrastructure research program.

## MINERAL AGGREGATE RESEARCH

Mineral aggregates are the principal components of hot mix asphalt. Any program of continuous improvement will find aggregate research to be a continuing necessity. In the fifth letter report (11/27/00) the Superpave Committee provided a white paper on HMA aggregate research developed by an ad hoc task force of the ETG on Mixtures and Aggregates. The committee recommended that several research needs cited in the white paper needed to be completed as part of the Superpave deployment effort. These recommendations led to NCHRP Project 9-35 Aggregate Properties and Their Relationship to the Performance of Superpave-Designed HMA: A Critical Review (now completed) and NCHRP Project 4-30A Test Methods for Characterizing Aggregate Shape, Texture, and Angularity (active).

Many other HMA-related research needs identified in the white paper remain unaddressed, however, and are worthy of consideration in future research programs addressing hot mix asphalt. (The white paper begins on p. 34 of the fifth letter report, which is online at [http://gulliver.trb.org/publications/sp/superpave.final.letter\\_5.pdf](http://gulliver.trb.org/publications/sp/superpave.final.letter_5.pdf))

## ASPHALT MODIFICATION

It has always been a goal to make the Superpave system "blind" to modifiers and additives. In other words, the system would be as reliable in characterizing critical properties of asphalt modified with any additive as it is with unmodified asphalts. Because various additives and modifiers rely on different mechanisms to modify the physical properties of asphalt, this is a challenging assignment and no other topic was addressed as frequently in the letter reports of the Superpave Committee. Research on methods or procedures to

reliably extend the Superpave performance grade specification was initiated by FHWA and the NCHRP during the ISTEA period. Since its organization, the Superpave Committee has consistently supported this research objective. In the fifth letter report, for example, the committee recommended continued funding be provided for the FHWA-managed study 90-07 to evaluate new or modified test methods to reliably characterize the properties of modified asphalts. The committee also advocated the creation of a state DOT pooled fund to use accelerated pavement testing to establish the relationship of pavement performance to the properties measured by the new tests.

Although incomplete, the FHWA research has identified some promising test methods to characterize the high-temperature behavior (i.e. rut resistance) of modified asphalts, but much remains to be done. There will always be new modifiers. The need for a set of laboratory test methods to adequately assess any modifier's potential to improve pavement performance is vitally important.

## SUPERPAVE FOR LOCAL ROADS

Among state DOTs, Superpave has largely supplanted other systems of hot mix asphalt materials selection and mixture design. The state DOTs, however, directly control only about 20% of the nation's 2 million miles of asphalt surfaced roadways. The remainder are under the custody and control of upwards of 15,000 local agencies. Among these local agencies, however, Superpave deployment is lagging. The responses to the committee's recent survey on Superpave usage indicated that local highway agencies were regularly specifying HMA purchases using the Superpave system in only 20 states. This lag in deployment is not unexpected. New highway technologies are often introduced at the state level and then disseminated among local agencies at a much slower pace.

In the case of Superpave, however, this situation is leading to adverse consequences for many local agencies. As deployment among state DOTs advanced and outpaced deployment among local agencies, the HMA paving industry has either had to support dual systems or supply Superpave selected materials to local roads agencies uninformed about the different performance characteristics of these materials. Because Superpave mixes are designed for specific traffic conditions, HMA

mixes designed for state highways, but supplied to local agencies, may be too coarse, too stiff, and too short on asphalt content to perform well on residential streets or farm-to-market roads.

Extending the deployment of new technology to the local roads community is always challenging. This community is very large, diverse in its needs, and generally must manage a full array of public services, not just roadways. It is unlikely that a single approach to deployment of Superpave among local agencies is to be found. Furthermore, until the true needs of local agencies are known and potential barriers identified, no effective strategy can be developed. The needs of large metropolitan areas will differ markedly from suburban and residential areas. Rural local roads agencies will have a different set of needs altogether.

