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THE SOUTH CENTRAL SUPERPAVE CENTER: REPORT OF ACTIVITIES

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16. Abstract

The planning of the South Central Superpave Center (SCSC) began in mid-1994. The Center hired its first staff in early 1995 and was fully staffed by June 1995, at which point it became operational. This report describes SCSC activities that took place between June 1995 (when it first became operational) and the end of August 1998.

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REPORT OF ACTIVITIES

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Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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INTRODUCTION

BACKGROUND

The Strategic Highway Research Program (SHRP) was a 5-year, $150 million research effort that mobilized state-of-the-art engineering and scientific expertise to solve problems faced by those in the highway engineering community. It was funded by the state departments of transportation (DOTs) and administered by the National Academy of Engineering. Most of the SHRP research was undertaken between 1987 and 1993. Of the $150 million that was expended, $50 million was spent in the area of asphalt research. As part of this effort, the SHRP Asphalt Research Program produced a product called *Superpave,* which stands for Superior Performing Asphalt Pavements. Although Superpave is called a product, it is actually a new system for specifying asphalt materials and consists of two principal features: (1) a new asphalt binder specification with a new set of tests to match and (2) a new mix design and analysis system.

At approximately the midpoint of SHRP's term, top managers in state DOTs, industry, and the Federal Highway Administration (FHWA) began to contemplate the implementation phase of the various SHRP research products. There was a clear belief that if the benefits of SHRP were to be realized, then a clear, aggressive implementation strategy needed to be followed. Consequently, the Intermodal Surface Transportation and Efficiency Act of 1991 allocated $105 million to facilitate implementation of SHRP research products, with the FHWA charged with coordinating the research efforts.

The FHWA developed a Superpave implementation plan that included many features, one of which was the establishment of Superpave centers that were to function as regional centers of expertise to expedite Superpave implementation. While the SHRP asphalt researchers produced a finished product in Superpave, there was general consensus that some of the features of Superpave remained in the research arena. As a result, the FHWA believed that the Superpave centers needed to possess engineering research capabilities. Thus, the FHWA arranged for the establishment of the centers at universities, each with a host state DOT, to serve as a liaison with other DOTs in the region. Table 1 outlines the centers that were established.

Plans for the South Central Superpave Center (SCSC) began in mid-1994. The Center hired its first staff in early 1995 and was fully staffed by June 1995, at which point it became fully operational. This report describes SCSC activities that took place between June 1995 (when it first became operational) and the end of August 1998.

Table 1. Superpave Regional Centers

Regional Center	Host University	Host State DOT
Northeast Superpave Center	Penn State University	Pennsylvania DOT
Southeast Superpave Center	Auburn University	Alabama DOT
North Central Superpave Center	Purdue University	Indiana DOT
Western Region Superpave Center	University of Nevada at Reno	Nevada DOT
South Central Superpave Center	University of Texas at Austin	Texas DOT

SOUTH CENTRAL SUPERPAVE CENTER STRUCTURE

ADMINISTRATIVE STRUCTURE

The Texas Department of Transportation (TxDOT) provided principal funding for the South Central Superpave Center (SCSC) in the amount of $300,000 per year, with an additional $100,000 provided to SCSC by the Federal Highway Administration (FHWA). For funding and other administrative purposes, SCSC was established by TxDOT through their normal cooperative research arrangement with The University of Texas at Austin, Center for Transportation Research (CTR). Center personnel were hired as employees of the University and all other administrative functions were conducted under the normal rules and regulations established by TxDOT that are part of the cooperative agreement. In other words, the SCSC was administered the way any other TxDOT-funded research project is administered at The University of Texas at Austin. TxDOT assigned Maghsoud Tahmoressi, head of Bituminous Branch, Materials and Tests Section, Construction Division, as its designated project director. Thus, he served as director of the SCSC. Dr. Thomas W. Kennedy, Engineering Foundation Professor, Department of Civil Engineering, was designated by the University as principal investigator.

MANAGEMENT STRUCTURE

As the host state department of transportation (DOT), TxDOT decided that the SCSC needed to be governed by a management committee consisting of individuals who represented organizations that were to be assisted or affected by Center activities. This committee included materials engineers from the state DOTs served by the Center, FHWA personnel, and industry representatives. Thus, in early 1995, TxDOT extended invitations to the state materials engineers in Arizona, New Mexico, Oklahoma, Arkansas, and Louisiana to serve as managers of the activities of the Center. Also invited were representatives of the FHWA Texas Division and FHWA Region 6, which included most of the states that would benefit from the activities of the Center. Additionally, TxDOT invited participation of the

Texas Hot Mix Asphalt Pavement Association in an attempt to attract industry participation. Table 2 shows the Center's original management committee.

Table 2. SCSC Management Committee

Management Committee Member	Affiliation
Fred Cooney	New Mexico DOT
James Cravens	FHWA Texas Division
Douglas Forstie	Arizona DOT
James Gee	Arkansas Highway and Transportation Dept.
Katherine Holtz [1]	TxDOT
Ross Martinez	FHWA Region 6
Jarvis Poche	Louisiana Dept. of Transportation and Development
Charles Smoot	Texas Hot Mix Asphalt Pavement Assn.
Jack Telford	Oklahoma DOT

[1] Committee Chair

At its initial meeting, the management committee outlined the following mission and vision of the Center:

> The SCSC represents a unique partnership among TxDOT, the FHWA, and The University of Texas at Austin, Center for Transportation Research. Cooperating partners include the Arizona Department of Transportation, Arkansas State Highway and Transportation Department, Louisiana Department of Transportation and Development, the New Mexico State Highway Department, the Oklahoma DOT, and the FHWA.
>
> The mission of the Center is to:
>
> 1. Evaluate and improve Superpave products through applied research.
> 2. Assist and promote uniform Superpave technology.
> 3. Be an information resource for management-level personnel.
> 4. Provide training in Superpave technology.
> 5. Provide testing and technical assistance to Superpave Center partners.
>
> The SCSC provides expert assistance to agencies, industry, and academia in all areas pertaining to the implementation of Superpave.

STAFFING

During its first 3 years of operation, the SCSC had a staff that consisted of five principal individuals. Robert B. McGennis managed the day-to-day affairs of the Center. Dr. Mansour Solaimanian served as project engineer for the Center. Daniel L. Quire functioned as technical staff and managed binder and performance testing. Eugene E. Betts also served as technical staff and managed the activities of the Center pertaining to aggregate processing and mix design. Jian N. Wang was a graduate student who served as technical staff at 50 percent time while he pursued a doctoral degree in civil engineering. Clair LaVaye worked at a 25 percent level and administered the Center's presence on the Internet. Other Center staff consisted of various graduate students and TxDOT loan staff that assisted the Center in such activities as laboratory experiments and training.

FUNDING

Principal funding of the SCSC was provided by TxDOT and the FHWA at a level of approximately $400,000 per year. Of this amount, $300,000 was provided by TxDOT while $100,000 was provided by the FHWA. By the completion of the SCSC project, TxDOT will have funded $1,600,000 toward Center activities and the FHWA will have funded $325,000. The SCSC management committee decided that each participating state would contribute $25,000 to the Center, although only $10,000 would be available for Center use. The remaining $15,000 was intended to be used by state DOT personnel to fund their travel to Center meetings and other meetings pertaining to Superpave implementation. However, of the five cooperating states, only Arkansas and Oklahoma elected to provide funding. Arizona, Louisiana, and New Mexico did not provide funding, although Center staff did provide a variety of services to those states.

In addition to direct funding, the FHWA loaned Superpave equipment to the Center. This equipment included a Pine Superpave gyratory compactor (SGC), a Superpave shear tester, a Superpave indirect tensile tester, and a Superpave direct tension tester. Other necessary equipment was purchased by Center staff through the Center's normal operating budget.

FACILITIES

In June 1995, the SCSC began operations in the pavement materials laboratory that is jointly operated by the Department of Civil Engineering and the Center for Transportation Research at The University of Texas at Austin. That facility is located on campus in Earnest Cockrell, Jr., Hall and occupies approximately 1,000 square feet of space. It was initially the desire of the principal funding agency, TxDOT, that the Center operate an independent, off-campus facility. Preliminary designs indicated that a 6,000 to 8,000 square foot facility would effectively accommodate all necessary activities.

During the search for an off-campus site, TxDOT expressed the desire for a shared facility, with Center space easily accessible to the Bituminous and Asphalt Sections of TxDOT's Materials and Tests Division. This proposed arrangement had two advantages: First, it alleviated a space problem these two sections had at TxDOT's Materials and Tests Division building. Second, a shared site would expose TxDOT engineering and technical staff to the expertise and equipment operating at the Center. Consequently, Center and TxDOT staff began a search for commercial lease space in the greater Austin vicinity. This search eventually led to a light-industry site in north Austin that is close to the University's Pickle Research Campus.

TxDOT and Center personnel designed a 25,000 square foot laboratory, research, and training facility. Of this total, the SCSC occupied a separate 5,000 square foot area, with an additional 1,000 square feet of shared space. Shared space included a storage area, classroom space, and kitchen/break rooms. This facility is located at 2311 West Rundberg Lane in Austin. Figure 1 shows the layout of the SCSC building.

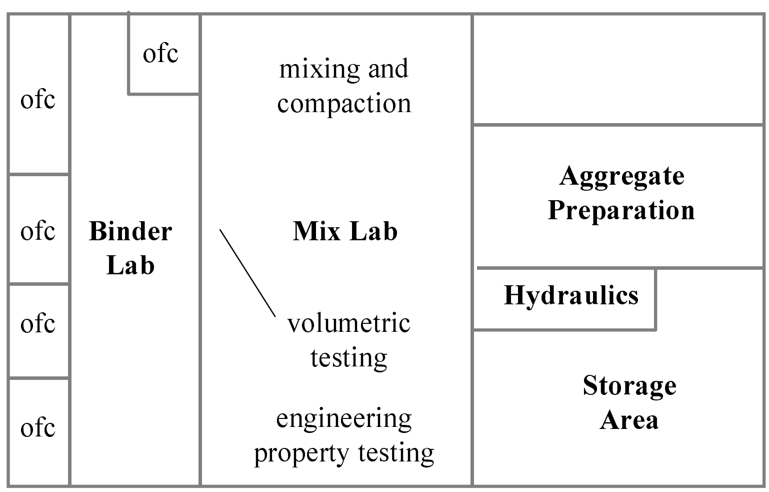

Figure 1. Layout of the SCSC

COMMUNICATIONS

NEWSLETTER

To meet the goals and objectives of the SCSC, the management committee directed Center staff to prepare a quarterly newsletter to outline Center activities and serve as a vehicle to communicate various information pertaining to Superpave implementation. Two newsletters were ultimately produced in 1996. Center staff prepared a mailing list of approximately 1,500 names to which these newsletters were mailed. Owing to a reduction in the Center budget of $50,000 directed by the Texas Department of Transportation (TxDOT), the staff decided to discontinue the newsletter in favor of the SCSC Internet site.

INTERNET SITE

The SCSC Web site began in April 1996. It was developed and administered by Clair LaVaye of The University of Texas at Austin, Center for Transportation Research. It is located on the UTS server at The University of Texas at Austin Computation Center. The site is mirrored and automatically backed up through the University's UNIX system. This system provides a weekly statistical report on hits and visitors to the site.

The site consists of text files in HTML with little Java Script, no frames, and compact graphics. This environment ensures that the site displays quickly and reliably to all browsers, including Netscape, Lynx, and Microsoft's Internet Explorer. The bulk of the Web site, and its main feature, is an extensive set of articles on Superpave technology and research. There is also an FTP directory that houses useful software for free download to Web visitors. An important feature of the site is the announcement of training in Superpave and announcements of Superpave-related events scheduled in the U.S.