In its seventh letter report (November 29, 2001), the Superpave Committee asked FHWA and AASHTO to consider if a special technology transfer effort to introduce the Superpave system to local agencies was warranted. The committee itself undertook several tentative steps in that regard. In March of 2003, the committee organized an “ask the experts” booth as part of the World of Asphalt exposition in Nashville, Tennessee. Exposition attendees could learn about using Superpave in local roads situations from a group of experienced users. At the 8th International Conference on Low-Volume Roads in Reno, Nevada, the committee conducted a pilot technology transfer workshop for local agencies built around actual case studies of Superpave applications for local roads. The case studies were contributed by county engineers in Maryland and New York.

In the eighth letter report (May 17, 2002), the committee also recommended that AASHTO develop criteria and design requirements for Superpave mixes suitable for application on light duty roadways. The committee’s recommendation forwarded a prototype specification suggested by the ETG on Mixtures and Aggregates. This mix, with a smaller nominal maximum-size aggregate, is more suitable for very thin overlays than the coarser mixes typically specified by state DOTs. AASHTO did amend the Superpave standards along these lines in the 24th edition of its standard specification. Criteria and requirements were included for 4.25mm and 9.5 mm nominal to size mixes (AASHTO, 2004).

The recent financial uncertainty associated with the sequence of short-term extensions of the federal aid surface transportation authorization has inhibited the development of any national program of technology transfer to local agencies. State DOTs and state asphalt paving associations have made efforts in this regard, however. Examples include the Iowa DOT’s development of a Superpave manual for local roads and materials developed by New York State DOT and the Cornell Local Roads Program. In the absence of a unified effort, however, deployment of Superpave among local agencies will continue to lag and the potential use of inappropriate materials and mixtures on lower volume roads will remain a problem.

## CONSTRUCTION

Performance related specifications and materials quality control and acceptance are the only construction elements considered in the Superpave system. The techniques of delivery, placement, and compaction of HMA are not addressed. However, construction related issues surfaced early in the Superpave deployment process—tender mixes, low mat densities, new compaction temperature requirements, handling of coarser mixes, and segregation were among them. From time to time, these issues reappear. It is not entirely clear, however, if these problems are unique to Superpave or systemic to HMA paving in general. Because poor construction can bring the best designs to naught, the committee remained cognizant of these issues and, where useful, recommended actions to FHWA and AASHTO that aid in resolving them.

From issues reported to the committee members by experienced paving contractors, it was evident that contractors and materials suppliers have encountered very real problems dealing with Superpave-designed asphalt mixes. In the great majority of instances, these problems have been satisfactorily resolved. While some of the problems relate to construction technique and the need to adapt techniques to Superpave mixes and other new materials, most seem related to construction quality control and apply generally to modern HMA paving. The Superpave Committee reached no specific conclusions on this topic but did recommend that AASHTO and FHWA maintain dialogue with the HMA construction industry regarding HMA construction.

## HISTORY OF SUPERPAVE

In May of 2005, the AASHTO Board of Directors formally adopted the NCHRP research program for fiscal year 2006. Included in that program is Project 9-42, History of Superpave and Its Implementation. In its eleventh letter report (April 8, 2005), the Superpave Committee expressed its support for such a project on the history of Superpave. In that letter, the committee stated:

Superpave is a research success story. The framers of the original Strategic Highway Research Program shared a vision that properly focused, high-intensity research could resolve growing concerns about unreliable performance of asphalt pavements. Now, as we approach the conclusion of the development and deployment program that has put that research into practice, we note that the documentary background of Superpave is scattered through more than 200 publications of at least six organizations. Even with the sophisticated capabilities of modern library science, we feel this disorganized state will ultimately prove injurious to the Superpave system and also limit the lessons to be learned from the Superpave experience.

Superpave has enjoyed high visibility among the organizations engaged in its deployment. Government and industry leaders were willing to invest the resources needed to secure the promised benefits. As the focused deployment effort draws to a close and the system blends into the engineering landscape, this profile might well change. Decisions about the application of Superpave to locally available materials, specific materials designs, laboratory workload, and other day-to-day issues will increasingly be made by individuals with no immediate familiarity with the background of Superpave. These individuals will lack the time and, in many cases, the training to consult the many technical references to determine if any particular decision is at odds with the systematic nature of Superpave. A single reference that illustrates how and why the Superpave system is organized as it is will limit the risk that would accompany otherwise uninformed decisions.

From the outset of the Superpave deployment campaign, members of academia have long advised us that a sourcebook was also needed if Superpave was to be incorporated into undergraduate and technical school

curricula. Particularly for engineering undergraduates, the “why” of any engineering system is a key element of successful teaching. While primers exist that deal with aspects of Superpave, no single text captures both the research foundation and practical application of the system. The committee sees the prospective project as a potential “sourcebook.”

Finally, because the Superpave Committee’s principal charge was to coordinate the finalization of the deployment effort, its greatest cause for concern is that the novel approaches and devices used in this very successful technology deployment program are little documented. Introduction of new technology systems among transportation agencies is always challenging. No lessons of successful deployment should go unrecorded. The brief exposition on technology transfer included in chapter 3 of this report only provides an indication of the innovative practices used to encourage the deployment of Superpave. The committee members believe these techniques can be used in other technology transfer efforts, but only if the reasons for their success are detailed.

## A SUCCESSFUL CONCLUSION

In the preliminary research plans for SHRP, AASHTO expressed its expectation of what the program’s asphalt research was designed to produce:

“...1) a specification for asphalt, with or without modification, which is designed to produce a binder with desired performance-based properties, and 2) a method for combining asphalt and aggregate to produce a mixture with desired performance-based characteristics.” (Page TRA 1-19, SHRP Research Plans, May 1986)

Under the rubric of Superpave, the SHRP research findings provided the building blocks of a prototype system to meet this goal. The deployment effort that followed provided the mechanisms for evolution, enhancement, and implementation among the state DOTs that converted the SHRP research results into a refined system that now forms the core of hot mix asphalt materials selection and mixture design specifications used throughout North America.

As reported in chapter 1, currently 50 of the 52 member state DOTs of AASHTO have adopted the

Superpave asphalt binder selection procedures and 48 are using the mixture design procedures. The non-user agencies have indicated plans to adopt both aspects of Superpave in the near future. Never before has a single set of hot mix asphalt materials standards been so widely used in the United States. Where the Superpave system is used, states have reported extended service life for asphalt pavements and reduced maintenance costs. Little or no increase in the cost of hot mix asphalt is attributable to adoption of the Superpave system. Full integration of the Superpave system into standard hot mix asphalt practice by the end of 2005 was the stated goal of the TRB Superpave

Committee at its inception. Clearly this goal has been met as well.

Work remains, however. Research is continuing in a number of areas, including moisture damage, testing of modified asphalts, mineral aggregates, and performance testing. Additional research in other areas, such as advanced performance models and construction quality control is indicated. The apparent lag in deployment and limited conversancy with Superpave among local highway agencies indicates that the system is still not fully comprehended by potential users.

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## TRB SUPERPAVE COMMITTEE BIOGRAPHICAL INFORMATION

### **Joseph A. Mickes, Chairman**

*Energy Absorption Systems, Inc.*

Mr. Mickes holds a BS (engineering), 1958, from the Missouri School of Mines (now the Univ. of Missouri, Rolla). He is a registered professional engineer with more than 40 years of highway engineering experience. Mr. Mickes currently works for Energy Absorption Systems, Inc., a highway safety technology supply firm now part of Quixote Safety Corporation. He was formerly Director and Chief Engineer of the Missouri Department of Transportation. He has served as Chairman of the TRB SHRP Committee and as a member of the TRB Executive Committee and the TRB Executive Committee's Subcommittee for NRC Oversight.