The content of the site consists of pages that explain what Superpave is, outlines Superpave mix design, provides the mission of the SCSC, lists staff and how to contact them, and posts job and internship opportunities in the Superpave area. Finally, there is a links page that lists extensive links to more online information about Superpave and companies that support this technology.

The Superpave Newsgroup began in December 1996 and has grown to over 250 subscribers. This has been a very popular feature associated with the SCSC Web site. The University of Texas mail server, McFeeley, handles e-mail functions around the clock, backs up the mail, archives it, and creates daily digests. The e-mail is periodically archived into an HTML file and posted on the Web site.

When the Web site began, it received between 700 and 1,000 hits per week, a figure that has now increased to approximately 2,300 hits per week. Many of the hits are on the site's articles' section, which is where the newest information is kept. Some articles have been hit as often as 250 times per week. The hits come from extremely diverse locations worldwide. Governmental agencies are among the most frequent users of the Web site. In a 1-week period in August 1998, personnel from the Federal Highway Administration (FHWA), the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), the City of Glendale, Arizona, and state departments of transportation (DOTs) in Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, Oregon, Texas, and Wisconsin accessed the site. Users from the following countries accessed the site during the same week: Austria, Australia, Brazil, Canada, Ecuador, Finland, Greece, Indonesia, Ireland, Italy, Japan, South Korea, Mexico, Peru, Sweden, Singapore, Turkey, and the U.S.

Because the articles portion of the SCSC Web site is its most popular feature, a list of representative articles is shown below:

- *Superpave Lead State Recommendations* — This document, provided by Paul Mack, Deputy Chief Engineer of the New York State DOT, outlines the latest recommendations of the Superpave Lead States team with respect to Superpave mix design and material requirements.

- *The Importance of Quality Management of Asphalt Concrete Production* — Manitoba's experience as related by Doug Fisher, Manager, Engineering Audit and Quality Assurance for the Province of Manitoba, Highways and Transportation.

- *FHWA Superpave Mixture Expert Task Group* — Minutes from the meeting held March 10–11, 1998, in Orlando, Florida.

- *Evaluation of Various Superpave Gyratory Compactors* — This article summarizes Superpave gyratory compactor (SGC) evaluations conducted at the SCSC using the American Association of State Highway and Transportation Officials (AASHTO) TP35. The new units evaluated include those produced by Pine, Troxler, Rainhart, Test Quip, and Interlaken.

- *AHTD's Experience with Superpave Pavement Permeability* — This article, by Jerry R. Westerman, Assistant Materials Engineer of the Arkansas State Highway and Transportation Department, was presented for the Arkansas Superpave Symposium, January 21, 1998, in Little Rock, Arkansas.

- *Summary of Superpave Projects in Arkansas* — This article, by Jim Gee of the Arkansas Highway and Transportation Department, presents a summary of experience of Superpave projects.

- *Summary of TxDOT Superpave Projects Constructed in 1997* — This article, by Maghsoud Tahmoressi of TxDOT, presents a summary of experience of Superpave projects constructed in Texas in 1997.

- *FHWA Superpave Mixtures Expert Task Group* — Meeting minutes of the September 1997 meeting of the FHWA Superpave Mixtures Expert Task Group.

- *Proper Design ESAL Selection Is Critical for Superpave Mix Design Success* — This article, by Phil Blankenship of Koch Materials Company, makes a case for using rate of equivalent single axle load (ESAL) application rather than total ESALs for the purpose of selecting Superpave mix designs.

- *A Test Method for Identifying Moisture Susceptible Asphalt Concrete* — This is a description of a study that was conducted to better analyze the moisture susceptibility of Superpave mixes.

- *Comparative Analysis of Superpave Gyratory Compactors and TxDOT Gyratory Compactors* — This study describes a comparison of the Superpave and Texas gyratory compactors for field control of hot mix asphalt (HMA) production.

- *Production and Placement of Superpave Hot Mix Asphaltic Concrete Pavement* — This article, by Tim Stone, describes a case study of a successful Superpave project in north Texas.

- *Resolution of SCOH-97 AM-1 (AASHTO Resolution): Uniform Implementation of SHRP Superpave* — This resolution, recently passed by AASHTO, outlines uniform implementation of Superpave.

- *U.S. Hot Mix Asphalt Conference and Superpave Workshop* — This documents presents a summary of the technical sessions held at the 1997 U.S. HMA Conference and Superpave Workshop in Phoenix, Arizona. The document was prepared by Phillip Arena of the Louisiana Division of the FHWA.

- *The Status of Superpave Binder Implementation* — This is a discussion of the acceptance procedures and specification impacts on TxDOT and the binder industry.

- *Roundtable Discussion on Superpave* — This article summarizes the roundtable discussion that took place at the AASHTO Subcommittee on Materials Meeting.

- *QC/QA in Utah* — This abstract is from a report by the Utah DOT; it describes the results of a QC/QA case study.

- *AASHTO Task Force on SHRP Implementation 1996 Superpave Implementation* — This article describes the activities of the AASHTO Lead States on Superpave Implementation. It includes a survey of 1996/1997 Superpave projects and a listing of the lead states' pool of expertise.

- *Investigation of Correction Factors in Backcalculation of Density Using the Superpave Gyratory Compactor* — The Bituminous Section of TxDOT, Materials and Tests Division, investigated some of the effects of using corrected backcalculated laboratory molded densities at N-design, as used in the Superpave design procedure. This article is a brief summary of some of the interim findings of the investigation.

- *Superpave Projects Review of Construction Experience* — This article, prepared by the engineering staff of Asphalt Institute, describes construction experience with Superpave projects constructed in 1996.

- *Evaluation of Recovered Binders from Swiss LTPP Sections with Superpave Binder Tests* — This is an abstract from a report by the Swiss Federal Laboratories for Materials Testing and Research. It describes a study characterizing binders recovered from a Swiss LTPP site using the Superpave binder tests.

- *What is Happening at WesTrack* — This article reports the latest news from the FHWA's performance-related test experiment at the Nevada Automotive Test Facility.

- *Development of Relationships between SHRP Asphalt Test Parameters and Structural Mixtures for Mechanistic Analysis and Rehabilitation Design of Flexible Pavements* — This article, from the Florida DOT, describes a study to investigate the relationship between Superpave binder properties and conventional binder properties.

- *Superpave Protocols for Modified Asphalt Binders* — This article, written by Dr. Hussain U. Bahia, describes the research approach used for National Cooperative Highway Research Program (NCHRP) Project 9–10, "Superpave Protocols for Modified Asphalt Binders."

- *AASHTO Lead State Guidance on Superpave Implementation* — This article, by Paul Mack of the New York DOT, offers guidance for implementation of Superpave by the AASHTO lead states.

- *Aggregate Production for Superpave HMA* — This article describes production of mineral aggregates for use in Superpave HMA.

- *Experiences with Superpave Volumetric Mix Designs* — This article, by Phillip Blankenship of Koch Materials Company, discusses issues pertaining to Superpave mix design.

- *Progress with the Performance Graded (PG) Specification for Asphalt* — This article, by Gayle N. King of Koch Materials Company, describes pertinent issues related to implementation and use of Superpave binders.

- *Protocol for Evaluation of Superpave Gyratory Compactors* — This article describes the method by which new Superpave gyratory compactors are evaluated for accuracy.

- *Implementing Strategic Highway Research Program Superpave Technology* — This article, by Donald Steinke, Chief, FHWA Highway Operations Division, outlines various important issues pertaining to Superpave implementation.

- *Superpave and Aggregate Properties: Where Did They Come From?* — This article, by John D'Angelo, presents the background and sources behind some of the Superpave aggregate requirements.

- *Guidelines for the Design of Superpave Mixtures Containing Reclaimed Asphalt Pavement (RAP)* — This guideline, developed by the FHWA Superpave Mixtures Expert Task Group, outlines the proper methods for incorporating RAP in Superpave mixtures.

- *Student Wins AAPT/Ward K. Parr Scholarship* — This article announces that Weng On-Tam was awarded the AAPT/Ward K. Parr Scholarship from the Association of Asphalt Pavement Technologists.

- *Use of Rolling Wheel Rut Testers* — This article provides a cautionary note from the FHWA Superpave Mixtures Expert Task Group pertaining to the use of rolling wheel rut testers.

- *The Use of Superpave PG Grading System for Selecting Asphalt Binders for Seal Coats* — This report summarizes the analysis and evaluation of the use of PG-graded asphalt for seal coats. This is an abstract of a research report suggesting a means for using Superpave PG binders for seal coat applications.

- *Performance-Based Seal Coat Asphalt Specifications* — TxDOT is moving to adopt the requirements and nomenclature of the asphalt binders developed for the Strategic Highway Research Program's (SHRP) Superpave design system for HMA concrete. This is an abstract of a research report describing test results that classified common seal coat binders used in Texas in the Superpave PG system.

- *Evaluation and Quality Control of Asphalt Mixture Additives* — This item establishes a procedure for highway agencies to use in the evaluation of mixtures containing solid additives.

- *The Bottom Line: The Superpave System Works* — This document is an editorial written by Thomas W. Kennedy, Technical Director of the SCSC.

- *Latin American/U.S. Asphalt Technical Conference* — This article describes the use of the Superpave system in South Central America (reprinted by permission from the January 1997 *Focus* magazine).

- *Meeting at SCSC by Members of the Superpave Advisory Committee* — This article documents an Austin meeting that focused on updates and strategies.

- *Implementing Superpave in Arkansas* — This is an update on Superpave activities in Arkansas by Jim Gee of the Arkansas Highway and Transportation Department.

- *Publications for Reference* — This article identifies resource and reference material assembled by the Transportation Research Board (TRB).

- *Superpave Models Update* — The FHWA has contracted with the University of Maryland at College Park to update and improve the asphalt pavement performance models in Superpave.

- *What is happening at WesTrack and what does it mean for the future?* — This is an article on WesTrack, the FHWA's HMA performance-related specification test facility in Nevada.

- *Proposed TxDOT Superpave Binder Implementation Plan* — This article describes the proposed method that TxDOT will use to implement Superpave binders.

- *Superpave Binder Testing (m-value)* — This memo from the FHWA defines the current issue of *m* value from different bending beam rheometers.

- *Superpave Gyratory Compactor Update* — This update is based on information presented at the recent FHWA Superpave Mixtures Expert Task Group meeting, and on conversations with FHWA, Troxler, Pine, Heritage Research, and the other Superpave Centers.

- *AASHTO Superpave Lead State Team* — AASHTO Superpave Lead State AASHTO Task Force on SHRP Implementation headed by Bob Templeton of TxDOT has initiated a concept that promises to become a new wave in technology implementation in coming years.

- *P.E. Katherine Holtz Welcomes New Superpave Center* — This article describes the effort to make the SCSC a truly regional, state-shared center.

- *Superpave Evaluation of Gradation* — This article describes the methodology of the Superpave gradation requirements.

- *Suggested Changes to Tests in Superpave Mix Design* — This article lists the proposed changes to standard and provisional AASHTO test procedures.

- *How to Increase Voids in Mineral Aggregate: Guidelines to Increase VMA of Superpave Mixtures* — Superpave mix design incorporates minimum VMA requirements. This document describes ways to increase VMA during Superpave mix design.

- *What is a Performance Based Property?* — This article discusses the background and purpose of Superpave mix analysis.

- *Development of the Superpave Gyratory Compactor (SGC)* — This document discusses the development of the SGC.

- *Superpave Regional Centers* — This article describes the five Superpave Centers, their plans and activities for 1996, strategies for long-term goals, and their coordination with other state DOTs and the asphalt industry.