### **David A. Anderson**

*Professor of Civil Engineering (Emeritus)*

*Pennsylvania State University*

Dr. David A. Anderson is emeritus professor of civil engineering at the Pennsylvania State University and director of the North East Center of Excellence for Pavement Technology at the Pennsylvania Transportation Institute. Dr. Anderson has worked on the Strategic Highway Research Program (SHRP) asphalt program in the development of new specifications and tests for asphalt cement binders. He was responsible for leading the Penn State team of faculty and graduate students that developed the test methods and specifications for the new SHRP binder specification. He is particularly interested in the development of test methods and equipment, the physical characterization of civil engineering materials, and the development of relationships between material properties and in-service performance. Dr. Anderson has extensive experience with accelerated loading facilities as well as test tracks and has supervised a number of field studies in which the performance of different aggregates, mixture designs, and pavement sections were evaluated. Other research interests and projects include pothole repair materials and methods, seal coat performance, skid resistance, flyash utilization, and pavement instrumentation. Dr. Anderson has authored more than 120 research reports and refereed publications and has been principal or primary investigator on research projects totaling more than \$15 million.

**Martin F. Barker**

*Engineer*

*City of Albuquerque, NM*

As the senior roads and streets manager for the City of Albuquerque, Mr. Barker is responsible for a substantial program of reconstruction or overlay of asphalt pavements. He has initiated the use of Superpave in this program and provides an experience base useful in developing Superpave technology transfer schemes suitable for other municipal transportation agencies.

**Jed S. Billings** (*Served through 2004*)

*President and Chief Executive Officer*

*FNF Construction, Inc.*

Mr. Billings is the president and chief executive officer of FNF Construction, Inc., a major highway construction firm operating in Arizona, New Mexico, and California. He has held this position since 1986. Mr. Billings has more than 30 years of asphalt pavement construction experience. His firm has been eager to introduce innovation into construction practices. He has direct experience with asphalt rubber and Superpave. His firm works both in states that are attempting to deploy the Superpave system and in those resisting its introduction, affording him a unique view of the deployment process. Mr. Billings has been active in leadership roles in a number of local and national industry associations including the National Asphalt Pavement Association, the American Road and Transportation Builders Association, and the Associated General Contractors.

**Frank L. Danchetz**

*Arcadis G&M, Inc.*

Mr. Danchetz holds a BS in civil engineering from the Georgia Institute of Technology and is a registered Professional Engineer. He was Chief Engineer of the Georgia DOT, where he was responsible for the management of all planning, design, construction, and maintenance activities. Past experience also includes environmental assessment and impact mitigation, rights-of-way management, and service as the departmental liaison to Congress. Mr. Danchetz served on the Standing Committee on Highways of AASHTO and was a member of the Research and Technology Coordinating Committee and the Committee for a Future Strategic Highway Research Program, both NRC-appointed committees of TRB.

**Fred M. Fehsenfeld, Sr.**

*Chairman of the Executive Committee, Heritage Group*

Mr. Fehsenfeld holds a mechanical engineering degree from Purdue University. He is currently chairman of the Heritage Group, which consists of 25 companies nationwide with more than 3,800 employees. This group of companies is involved in petroleum marketing, oil refining, road building, aggregate production, and environmental management, with a strong corporate emphasis on research and development. Mr. Fehsenfeld has held many voluntary posts within the Asphalt Institute, including Director and Chairman, and has held similar positions in other petroleum industry associations. He is currently a member of the Association of Asphalt Paving Technologists, the Technical Oversight Committee of the National Center for Asphalt Technology, TRB's standing technical Committee on General Asphalt Problems, the National Asphalt Pavement Association (NAPA), and the Asphalt

Institute (AI). He has been named to NAPA's "Hot Mix Hall of Fame" and AI's "Roll of Honor" for his industry contributions and has received the Distinguished Engineering Alumni Award from Purdue University. He is the author of a number of professional papers and holds several industrial patents.