- *Superpave Binder Selection for Low Temperature Performance* — This article describes a rational approach to the selection of PG binders for low-temperature performance.

TRAINING ACTIVITIES

Technology transfer was a principal activity of the South Central Superpave Center (SCSC). This section describes the variety of training opportunities offered by Center staff.

INTRODUCTION TO SUPERPAVE

During the initial phase of the SCSC, the staff developed a 1-day, "Introduction to Superpave" seminar. The goal of this seminar was to quickly acquaint agency and industry personnel with the Superpave system in preparation for the letting of early Superpave projects. The first seminar program dealt with both Superpave binder and mixture technology. Table 3 shows the schedule and topics for this seminar.

Table 3. Outline of Introduction to Superpave Seminar

Time	Topic
8:00 a.m.	Introduction and Background of Superpave
8:30	Superpave Asphalt Binder Tests
10:00	BREAK
10:15	Superpave Binder Specification and Selection
11:15	Local Agency Selection
11:30	LUNCH
1:00 p.m.	Superpave Material Requirements
2:30	BREAK
2:45	Superpave Gyratory Compactor
3:30	Superpave Mix Design
4:30	Local Agency Considerations
5:00	End of Workshop

These workshops were usually coordinated by local agency and/or industry groups, with Center staff members responsible only for assembling and distributing course materials and for conducting the actual teaching. The local agency features of this program allowed the sponsoring agencies to provide attendees with up-to-date information specific to the local or regional implementation of Superpave. Flexibility in this portion of the program allowed topics such as regional binder selection, aggregate issues, and quality control/quality assurance to be addressed. The principal handout distributed at these seminars was a training manual developed and used at the National Asphalt Training Center (Ref 1). Approximately 1,000 individuals were trained at these programs. Table 4 shows the dates and locations of these workshops.

Table 4. Summary of Introduction to Superpave Seminars

Dates	Locations	Sponsoring Agency	No. of Attendees
Dec 95	Oklahoma City, OK	Oklahoma DOT	85
May – June 1996	Ft. Worth, Lubbock, Corpus Christi, TX	TxDOT and Texas Hot Mix Asphalt Pavement Association	118
January 97	Albuquerque, NM	University of New Mexico	223
January and March 97	Little Rock, AR	Arkansas Highway and Transportation Department	160
February, March, and April 97	Austin, Corpus Christi, Arlington, and Odessa, TX	TxDOT	243
April 97	Austin, TX	TxDOT and FHWA Texas Division	20
May 97	Austin, TX	University of Texas, Continuing Engineering Studies Superpave Symposium	49
October 97	Phoenix, AZ	Arizona Rock Products Association and Arizona Department of Transportation	65
TOTAL ATTENDEES FOR INTRODUCTION TO SUPERPAVE			963

SUPERPAVE BINDER ANALYSIS WORKSHOPS

To properly implement Superpave, technical staff needed to be trained in the proper methods for conducting the new Superpave binder tests, which include the dynamic shear rheometer, rotational viscometer, rolling thin film oven, pressure aging vessel, and bending beam rheometer. Through The University of Texas at Austin, Division of Continuing Engineering Studies, the SCSC offered a hands-on Superpave Binder Analysis Workshop to fulfill this need. This 4-day program included two classroom days and two laboratory days. Table 5 shows the schedule for these workshops.

The numbers in Table 5 indicate the laboratory work group. Monday was a classroom session devoted to introducing and explaining the principles underlying the new Superpave binder tests. Tuesday and Wednesday were laboratory sessions where students received hands-on test procedure training. Thursday was a classroom session where students learned how to apply the Superpave binder specification (their test results were also interpreted). By sharing data gathered during the laboratory session, students were able to classify the PG 64–22 binder upon which all testing was conducted. The workshop manual used in this training was the text developed and used at the National Asphalt Training Center

(Ref 2). One of the key features of this workshop was the laboratory instructional assistance of John Casola of Bohlin Instruments, the manufacturer of the dynamic shear rheometer used by most agency and industry personnel. Approximately 100 individuals were trained using this approach. Table 6 lists the Superpave binder analysis workshops that were conducted at the SCSC.

Table 5. Schedule for Superpave Binder Analysis Workshops

Time	Monday	Tuesday	Wednesday	Thursday
a.m. (8:00–12:00)	1 - Intro 2 - Intro 3 - Intro	1 - BBR, RTV, and Aging 2 - DSR 3 - DSR	1 - DSR 2 - BBR, RTV, and Aging 3 - BBR, RTV, and Aging	1 - Spec 2 - Spec 3 - Spec
12:00–1:00	Lunch (provided on site)			
p.m. (1:00–5:00)	1 - Intro 2 - Intro 3 - Intro	1 - BBR, RTV, and Aging 2 - DSR 3 - DSR	1 - DSR 2 - BBR, RTV, and Aging 3 - BBR, RTV, and Aging	1 - Discussion 2 - Discussion 3 - Discussion

Intro - Introduction to SHRP Binder Testing Equipment (classroom session)
DSR - Dynamic Shear Rheometer
RTV - Rotational Viscometer
Aging - Pressure Aging Vessel and Rolling Thin Film Oven
BBR - Bending Beam Rheometer
Spec - Specification Testing (classroom session)
Disc - Class discussion of binder test results (classroom session)

Table 6. Superpave Binder Workshops

Date	No. of Attendees
4/14/97	12
6/9/97	13
6/23/97	11
9/16/97	15
11/10/97	18
1/26/98	17
3/9/98	15
Total Attendees	101

SUPERPAVE MIX DESIGN WORKSHOP

It was our belief that the proper implementation of Superpave required a workshop devoted to hands-on mix design training. Thus, SCSC staff developed and conducted a workshop pertaining to Superpave mix design. Like the binder analysis workshops, the mix design workshops were coordinated through The University of Texas at Austin, Division of Continuing Engineering Studies. The program was three-and-a-half days in length. Table 7 shows the schedule for this workshop.

Table 7. Schedule for Superpave Mix Design Workshops

Time	Monday	Tuesday	Wednesday	Thursday
a.m.	1 - Intro	1 - SGC	1 - TEST	1 - ANALYSIS
(8:00–12:00)	2 - Intro	2 - Demo	2 - TEST	2 - ANALYSIS
	3 - Intro	3 - VOL	3 - SGC	3 - ANALYSIS
12:00–1:00	Lunch (provided on site)			
p.m.	1 - Intro	1 - Demo	1 - VOL	
(1:00–4:30)	2 - Intro	2 - SGC	2 - VOL	
	3 - Intro	3 - Demo	3 - TEST	

INTRO - Intro to Superpave Mix Test Equipment and Construction (classroom session)

SGC - Superpave Gyratory compactor (laboratory exercise)

DEMO - Superpave aggregate, binder, and performance testing (laboratory demonstration)

VOL - Principles of asphalt mixture volumetrics (group classroom session)

TEST - Volumetric testing of gyratory specimens (laboratory exercise)

ANALYSIS - Analysis/Selection of design aggregate structure and evaluation of simulated field control data (classroom session)

The numbers in the table indicate the laboratory work group number. The first day was a classroom day aimed at explaining Superpave mix design features. This included Superpave material requirements, the SGC, and mix design calculations. Days 2 and 3 included hands-on use of the SGC and measurement of volumetric properties of asphalt mixes. The materials used by students were the laboratory standard materials employed by the SCSC. (A description of these materials is provided elsewhere in this report.) Each laboratory group compacted a different trial blend of aggregate and binder. A demonstration of all the Superpave binder, consensus aggregate, and performance tests was included, although participants did not receive hands-on training in these activities. The remaining half-day was spent analyzing the data gathered by participants in order to complete a major portion of a Superpave mix design. Over 100 individuals were trained using this approach. Table 8 lists the Superpave mix design workshops that were conducted at the SCSC.

Table 8. Superpave Mix Design Workshops

Date	No. of Attendees
4/28/97	18
7/7/98	16
10/6/97	19
12/1/97	20
2/16/98	24
4/6/98	18
Total Attendees	115

WORKSHOPS FOR STATE DEPARTMENTS OF TRANSPORTATION

Many agencies requested that hands-on training be conducted specifically for their personnel. Most of these workshops involved Center personnel traveling to the state's central materials laboratory and conducting remote training. This service was provided to state departments of transportation (DOTs) in Illinois, Wyoming, Louisiana, and Arizona. The state DOTs in Texas and New Mexico requested similar services, the only difference being that DOT personnel traveled to the SCSC to receive training. A brief description of this activity follows.

Illinois Department of Transportation

In 1995, the Illinois DOT (IDOT) moved aggressively to implement Superpave technology. This was manifested by IDOT purchasing fifteen SGCs, one for each of its districts. Consequently, in August 1995, SCSC staff conducted a 3-day workshop for IDOT personnel at the Advanced Transportation Research and Engineering Laboratory (ATREL), a facility operated by the civil engineering department at the University of Illinois. An abbreviated, 3-day version of the program outlined in Table 6 was employed for this training. Laboratory materials were prepared by ATREL staff. SCSC staff received assistance in this training from graduate students and technical staff at ATREL. Approximately twenty individuals attended this event.

Wyoming Department of Transportation

The Wyoming DOT requested training assistance from the SCSC in the area of Superpave binder and mixture technology. Thus, a 1-week workshop was conducted in March 1996 at the central materials laboratory in Cheyenne. Dr. Jon A. Epps of the Western Region Superpave Center assisted during the classroom portion of this training. This was a hybrid program combining elements of the schedules outlined in Tables 5 and 7. Approximately twenty individuals attended this event.

Louisiana Department of Transportation and Development

In 1998, the Louisiana Department of Transportation and Development (LADOTD) desired to let nine Superpave projects. A critical issue was that neither DOT nor industry personnel in Louisiana had received training in Superpave technology. Consequently, the Louisiana Transportation Research Center (LTRC) requested that SCSC staff travel to Baton Rouge to conduct four mix design workshops at the LTRC pavement materials laboratory.

The workshops utilized the program outlined in Table 7. SCSC staff preblended SCSC lab standard materials and shipped them to LTRC. Dr. Louay Mohammad of LTRC and Chris Abadie of LADOTD assisted in the classroom and laboratory portions of this training, respectively. Eighty individuals, including forty LADOTD and forty industry personnel, were trained in these workshops. Table 9 lists the workshops conducted for LADOTD at LTRC.

In addition to these workshops, the SCSC provided mix design training in May 1996 to four personnel from the LADOTD. LADOTD requested that SCSC develop a mix design (described in another part of this report) for a section of IH-10 near Baton Rouge. As part of this mix design, the four LADOTD employees traveled to Austin to observe and consult with SCSC staff on this design.

Table 9. Louisiana Mix Design Workshops

Date	No. of Attendees
9/17/97	20
9/29/98	20
10/20/98	20
11/17/98	20
Total Attendees	80

New Mexico Department of Transportation

In 1997, the New Mexico DOT requested Superpave mix design training in anticipation of three Superpave projects to be let during the 1997 construction season. Unlike the other state DOTs, the New Mexico DOT desired to send its personnel to the SCSC to receive this training. Thus, a Superpave mix design workshop was conducted beginning March 24, 1997, at SCSC facilities. A program identical to that in Table 7 was used. A total of twenty-one individuals from New Mexico were trained. Of this number, seventeen were from the New Mexico DOT and four represented industry in New Mexico.

Texas Department of Transportation

Prior to 1998, the Texas Department of Transportation (TxDOT) had let eight Superpave projects and anticipated as many as fifty new projects during 1998. In fact, by July 1997 all TxDOT projects required the use of PG binders, with the agency also requiring asphalt suppliers to show that their laboratory personnel had been trained using a program such as that offered at the SCSC. Thus, there was a need for training of TxDOT personnel in Superpave principles. Four workshops were conducted for TxDOT, three in late 1997 devoted to Superpave mix design and one in 1998 devoted to Superpave binder analysis.

The mix design workshops were conducted during the weeks of June 17, November 4, and December 9, 1997, and employed the schedule shown in Table 7. Fifty-nine TxDOT personnel were trained at these workshops. Of this total, fifty-six were district personnel and three were from the Materials and Tests Division.

The Superpave binder analysis workshop was conducted the week of March 31, 1998. Twenty individuals were trained. Nineteen of the twenty personnel were from districts and one was from the Materials and Tests Division. An abbreviated version of the schedule shown in Table 4 was used. At the time this workshop was conducted, it had been proposed that TxDOT districts conduct quality assurance testing of binders sampled from the hot mix producer's plant. This activity required using the dynamic shear rheometer to measure binder stiffness properties on rolling thin film oven residue. Consequently, there was no need for hands-on training using other Superpave binder test methods; the laboratory portion of the workshop thus included training on only these devices.

VISITING PERSONNEL

One of the early goals of the SCSC was to utilize the loan staff concept, which was intended to allow experienced asphalt laboratory personnel to be placed on loan to the SCSC. Thus, the SCSC could make use of experienced personnel to conduct its various activities, and the loaning organization would receive an employee with basic Superpave experience. Unfortunately, the loan staff concept was not fully realized during Center operations because very few agencies were able to provide travel funds for a several-months-long assignment of their personnel.

TxDOT was the principal supplier of loan staff to the Center. At any point in time, SCSC had the services of an employee from the Bituminous Section of TxDOT. Their nominal term of duty with SCSC was 3 months. Through this program, three engineers and four technical staff personnel were utilized. This was a very rewarding arrangement for both organizations.

Although the loan staff concept was not fully realized, several individuals representing agencies and industry sent their staff to SCSC for short tours of duty. The Oklahoma DOT sent five individuals to SCSC, each for 2-week tours. The Louisiana DOTD sent four employees to SCSC for 1 week to assist in the completion of an SCSC-designed mix for a Louisiana Superpave project. Shell Canada Ltd. sent an employee to the SCSC who assisted in a compactor comparison experiment.

NATIONAL HIGHWAY INSTITUTE WORKSHOPS

Center staff were subcontractors to the Asphalt Institute (AI) on its National Asphalt Training Center II project, which was sponsored by the Federal Highway Administration (FHWA). As subcontractors to AI, the SCSC assisted in the development of Superpave training materials for the National Highway Institute (NHI). Subsequently, SCSC staff served as instructors at the two pilot workshops, the purpose of which was to evaluate these training materials. These pilot workshops were conducted on April 23 and September 8, 1997, at AI headquarters in Lexington, Kentucky. Thirty-eight individuals attended, including staff of the other four Superpave Centers, state DOT personnel, and the FHWA's Superpave Extended Technology Delivery Team. Based on the comments and suggestions of those attending the pilot workshops, final course materials were developed for three NHI Superpave workshops:

- Superpave for the Generalist Engineer and Project Staff (3-day workshop)
- Superpave for Local Agencies (1-day workshop)
- Superpave for Managers (half-day workshop)

Staff members from the other Superpave centers, as well as from the SCSC, were given the task of delivering these workshops on an as-requested basis. Table 10 shows the NHI Workshops conducted by SCSC staff. Except as noted, all NHI workshops presented by SCSC staff were Superpave for the generalist engineer and project staff.

Table 10. NHI Workshops Conducted by SCSC Staff

Date	Sponsoring Agency	Length	Location	No. of Attendees
2/4/98	New Mexico DOT	2-day	Albuquerque, NM	56
3/25/98	Arizona DOT	2-day	Phoenix, AZ	37
4/13/98	LADOT	2-day	Baton Rouge, LA	126
4/15/98	LADOT	2-day	Alexandria, LA	86
5/4/98	New Mexico DOT	1-day	Las Cruces, NM	24
5/5/98	New Mexico DOT	1-day	Roswell, NM	22
5/7/98	New Mexico DOT	1-day	Las Vegas, NM	36
5/8/98	New Mexico DOT	1-day	Albuquerque, NM	51
10/26/98	New Mexico DOT	1-day	Alamogordo, NM	13
10/27/98	New Mexico DOT	1-day	Santa Rosa, NM	13
10/28/98	New Mexico DOT	1-day	Santa Fe, NM	33
10/28/98	New Mexico DOT	1-day	Albuquerque, NM	38
11/9/98	Arizona LTAP	1-day	Phoenix, AZ	28
Total Attendees at NHI Workshops				563

AUSTIN SUPERPAVE SHOWCASE

At the request of the FHWA Texas Division, the Austin District of TxDOT was asked to host a Superpave showcase to demonstrate construction of a Superpave mix. The Austin District solicited the assistance of the Center in this endeavor. Work on the showcase involved the efforts of personnel from the Austin District of TxDOT, the FHWA Texas Division, the Austin Bridge and Road Company, the Bituminous Section of TxDOT's Materials and Tests Division, BRE/Fugro Inc., and the SCSC. Table 11 shows the schedule and a summary of activities of the showcase.

Table 11. Austin Superpave Showcase

Time	Item	Speaker
7:30	Registration and Continental Breakfast	Breakfast sponsored by the FHWA Texas Division
8:00	Welcome	William Garbade, TxDOT, Austin District Dan Reagan, FHWA, Texas Division
8:20	Announcements	Danny Stabeno, TxDOT, Austin District
8:30	Tour of Superpave Construction Site and SCSC	
12:00	LUNCH	Lunch provided by Austin Bridge and Road Company
1:00	Session 1 - National Experience Using Superpave	Moderator: John Bukowski, FHWA Pavements Division
	State DOT Experience in Superpave Implementation	Larry Michael, Maryland DOT, Hancock, MD
	U.S. Industry Experience Using Superpave	Dale Decker, National Asphalt Pavement Assn., Lanham, MD
2:15	BREAK	Break provided by BRE/FUGRO, Inc.
2:30	Session 2 - Experience Using Superpave in Texas	Moderator: Bob McGennis, S. Central Superpave Center, Austin, TX
	Superpave in Texas – TxDOT Experience	Maghsoud Tahmoressi, TxDOT Bituminous Branch, Austin, TX
	Superpave in Texas – Industry Experience	Ned Finney, Jobe Concrete, El Paso, TX
	Panel Discussion - Design and Construction of Superpave HMA	Lenny Bobrowski, TxDOT, Austin District Gary Atwood, Austin Bridge and Road Company Charles Smoot, TX Hot Mix Asph. Pavement Assn. Lisa Lukefahr, TxDOT, Bituminous Branch, Austin, TX Ross Martinez, FHWA, Region 6, Ft. Worth, TX
4:45	Closing Comments	
5:00	End of Symposium	

The showcase was conducted on July 8, 1998. It involved an overlay of FM 3406 in Round Rock, Texas. During the morning, participants were transported by bus to the project site to observe the construction of a Superpave 0.5-in. (12.5-mm) mix. Next, participants were transported to the Center for a tour and demonstration of Superpave test equipment. Eighty-five individuals attended this event.

OTHER SYMPOSIA

In addition to the training activities already described, Center staff appeared on numerous programs, conferences, and workshops. While these symposia did not represent coordinating efforts of Center staff, they nevertheless presented the opportunity for the Center to fulfill its mission of transferring Superpave technology. Table 12 lists these events.

Table 12. Other Symposia with SCSC Participation

Date	Event	Location	No. of Attendees
12/7/95	FHWA Region 6 SHRP Coordinator's Meeting	Austin, TX	40
8/11/97	8th International Conference on Asphalt Pavements	Seattle, WA	95
11/20/97	Annual Meeting of Minnesota Assn. of Asphalt Paving Technologists	Minneapolis, MN	150
1/21/98	Arkansas Superpave Symposium	Little Rock, AR	250
1/27/98	Iowa Paving Conference	Ames, IA	150
1/3/98	Nebraska Quality Conference	Kearney, NE	40
4/23/98	AI/FHWA Superpave Symposium	St. Louis, MO	250
2/29/98	Annual Meeting of the National Association of County Engineers	Rapid City, SD	75
Total Attendees			1,050

SUMMARY OF TRAINING ACTIVITIES

Clearly, training was a major effort of the SCSC. By November 1998, Center staff had provided Superpave training to 2,000 individuals representing all facets of the asphalt materials community. Approximately 1,000 more were reached through miscellaneous symposia.

DIRECTED RESEARCH

One of the expectations of all Superpave centers, including the South Central Superpave Center (SCSC), was that they would conduct applied research to update or improve Superpave technology. This activity involved conducting experiments using the test equipment that was furnished to each Superpave center. This section describes these experiments.

RUGGEDNESS OF THE AMERICAN ASSOCIATION OF STATE HIGHWAY TRANSPORTATION OFFICIALS TP4

As the American Association of State Highway and Transportation Officials (AASHTO) was adopting test methods produced by the Strategic Highway Research Program (SHRP) researchers, there was a need to evaluate the ruggedness of the methods. Ruggedness experiments are conducted according to ASTM C1067, "Conducting a Ruggedness or Screening Program for Test Methods for Construction Materials." They are intended to determine whether tolerable variations in test parameters produce significant changes in test results. For example, a test method may allow the test temperature to vary by ± 2°C. A ruggedness experiment would determine whether this tolerance was too large or unnecessarily restrictive. If tolerable variations in test parameters do not produce significantly different test results, then the test method is considered rugged. Consequently, one of the first experiments conducted at the SCSC involved estimating the ruggedness of AASHTO TP4, "Standard Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor."

SCSC staff fulfilled two roles in this experiment. First, SCSC staff designed the experiment and was primarily responsible for analyzing its results. Second, the SCSC served as one of the participating laboratories on behalf of the Texas Department of Transportation (TxDOT). The experiment analyzed seven main factors using the approach outlined in ASTM C1067. Table 13 shows the main factors evaluated and Table 14 outlines the participating laboratories.

McGennis et al. (Ref 3) present a detailed treatment of this experiment in which the following conclusions were drawn:

- The tolerance on compaction angle (±0.02°C) is reasonable.
- A transfer bowl is preferable but not necessary for mold loading.
- The tolerance on compaction pressure (±18 kPa) is too high.
- Precompaction using a blunt-nosed rod is ineffectual.
- The tolerance on equiviscous compaction temperature (±0.030 Pa·s) is reasonable.

- The tolerance on specimen height (±1 mm) is too narrow.
- For binders similar to the one used in this experiment, the 30-minute compaction temperature equilibration period can be included in the 4-hour aging period as long as mixture volumetrics are the main response variables.

Table 13. Main Factors Evaluated in Ruggedness of AASHTO TP4

Main Factor	Levels
Angle of Gyration, degrees	Low Range (1.22 to 1.24) and High Range (1.26 to 1.28)
Mold Loading Procedure	Transfer Bowl Method and Direct Loading Method
Compaction Pressure, kPa	582 and 618
Precompaction	None and 10 thrusts with Standard Rod
Compaction Temperature, °C	at 0.250 Pa·s viscosity and at 0.310 Pa·s viscosity
Specimen Height, mm	Low (around 4 in. [110 mm]) and High (around 4.4 in. [120 mm])
Aging Period at 135°C, hrs	3.5 and 4

Table 14. Participating Laboratories

Compactor	Participating Laboratory
Pine	Illinois DOT[1] TxDOT[2] Asphalt Institute[3]
Troxler	Washington DOT Heritage Research

[1] Performed by University of Illinois, Advanced Transportation Research and Engineering Laboratory

[2] Performed by the SCSC, The University of Texas at Austin

[3] Originating laboratory

EFFECT OF GRADATION ON VOLUMETRIC AND MECHANICAL PROPERTIES

This experiment was requested by and conducted on behalf of the Federal Highway Administration (FHWA). Izzo et al. (Ref 4) present a detailed report of the experimental findings. The purpose of this experiment was to evaluate the effect of aggregate gradation and aggregate mineralogy on voids in the mineral aggregate (VMA). Four aggregate types were evaluated: limestone, gravel, sandstone, and basalt. For each of these aggregate types, three gradations were evaluated: fine, coarse, and very coarse. The fine gradations were designed to plot above the Superpave restricted zone. Coarse gradations plotted below the restricted zone, while very coarse gradations plotted below the lower control point on the

0.09-in. (2.36-mm) sieve. The very coarse gradation corresponded to mixtures developed by TxDOT called *coarse matrix high binder* (CMHB) mixtures. Figure 2 shows the gradations of the mixes evaluated in the study.