**John E. Haddock**

*Assistant Professor of Civil Engineering  
Purdue University*

Dr. John E. Haddock is currently an Assistant Professor of Civil Engineering at Purdue University and a registered Professional Engineer in Indiana. His work experience includes several years in the hot mix asphalt industry, during which time he was responsible for the production of asphalt mixture designs, problem resolution, forensic pavement investigation, and pavement design and analysis in a five-state region. He was also involved in national research initiatives while working as a Senior Research Associate for the National Center for Asphalt Technology in Auburn, Alabama. While there he was Principal and/or Co-Principal Investigator on projects funded by various state departments of transportation, the National Asphalt Pavement Association Research and Education Foundation, the Federal Highway Administration, and the National Cooperative Highway Research Program. Through this research he has participated in adapting Superpave techniques and specifications to specialized hot mix asphalt mixtures, preparation of specialized hot mix asphalt construction guidelines, development of new test methods, and specification writing. Subsequently, Dr. Haddock has worked as a research engineer for the Indiana Dept. of Transportation and the Asphalt Institute, before joining the Purdue University faculty.

**Eric E. Harm**

*Deputy Director for Project Implementation  
Illinois Department of Transportation*

Mr. Harm holds a BS in civil engineering from the University of Illinois and an MS in civil engineering from the University of California, Berkeley. He is a registered professional engineer and has been with the Illinois DOT since 1980. Previous DOT positions include Engineer of Materials and Physical Research, Bituminous Operations Engineer, and Materials Investigations Engineer. He is a member of a number of TRB committees and task groups including the standing technical committee on the Conduct of Research. He is a member of the AASHTO Technical Subcommittee on Materials and the Standing Committee on Research. He is also a member of the Association of Asphalt Paving Technologists.

**Paul J. Mack**

*Consultant Schenectady, New York*

Mr. Mack holds a bachelor's degree in civil engineering from Manhattan College and is a registered professional engineer. He is a recently retired 30-year veteran of the New York State Department of Transportation (NYSDOT), where he held a variety of engineering posts in highway and waterway design, construction, and operations. Most recently he directed the Technical Services Division of the DOT. Mr. Mack was the national team leader for the AASHTO Superpave Lead State Team. He was also a member of the AASHTO Subcommittee on Materials and the NYSDOT state representative. In 1985, he was named Statewide Engineer of the Year.

**Charles R. Marek**

*Principal Materials Engineer  
Vulcan Materials Company*

Dr. Marek holds a BS and Ph.D. in civil engineering from the University of Illinois. From 1967-1972, he was a member of the civil engineering faculty at the same institution. He joined Vulcan in 1972 and was named to his current position in 1986. Dr. Marek is a member of the American Society of Civil Engineers, the Association of Asphalt Technologists, and ASTM. He has served on several SHRP committees, including the Pavement Performance Advisory Committee, and is a member of the TRB standing technical committee on Mineral Aggregates.

**John B. Metcalf**

*Professor of Engineering  
Louisiana State University*

Dr. Metcalf is the Freeport-McMoRan Professor of Engineering at the Louisiana State University (LSU). He holds a BS and Ph.D. in civil engineering from Leeds University (U.K.). He is a fellow of the Geological Society of London, the Institution of Civil Engineers (U.K.), and the Institution of Engineers (Australia). He is also a member of the American Society of Civil Engineers. From 1958 to 1992, Dr. Metcalf worked for the Transport and Road Research Laboratory (U.K.), the National Research Council of Canada, the Queensland Main Roads Dept. (Australia), and the Australian Road Research Board, where he served as deputy director from 1975 to 1992. He joined the LSU faculty in 1992. His main areas of academic interest are technology transfer, low-cost roads, non-standard materials, pavement design and quality control. He is the author of more than 120 technical papers. Dr. Metcalf has provided consulting services to the United Nations, the World Bank, government agencies, and branches of industry in various countries. He is currently engaged in research on accelerated pavement testing, asphalt quality control, maintenance management, and recycled rubber in highway construction. Dr. Metcalf is a member of, and formerly chaired, the Permanent Association of Road Congresses Committee on Roads in Developing Regions. He is a member of a number of TRB standing technical committees.