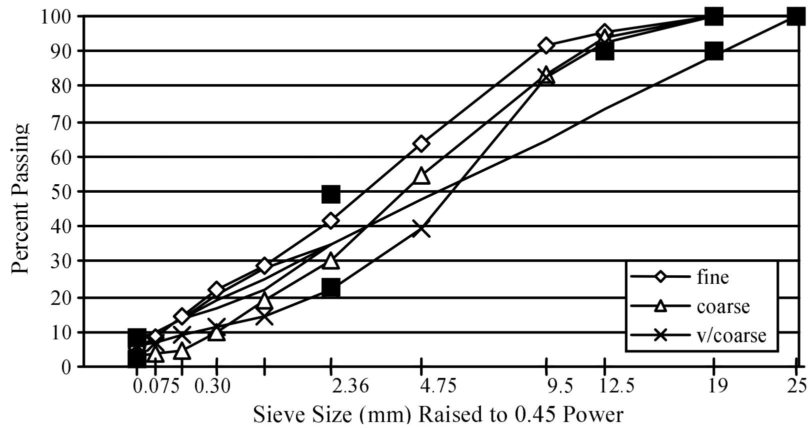

Figure 2. Gradation of Mixes Evaluated in VMA Experiment

One of the goals of this study was to test whether gradation (and its effect on aggregate structure) influenced VMA. It is a well-known, but not well-documented, axiom that gradations plotting farther away from the maximum density line tend to develop aggregate structures that resist compaction, thus increasing VMA. Table 15 shows the VMA of the mixtures evaluated.

The experiment validated this axiom in that the coarse and very coarse mixtures, which plotted farthest from the maximum density line, possessed higher VMA values. There was no difference in the VMAs resulting from coarse or very coarse mixes. Sandstone, gravel, and basalt mixes exhibited about 3 percent higher VMA than the limestone mixes. A somewhat remarkable feature of the VMA data was the relatively high values evident — approximately 18 percent for the sandstone, gravel, and basalt aggregates.

While the original intent of this experiment was to evaluate the effect of gradation on VMA, it was decided that the same mixtures could also be evaluated for the effect of gradation on mechanical properties. Thus, the designed mixtures were evaluated using the Hamburg Wheel Tracking Device (HWTD), the Superpave Shear Tester (SST), and the TxDOT static creep test. The SST tests that were used were the repeated simple shear test at constant height (RSSTCH) and frequency sweep test (FS).

SST tests generally showed that the fine mixtures with low VMA and low asphalt content had the highest stiffness and lowest permanent strain. This was an expected finding because the volume of asphalt binder was significantly higher for the coarse and very coarse mixtures. Because there is no specimen confinement in the RSSTCH or FS test, it was difficult for the aggregate skeleton to mobilize its full stiffness potential.

Table 15. VMA of Asphalt Mixtures Evaluated

Aggregate Type	Gradation	VMA, %[1]	Asphalt Content, %
Limestone	Fine	11.4	4.1
	Coarse	14.1	5.5
	Very Coarse	13.9	5.5
Sandstone	Fine	14.0	4.7
	Coarse	17.8	6.5
	Very Coarse	17.9	6.6
Gravel	Fine	13.6	4.2
	Coarse	18.2	6.7
	Very Coarse	17.6	6.3
Basalt	Fine	14.4	4.2
	Coarse	17.7	5.4
	Very Coarse	17.9	6.0

[1] Air void content was 4 percent in all cases.

Static creep tests did not produce significant differences in the mechanical behavior of the mixes, although there was a tendency for the fine mixtures with the lowest VMA to exhibit higher creep stiffness. Once again, without specimen confinement, the stiffest mixtures were those that had the lowest VMA and lowest asphalt content.

The HWTD showed some differences among the mixtures with different VMA. While there were no definitive trends in creep slope data, the stripping slope data suggested that very coarse mixtures with the highest VMA were more favorable. This was an expected finding because the greater volume of asphalt with these mixtures would tend to inhibit the stripping mechanism.

RUGGEDNESS OF THE AMERICAN ASSOCIATION OF STATE HIGHWAY TRANSPORTATION OFFICIALS TP7

This experiment, conducted for the FHWA, was one of the experiments in which some Superpave Centers were expected to participate. As with the ruggedness analysis of AASHTO TP4, SCSC staff developed the experiment and then participated in its conduct. The purpose of this experiment was to evaluate the ruggedness of AASHTO TP7, "Standard Test Method for Determining the Permanent Deformation and Fatigue Cracking Characteristics of Hot Mix Asphalt Using the Simple Shear Test." This test method outlines six separate test procedures using the SST. The test method evaluated using this experiment was the simple shear test at constant height. This is a controlled stress test in which a test specimen is subjected to a shear load for approximately 10 seconds. During this shearing action, the specimen attempts to dilate. A vertical linear variable displacement transducer (LVDT) is used to control the actions of a vertical actuator, which places sufficient axial force to maintain a constant height. The seven main factors evaluated as part of this experiment are shown in Table 16.

Table 16. Main Factors Evaluated in Ruggedness of AASHTO TP7, Simple Shear Test at Constant Height

Main Factor	Levels
Specimen Air Void Content	6.5 and 7.5 %
Temperature Stabilization Time[1]	30 and 60 minutes
Test Temperature[2]	100°F and 107°F (38°C and 42°C)
Stress Loading Rate	65 and 75 kPa/s
Glue Type	5-minute and 2-hour epoxy
Specimen Orientation	top and bottom
Order of Test	before and after frequency sweep test

[1] Temperature precondition time held constant at 2 hours.

[2] Assumed test temperature = 104°F (40°C).

Five laboratories participated in this experiment:

- University of California at Berkeley (originating laboratory)
- Western Region Superpave Center
- Southeast Superpave Center
- South Central Superpave Center
- Asphalt Institute

Of the seven main factors, only temperature stabilization time, 30 versus 60 minutes, indicated a significant effect on test results.

UPDATE OF DESIGN NUMBER OF GYRATIONS

In its role as a subcontractor to the Asphalt Institute (AI), the SCSC participated in a study to evaluate and update the design gyration table for use with the Superpave gyratory compactor (SGC). Personnel from the Heritage Research Group and Advanced Asphalt Technology were also active in this study. Most of the effort was expended between May 1997 and August 1998. The study was initiated at the request of the FHWA and employed a five-task approach:

1. Evaluate in-place air void content of existing Superpave mixtures.
2. Evaluate and select an engineering property that indicates mixture performance.
3. Measure the sensitivity of the engineering property to number of gyrations.
4. Measure the sensitivity of mixture volumetric properties to number of gyrations.
5. Recommend a revised table for number of design gyrations.

The principal goal of this study was to validate, update, and simplify the N-design table using a research approach that differed from that used by the SHRP researchers. The central premise of the study was that the design number of gyrations could be established on the basis of an engineering stiffness property, in addition to mix volumetrics. SCSC was primarily responsible for Tasks 1 and 3.

The purpose of Task 1 was to develop a gross estimate of the validity of the N-design table as it was developed by the SHRP researchers. This task operated under the hypothesis that the existing table was mostly correct in terms of its ability to specify the proper number of gyrations. Superpave mixes are designed using 4 percent air voids. Consequently, if the in-place air void content of an existing Superpave mix, after trafficking, was at approximately 4 percent (e.g., 3 to 6 percent), then it could be assumed that the design number of gyrations selected from the N-design table for the project was reasonably valid.

SCSC staff mailed a questionnaire to those state departments of transportation (DOTs) that had a significant number of Superpave projects. In addition, staff interfaced with regional long-term pavement performance (LTPP) contractors who were responsible for collecting data from SPS-9 projects. Members of the FHWA Superpave Mixtures Expert Task Group were also consulted. All those surveyed were asked whether they had data from coring that would track the in-place air void content of Superpave mixtures. Surprisingly, not a great amount of data was forthcoming. Thus, SCSC staff contacted various state DOTs by phone with a personal appeal for data. As a result, project in-place air void content was secured from Arizona, Arkansas, Louisiana, Texas, Florida, and New York. The New York DOT was particularly forthcoming and made a special effort to core projects representing the six traffic levels in the N-design table. Figure 3 shows the New York data. The results of this task generally showed that the in-place air void content of Superpave mixes was in reasonable proximity to 4 percent, which suggested that the number of design gyrations was approximately correct.

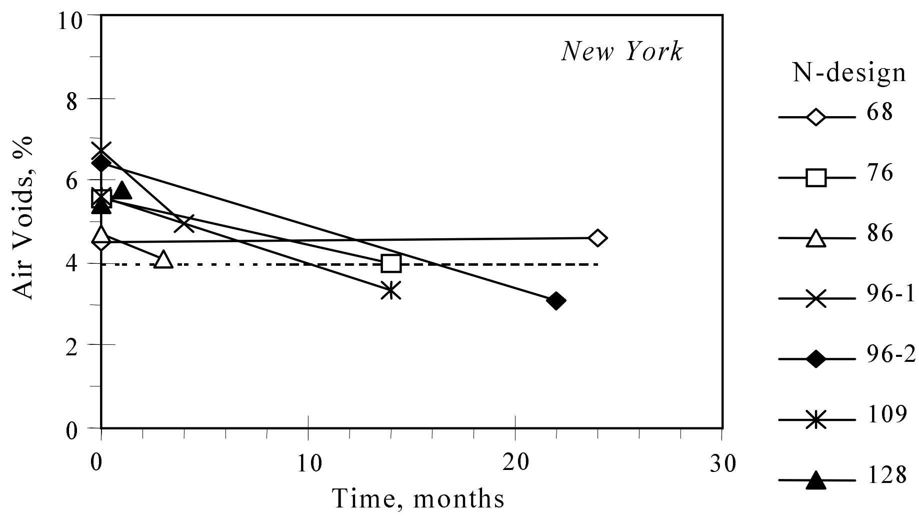

Figure 3. In-Place Air Void Content of New York Mixtures

Task 2 was conducted by Heritage Research, which undertook various mechanical property tests on cores from WesTrack, a test facility in Nevada. Cores were taken from Superpave mixtures exhibiting good and bad rutting performance. The results of this task showed that the complex shear modulus (G*) arising from the shear frequency sweep test adequately discriminated between good and bad rutting performance.

Task 4, originally designed to be a part of this study, was abandoned because a similar and more extensive evaluation was at the time being conducted at Auburn University as part of National Cooperative Highway Research Program (NCHRP) Project 9-9. That study indicated that a change of thirty gyrations resulted in a change in VMA and air voids of about 1 percent.