**Gale C. Page**

*State Flexible Pavement Materials Engineer  
Florida Department of Transportation*

Mr. Page holds a BSCE from the University of Wisconsin-Madison and a master's degree in engineering from the University of Wisconsin-Milwaukee. Mr. Page is a registered professional engineer. He has been with the Florida DOT for 23 years and has also had 10 years of experience with the Wisconsin DOT. He is familiar with all aspects of highway design and construction, but his specialty is highway construction materials, especially asphalt and asphalt mixtures. He is broadly experienced in the introduction of new materials technology within highway agencies, including standards development, technology transfer and deployment strategies. Mr. Page is a member of ASTM, the American Society of Civil Engineers, and past president of the Association of Asphalt Paving Technologists, the International Society of Asphalt Pavements, and the Asphalt Recycling and Reclaiming Association. He serves or has served on several TRB standing technical committees, chairing two, and on several NCHRP project panels. Mr. Page served as a member and vice-chair of the SHRP Asphalt Advisory Committee through 1993. He is the author of 15 refereed papers and many technical reports.

**Douglas R. Rose**

*Deputy Administrator, Chief Engineer  
Maryland State Highway Administration*

Mr. Rose holds a BS in civil and environmental engineering from Clarkson College of Technology and an MS in civil engineering from the University of Maryland. Mr. Rose was appointed Chief Engineer in 1995 and has more than 20 years of experience in highway construction, maintenance, and traffic operations. Mr. Rose is active on a number of AASHTO committees including the Technology Implementation Group and the Joint Associated General Contractors-American Road and Transportation Builders Association-AASHTO Task Force. He serves on the Board of Directors of the Maryland Association of Engineers and is a member of the American Society of Civil Engineers, the American Society of Highway Engineers, and the American Public Works Association.

**Byron E. Ruth** (*Served through 2004*)

*Professor of Civil Engineering, Emeritus  
University of Florida*

Dr. Ruth holds BS, MS, and Ph.D. degrees in civil engineering, respectively, from Montana State University, Purdue University, and West Virginia University. Dr. Ruth is a registered professional engineer. He has specialized in pavement design, highway materials, and soil mechanics. Dr. Ruth has authored or co-authored numerous publications on the performance of asphalt pavements and paving materials. He is a life member of the American Society of Civil Engineers, ASTM (where he chaired the Committee on Road and Paving Materials), a member of the Association of Asphalt Paving Technologists (past president), and serves on several TRB standing technical committees related to asphalt and asphalt paving.

**Dean C. Weitzel**

*Chief Materials Engineer  
Nevada Department of Transportation*

As Chief Materials Engineer for the Nevada DOT, Mr. Weitzel is responsible for the administration of a multimillion dollar activity devoted to highway materials selection and quality assurance, development and application of specification, and the conduct of physical research. Mr. Weitzel holds a bachelor of science degree in civil engineering from the University of Nevada and is a registered professional engineer in the states of Nevada and California. Mr. Weitzel has a total of 20 years of experience in highway design and construction. In addition to his experience in highway materials and research, Mr. Weitzel has experience in bridge and roadway design.

**J.T. Yarnell**

*Chief Engineer  
Missouri Department of Transportation (retired)*

Mr. Yarnell is a graduate of the University of Kansas (B.Sc., civil engineering). He was with the Missouri Department of Transportation for 35 years, where he has held a series of progressively important posts. This experience has provided a broad background in highway engineering and operations. Mr. Yarnell was appointed Chief Engineer of the Department in 1998 and retired from the department in 2001. He is a registered professional engineer and a member of the American Society of Civil Engineers and the Missouri Society of Professional Engineers.





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