Task 3, conducted at SCSC, was aimed at measuring the sensitivity of G* to the number of gyrations. Ultimately, it was hoped that this stiffness property could be used as the basis of a new N-design table. The first step in Task 3 was to design six basic mixtures for measurement of G*. Three of the mixtures (A, B, and C) were composed of crushed limestone, while the remaining three were composed of crushed gravel (D, E, and F). Three levels of design gyrations were used — 70, 100, and 130 — to bracket the values in the existing N-design table. The aggregate structure was varied to achieve approximately the same VMA and asphalt content. Table 17 indicates the properties of the six mixtures that were designed.

Table 17. Summary of Mixtures Designed for Task 3

Aggregate Type	Mix Designation	Design Gyrations	VMA, % (1)	Asphalt Content, %
Limestone	A	130	14.6	4.6
	B	100	14.6	4.6
	C	70	14.3	4.6
Gravel	D	130	14.2	4.7
	E	100	14.3	4.7
	F	70	14.3	4.7

[1] All mixtures designed at 4 percent air voids.

Once the six mixtures were designed, nine specimens were fabricated for each mix. Three of these specimens were compacted to 70, 100, and 130 gyrations. These specimens were tested to measure VMA, air void content, and (in the SST) G*. Table 18 shows the test matrix.

The volumetric properties observed in this experiment agreed very closely with the findings of the NCHRP 9-9 study in that a change of thirty gyrations resulted in a change of approximately 1 percent in air void content and VMA. The frequency sweep test results showed that a change of thirty gyrations resulted in a change in G* of about 30 percent for both the limestone and gravel mixtures. Figure 4 shows a typical analysis of the G* data for the limestone mixtures.

Table 18. Testing Matrix for Mixtures Evaluated

Mix Designation	Specimen No.	Number of Gyrations	Response Variable: Air Voids	VMA	G*
A	A1, A2, A3	130	√	√	√
	A4, A5, A6	100	√	√	√
	A7, A8, A9	70	√	√	√
B	B1, B2, B3	130	√	√	√
	B4, B5, B6	100	√	√	√
	B7, B8, B9	70	√	√	√
C	C1, C2, C3	130	√	√	√
	C4, C5, C6	100	√	√	√
	C7, C8, C9	70	√	√	√
D	D1, D2, D3	130	√	√	√
	D4, D5, D6	100	√	√	√
	D7, D8, D9	70	√	√	√
E	E1, E2, E3	130	√	√	√
	E4, E5, E6	100	√	√	√
	E7, E8, E9	70	√	√	√
F	F1, F2, F3	130	√	√	√
	F4, F5, F6	100	√	√	√
	F7, F8, F9	70	√	√	√

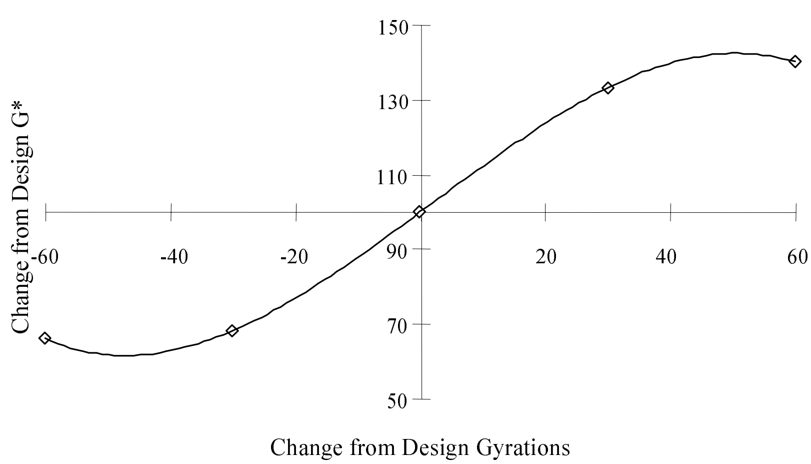

Figure 4. Sensitivity of G* to Number of Gyrations (Limestone Mixtures)

Based on the results of Tasks 1, 2, and 3, and considering the NCHRP 9-9 experimental results, a recommended N-design table was developed. This table, shown in Table 19, was presented to the FHWA Superpave Mixtures Expert Task Group for the ultimate purpose of recommending it to AASHTO for adoption. The task group rejected it in favor of a revised N-design table that combined principles of this and the NCHRP 9-9 study.

Table 19. Revised N-Design Table Based on an Engineering Stiffness Property (G*)

Traffic Level, Millions of ESALs	Design Number of Gyrations
Less than 1	60
1–10	80
10–30	100
Greater than 30	120

GRADUATE STUDENT RESEARCH

The University of Texas at Austin urges that all funded research support graduate student research. Thus, while the South Central Superpave Center (SCSC) remained a center of applied research, it also supported numerous graduate students who conducted research that addressed issues pertaining to the implementation of Superpave technology. The following sections describe the research activities conducted by graduate students.

EVALUATION OF SPECIAL PAVEMENT STUDIES (SPS-9) PROJECT FM 1604

When the Federal Highway Administration (FHWA) developed the concept of the Superpave Centers, one of the expectations was that these Centers would provide support for Special Pavement Studies (SPS) projects. SPS-9 projects were experimental test sections aimed at evaluating Superpave. State departments of transportation (DOTs) were asked to construct these test sections and provide Superpave testing services during construction and periodically after construction. For various reasons the Centers never provided a significant amount of assistance to state DOTs on SPS-9 projects. One exception was an SPS-9 project on FM 1604 near San Antonio, Texas. For this project (constructed in 1994) the Texas Department of Transportation (TxDOT) requested SCSC assistance in testing project materials. A University of Texas at Austin civil engineering graduate student, Renato Ceccovilli, was assigned to this project. Ceccovilli produced a master's thesis from this project, which partially fulfilled the requirements for a master's of science in civil engineering from The University of Texas at Austin.

The FM 1604 SPS-9 experiment involved testing raw asphalt and aggregate materials and the Superpave mixtures as produced. It also involved testing cores from two test sections at various periods of time following construction. Both sections utilized the same mix but with different binders, a PG 64-22 and a PG 70-22. The PG 64-22 binder was the binder that would have been selected based on the climate of the project site. The PG 70-22 binder was a "bumped" grade.

This experiment involved a considerable amount of materials characterization. This ranged from compositional analyses on the hot mix as produced, to mechanical property testing of laboratory fabricated specimens and cores using the Superpave shear tester and indirect tensile tester. All test data were submitted to the FHWA Long-Term Pavement Performance Division through the south central regional contractor, Brent Rauhut Engineering, Inc., in Austin, Texas. Presumably, the test data will be combined with similar data sets from other projects for analysis.

Perhaps the most interesting and useful information gleaned from this testing was the densification of the Superpave mix over time. Figure 5 shows this relationship. This information was combined with similar information from other Superpave projects to validate and update the N-design table used with the Superpave gyratory compactor (SGC).

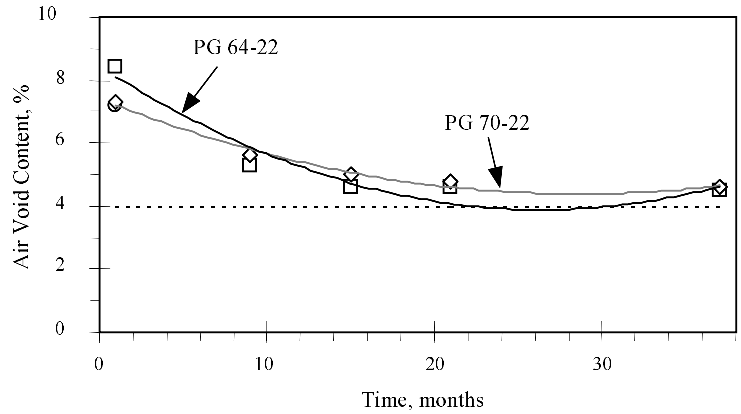

Figure 5. Densification of Superpave Mix on FM 1604

COMPARATIVE ANALYSIS OF SUPERPAVE AND TEXAS GYRATORY COMPACTORS

One of the critical issues in TxDOT's implementation of Superpave has been the transition from the existing method of laboratory compaction, the Texas gyratory compactor (TGC), to the SGC. TxDOT owns approximately 300 SGCs. An approximately equal number is owned by industry and engineering testing laboratories in Texas. Thus, there was a need to evaluate the efficacy of the SGC in comparison with the TGC in terms of a mix design and field control device. Consequently, an experiment was designed and conducted by Dale Rand, a TxDOT employee pursuing a master's degree in civil engineering at The University of Texas at Austin. It was particularly appropriate to have Rand working on this experiment because his work assignment at the time was in the Bituminous Section of the Materials and Tests Division; as a consequence, he had extensive experience in routine and experimental use of the TGC.

Rand (Ref 6) developed a two-phase experiment. Phase I focused on precision and bias of the two gyratory compactors. He utilized three asphalt mixtures compacted using fourteen SGCs and twelve TGCs. Phase II evaluated strength properties developed in specimens molded using the two devices. In this phase, he compared the slope of the compaction curves of specimens molded in the SGC with Hveem stability and static creep test results from TGC-molded specimens. In contrast to Phase I, Phase II involved the use of twenty-seven different mixtures. These included fine, coarse, and very coarse mixtures based on the percent passing the 0.09-in. (2.36-mm) sieve and each of these at multiple asphalt contents. Rand's conclusions were as follows:

- For Superpave mixes the SGC produced specimens that were 33 to 42 percent less variable in terms of bulk specific gravity.
- For very coarse mixes, such as TxDOT coarse matrix high binder (CMHB) mixes, SGCs produced specimens that were slightly more variable in bulk specific gravity than those produced with the TGC, although the differences were not statistically significant.
- For laboratory-batched specimens with a design number of gyrations of ninety-six and a compaction temperature of 250°F (121°C), the SGC produced specimens that were significantly lower in density than those compacted in the TGC.
- The slope of the compaction curve does not correlate well with either Hveem stability or static creep slope.
- The slope of the SGC compaction curve correlates very well with coarse aggregate content (percent retained on 0.09-in. [2.36-mm] sieve); Hveem stability and static creep slope also correlate well with coarse aggregate content.

Rand recommended that TxDOT allow the use of the SGC for field control of hot mix asphalt (HMA). He also suggested that TxDOT require that the field control compactor be correlated with the mix design compactor regardless of the type of field control compaction device. Rand believed that the Hveem stability measured during field production could be eliminated in favor of tolerances on gradation, particularly the coarse aggregate content when coarse mixes were being evaluated. With respect to pay adjustments on field-produced mixtures, Rand suggested that TxDOT's current bonus/penalty tolerances be adjusted when an SGC is used for field control.

COMPARATIVE ANALYSIS OF SUPERPAVE AND TEXAS GYRATORY COMPACTORS FOR FIELD CONTROL

While Rand's study involving the SGC and TGC was very extensive, it was conducted entirely on laboratory-prepared specimens and included no plant-produced materials. Thus, there was a need to evaluate the usefulness of the SGC in a field-control mode. This was the nature of the research conducted by Wesley Nauman. Like Rand, Nauman was a TxDOT employee working toward a master's degree in civil engineering at The University of Texas at Austin. With the assistance of SCSC staff, Nauman transported a SGC to a HMA mixing facility for the purpose of evaluating the use of the SGC in a field-control mode. This facility was owned and operated by the Colorado Materials Company in Hunter, Texas. A primary objective of Nauman's study was to determine whether the TGC could be used for field control of HMA when the SGC was used for design. A secondary objective was to analyze mixture volumetric properties to determine whether there was a trend between specimens compacted in the SGC and TGC. Three plant-produced TxDOT-type mixtures were evaluated: Type B (0.9 in., or 25 mm), Type C (0.7 in., or 19 mm), and Type D (0.5 in., or 12.5 mm). Nauman's experiment involved compacting split samples in the SGC and TGC for a direct comparison of results.

This experiment showed that there was no constant correlation between the bulk specific gravity of TGC and SGC specimens. Nauman found that for plant-produced specimens, the SGC resulted in higher bulk specific gravity than the TGC. In addition, the SGC produced less or equal variability in specimens in terms of bulk specific gravity. Nauman's most significant finding was that it was possible to utilize a TGC for field control of SGC-designed mixes, but that individual mixes reacted differently, which would necessitate a different correlation factor for each mix type. Nauman's report (Ref 7) provides a detailed description of test results and analyses.

DETERMINATION OF RECLAIMED ASPHALT PAVEMENT CONTENT IN ASPHALT MIXES USING SUPERPAVE BINDER SPECIFICATIONS

With the development of Superpave there was a need to develop a methodology for considering the use of reclaimed asphalt pavement (RAP) in Superpave mixes. To respond to this need, the FHWA Superpave Mixtures Expert Task Group developed a set of guidelines for the use of RAP (Ref 8). To support that effort, a civil engineering master's degree student at The University of Texas at Austin, Weng-On Tam, developed an experiment to study the rheological properties of different combinations of simulated RAP binders and virgin binders.

Tam chose six asphalts from the Strategic Highway Research Program (SHRP) Materials Reference Library (MRL) to use in his experiment. Four of the asphalts used as virgin binders were selected to represent a wide range of temperature susceptibility. Two MRL asphalts were chosen to represent a range of aging susceptibility. They were subsequently aged to produce simulated RAP binders. Five levels of RAP binders, 0, 15, 25, 55, and 100 percent, were produced. These represented a combination of the four virgin binders mixed with the two aged RAP binders. A dynamic shear rheometer (DSR) was used to capture the high and intermediate temperature stiffness characteristics. A bending beam rheometer (BBR) was used to measure low temperature creep properties.

Tam's experiment and analysis verified that high and low temperature stiffness characteristics are significantly affected by the amount of RAP binder used. The rate of change of stiffness was either constant from 0 to 100 percent RAP binder or increased with lower temperatures. His practical method for determining the maximum percentage of RAP to be used showed that, rather than it being a function of the rheological properties of the RAP binder, the amount of RAP that can be used is most often governed by other factors (Ref 9).

EVALUATION OF HOT MIX ASPHALT PAVEMENT PERFORMANCE FOR TAIWAN'S FREEWAY NETWORK USING THE SUPERPAVE SYSTEM

Inevitably Superpave will be evaluated for use outside the U.S. One example of such an evaluation was conducted by Jian-Neng Wang, a doctoral candidate in civil engineering at The University of Texas at Austin. In noting asphalt pavement performance problems on Taiwan's freeway system, Wang proposed to utilize the Superpave system to correct these problems. Wang's premise was that Superpave represented a significant improvement over that asphalt technology used in Taiwan, which involved the use of penetration-graded asphalt and an older version of the Marshall mix design system.

Wang desired to import experimental quantities of Taiwanese materials for analysis. Unfortunately, this plan proved impractical because of high shipping costs. Consequently, he interviewed highway materials engineers in Taiwan to assess the characteristics of Taiwanese materials. He determined that primarily two grades of asphalt binder were used, 85−100 and 60−70 pen-graded asphalt. He also determined that crushed sandstone gravel aggregate was the most common aggregate type. Based on this information, Wang procured materials in Texas that simulated these Taiwanese materials.

Wang's experiment was extensive and unique. He evaluated sixteen asphalt mixtures for their volumetric properties using both the Marshall and Superpave systems. Based on this study, he selected three mixtures for further analysis. One mixture simulated a typical Taiwanese asphalt concrete. The second mixture met both Superpave and current Taiwan requirements, although it would not represent a typical Taiwanese mix. The third mixture met only Superpave requirements.

The final part of the experiment involved using the simple and repeated shear test at constant height, the frequency sweep test, and the Hamburg Wheel Tracking Device to measure mechanical properties related to rutting mixture resistance. His test results led to the conclusion that the typical Taiwanese mix was considerably more prone to rutting. Both the Taiwanese/Superpave mixture and the Superpave mixture exhibited very similar mechanical properties that indicated significantly more rutting resistance when compared with the typical Taiwanese mix. Wang was ultimately awarded a doctorate of philosophy upon the successful defense of his dissertation (Ref 10).

SPECIAL PROJECTS

Numerous special experimental projects were conducted at the South Central Superpave Center (SCSC). These experiments were normally undertaken at the request of various organizations participating in Center activities or as activities pursuant to the normal goals and objectives of an applied research and training facility.

SOUTH CENTRAL SUPERPAVE CENTER LABORATORY STANDARD EXPERIMENT

At the outset of the SCSC project, an experiment was conducted to develop a set of laboratory standard materials for routine Center use. The intention was that these materials be used in Center training activities as well as in various Center experiments. Like the other Superpave centers, the SCSC was a highly visible organization; and as such, it probably could have obtained highly superior aggregates from any source in the U.S. However, that strategy was not employed. Center staff believed that a set of standard materials, representing those that an average state highway agency would commonly use, would set a better standard for training and experimental purposes. Consequently, it was decided that a typical central Texas crushed limestone would form the basis of the SCSC laboratory standard aggregate. This material was graciously supplied in large quantities by the Colorado Materials Company from its quarry and hot mix facility in Hunter, Texas.

Colorado Materials provided five stockpiles of approximately 424 cubic feet (12 cubic meters) each. There were two coarse aggregates, one intermediate aggregate, and two manufactured sands, washed and unwashed. These five stockpiles were stored in aggregate bins located behind the SCSC facility. This limestone aggregate was of medium hardness and primarily calcareous in nature, with a combined aggregate absorption of approximately 1 percent. Its combined bulk specific gravity was approximately 2.600. It had a proven track record of good performance on a wide variety of pavements in Texas. A natural sand aggregate was furnished by Texas Industries (TXI) from its pit near Austin, Texas. This was a clean, coarse, natural sand with a bulk specific gravity of about 2.640. Traditionally, it had not been used as an asphalt concrete aggregate in Texas. Ironically, it had been more commonly used in portland cement concrete in Texas because its high quality and attendant higher cost made it economically unattractive for hot mix producers for use in asphalt concrete. While the TXI natural sand was not a normal fine aggregate in Texas projects, it represented natural sands used in asphalt concrete in other parts of the U.S. and possessed properties that made it favorable in terms of Superpave aggregate specifications. Table 20 shows the gradation and other properties of the SCSC laboratory standard aggregates.

Table 20. Properties of SCSC Laboratory Standard Aggregates

Size, mm	Coarse Aggregate C-Rock	D-Rock	F-Rock	Fine Aggregate Washed Screenings	Unwashed Screenings	Natural Sand
19	100.0	100.0	100.0	100.0	100.0	100.0
12.5	49.3	97.4	100.0	100.0	100.0	100.0
9.5	4.5	70.0	100.0	100.0	100.0	100.0
4.75	1.8	7.4	68.4	99.1	100.0	100.0
2.36	1.8	3.8	17.0	84.3	79.6	100.0
1.18	1.7	3.3	6.4	53.1	61.0	71.0
0.6	1.6	3.0	4.0	31.7	33.4	27.8
0.3	1.6	2.9	2.8	17.2	21.1	2.2
0.15	1.5	2.7	2.4	10.7	16.7	1.0
0.075	1.4	2.0	2.1	8.6	20.3	0.9
Coarse Aggr. Angularity, %	100	100	100	n/a	n/a	n/a
Fine Aggregate Angularity, %	n/a	n/a	n/a	48	48	42
Flat and Elongated Particles, %	0	0	0	n/a	n/a	n/a
Sand Equivalent Value	n/a	n/a	n/a	75	73	85

Laboratory standard binders were furnished by Neste Trifinery of Corpus Christi, Texas. Bulk quantities were furnished in 5-gallon (19-liter) buckets. Two grades were used, a PG 64-22 and a PG 70-22. Tables 21 and 22 show the properties of the asphalt binders used. Both materials proved to be of consistently high quality and suitable for a wide variety of uses at the Center.

Table 21. Properties of SCSC Laboratory Standard PG 64-22

Property	PG 64-22	Specification
Unaged Binders		
Viscosity at 243°F (135°C)	0.410 Pa·s	3 Pa·s min
Flash Point, COC	558°F (310°C)	414°F (230°C) min
G*/sin δ at 115°F (64°C)	0.18 psi (1.26 kPa)	0.14 psi (1.00 kPa) min
Rolling Thin Film Oven Residue		
Mass Loss, %	0.08%	1.00% max
G*/sin δ at 115°F (64° C)	0.4 psi (2.88 kPa)	0.32 psi (2.20 kPa) min
Pressure-Aging Vessel Residue		
G*sin δ at 39°F (22°C)	519 psi (3,578 kPa)	725 psi (5,000 kPa) max
Creep Stiffness at -21°F (-12°C)	29 ksi (198 MPa)	43.5 ksi (300 MPa) max
Creep Rate at -21°F (-12°C)	0.316	0.300 min

Table 22. Properties of SCSC Laboratory Standard PG 70-22

Property	PG 70-22	Specification
Unaged Binders		
Viscosity at 243°F (135°C)	0.520 Pa·s	3 Pa·s min
Flash Point, COC	581°F (323°C)	414°F (230°C) min
G*/sin δ at 126°F (70°C)	0.17 psi (1.18 kPa)	0.14 psi (1.00 kPa) min
Rolling Thin Film Oven Residue		
Mass Loss, %	0.03%	1.00% max
G*/sin δ at 126°F (70°C)	0.38 psi (2.63 kPa)	0.32 psi (2.20 kPa) min
Pressure Aging Vessel Residue		
G*sin δ at 45°F (25°C)	556 psi (3,838 kPa)	725 psi (5,000) max
Creep Stiffness at -21°F (-12°C)	29 ksi (201 MPa)	43.5 ksi (300 MPa) max
Creep Rate at -21°F (-12°C)	0.309	0.300 min

The SCSC staff and staff of the Texas Department of Transportation (TxDOT) Bituminous Section made extensive use of this set of materials. Numerous asphalt mixtures were developed for training purposes. Figure 6 shows three typical Superpave gradations that used the SCSC laboratory standard materials.

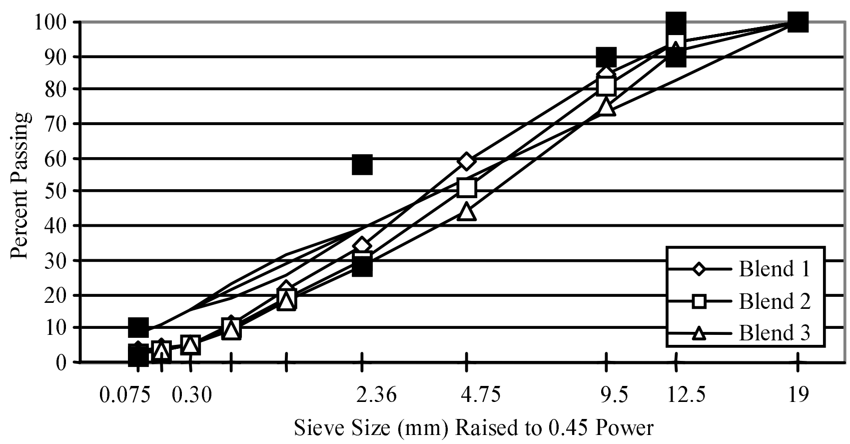

Figure 6. Gradation of Typical SCSC Laboratory Standard Mixtures

EVALUATION OF MATERIALS IN NORTHEAST TEXAS

In 1996, the SCSC assisted a task force of TxDOT and industry officials from northeast Texas. The task force was charged with determining the cause of poor asphalt pavement performance in the Atlanta and Tyler districts of TxDOT. The poor performance was manifested in a variety of ways, but there was a general consensus that the primary cause was moisture damage. TxDOT officials believed that a local gravel source, which began to be used at approximately the same time that the moisture damage occurred, was a causative factor. As a result, TxDOT prohibited the use of the local gravels. SCSC was asked to serve as a materials evaluation resource for the task force.

Because Superpave utilizes a stripping test that was already in common use in Texas, that feature of the Superpave system did not offer promise in terms of evaluating the northeast Texas materials. However, other Superpave mixture requirements, such as the Superpave gyratory compactor (SGC) densification requirements and consensus aggregate requirements, needed to be investigated to determine whether the troublesome mixtures would have been identified.

The TxDOT Atlanta District provided typical materials, including the local coarse gravel aggregates and three natural sands. The SCSC reproduced some of the poor performing mixtures and evaluated the mixtures and component materials using the Superpave system. This experiment showed that the gravel/sand mixtures failed the Superpave densification criterion at an initial number of gyrations. Several of the gravel/sand mixtures failed the Superpave sand equivalent requirement for moderate or high trafficked pavements. The SCSC experiment identified two of the three natural sands as being inappropriate for use on moderate or highly trafficked pavements.

An additional experiment was conducted to determine whether substituting a higher quality fine aggregate would provide better Superpave mix design properties. The SCSC laboratory standard manufactured sand and natural sand were employed for this purpose. This study indicated that, by using a limestone-manufactured sand similar to the SCSC standard, it was possible to use the local gravel aggregates with an expectation of reasonable performance. Wang (Ref 10) presents a more thorough explanation of the northeast Texas materials evaluation.

SUPERPAVE MIX DESIGNS

For the first 2 years of SCSC activity there was a general lack of Superpave mix design expertise. (Such a lack of expertise is customarily the case when implementing new technology.) Thus, one of the early functions of the Center was to provide mix designs for requesting agencies. The following paragraphs summarize this activity.

Texas US 59

The first mix design conducted at the SCSC was in September 1995 at the request of TxDOT. The project was an overlay of US 59 in Livingston, Texas. The hot mix producer was Redland Stone, and the mix was placed by Jones Finke, Inc. The PG 76-22 binder was furnished by Gulf States Asphalt. Figure 7 shows the job-mix gradation of the 0.5-in. (12.5-mm) selected trial blend while Table 23 shows the Superpave mix design properties.

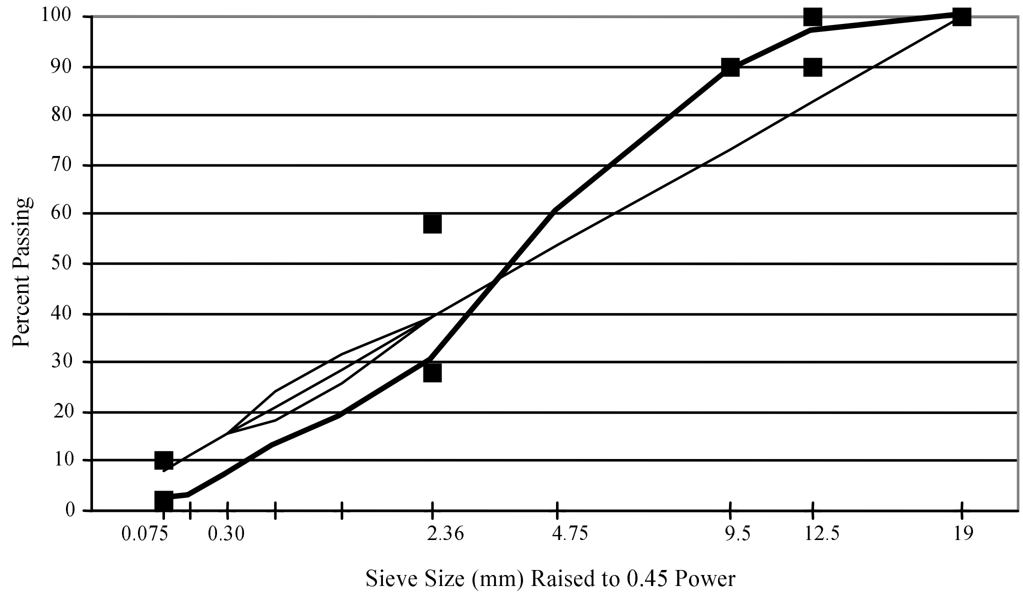

Figure 7. US 59 Superpave Gradation

Table 23. US 59 Mix Design Properties

Design Property	Value	Criteria
Design Asphalt Content, %	4.9	n/a
Air Void Content, %	4.0	3.0 – 5.0
Voids in Mineral Aggr., %	13.8	14.0 min
Voids Filled with Asphalt, %	71.0	65.0 – 75.0
$\%G_{mm}$ at N_{ini}	84.4	89.0 max
$\%G_{mm}$ at N_{max}	97.6	98.0 max
Absorbed Asph. Content, %	0.8	n/a
Dust Proportion	0.6	0.6 – 1.2
Tensile Strength Ratio	0.86	$\geq$ 0.80
Coarse Aggr. Angularity, %	100/100	85/80
Fine Aggr. Angularity, %	45	45 min
Flat and Elongated Particles, %	0	10 max
Sand Equivalent Value	78	45 min

Louisiana Interstate Highway 10

The Louisiana Department of Transportation and Development (LADOTD) developed a showcase project in May 1996 on IH-10 near Baton Rouge. Several innovative technologies were demonstrated, including Superpave. The LADOTD requested that the SCSC develop a Superpave mix design. Materials were shipped from the hot mix producer, George Sullivan, Inc., to the Center. Vulcan Materials provided the aggregates and Marathon Oil Company provided the PG 76-22 asphalt binder. Figure 8 shows the job-mix gradation of the 0.75-in. (19-mm) selected blend while Table 24 indicates the Superpave mix design properties.

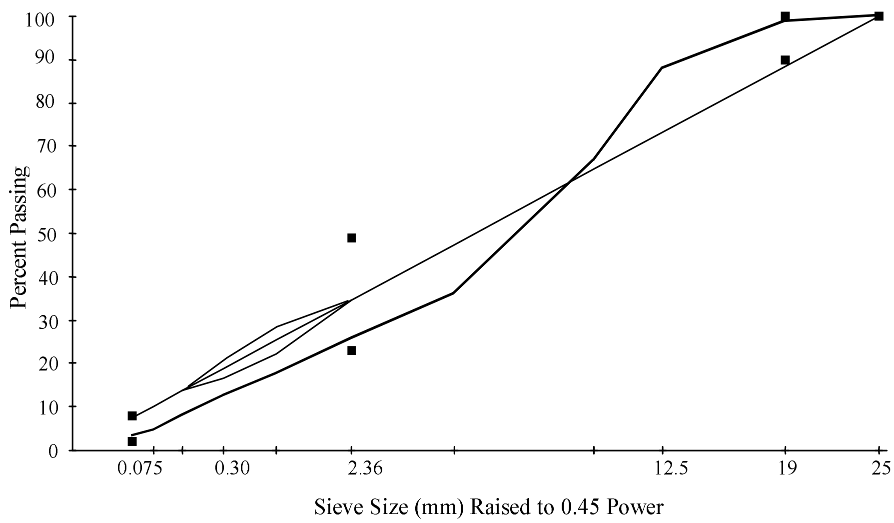

Figure 8. IH-10 Superpave Gradation

Table 24. IH-10 Mix Design Properties

Design Property	Value	Criteria
Design Asphalt Content, %	4.3	n/a
Air Void Content, %	4.0	3.0 – 5.0
Voids in Mineral Aggr., %	14.1	13.0 min
Voids Filled with Asphalt, %	71.6	65.0 – 75.0
$\%G_{mm}$ at N_{ini}	85.6	89.0 max
$\%G_{mm}$ at N_{max}	97.6	98.0 max
Absorbed Asph. Content, %	0.2	n/a
Dust Proportion	0.7	0.6 – 1.2
Tensile Strength Ratio	1.00	$\geq$ 0.80
Coarse Aggr. Angularity, %	100/100	85/80
Fine Aggr. Angularity, %	48	45 min
Flat and Elongated Particles, %	0	10 max
Sand Equivalent Value	72	45 min

Texas US 79

The Austin District of TxDOT requested that the SCSC conduct a mix design for US 79 near Taylor, Texas, for an overlay project in 1997. The mixture was produced and placed by the Austin Road and Bridge Company of Austin. The PG 64-22 binder was furnished by Coastal Refining and Marketing. Figure 9 shows the job-mix gradation of the 0-75-in. (19-mm) selected blend while Table 25 indicates the Superpave mix design properties.

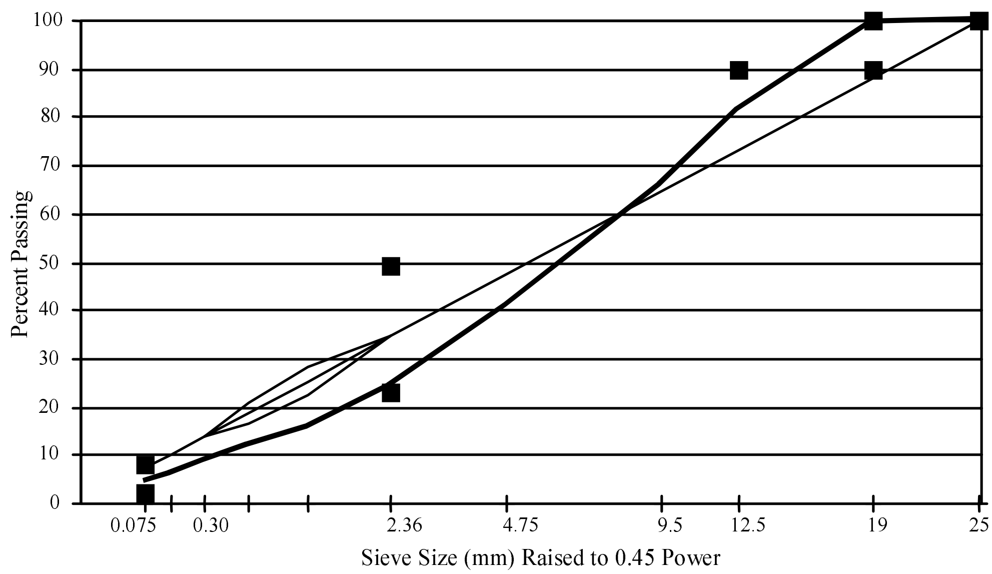

Figure 9. US 79 Superpave Gradation

Table 25. US 79 Mix Design Properties

Design Property	Value	Criteria
Design Asphalt Content, %	5.4	n/a
Air Void Content, %	4.0	3.0 – 5.0
Voids in Mineral Aggr., %	13.8	13.0 min
Voids Filled with Asphalt, %	71.0	65.0 – 75.0
%G_{mm} at N_{ini}	85.8	89.0 max
%G_{mm} at N_{max}	97.8	98.0 max
Absorbed Asph. Content, %	1.0	n/a
Dust Proportion	0.7	0.6 – 1.2
Tensile Strength Ratio	95.3	$\geq$ 0.80
Coarse Aggr. Angularity, %	100/100	85/80
Fine Aggr. Angularity, %	46	45 min
Flat and Elongated Particles, %	0	10 max
Sand Equivalent Value	75	45 min

Eckert Road

In October 1996, the San Antonio District of TxDOT requested that the SCSC conduct a mix design for an overlay of Eckert Road in San Antonio. The mixture was produced in early 1997 by Vulcan Materials, and the PG 70-22 binder was provided by Coastal Refining and Marketing. Figure 10 shows the job-mix gradation of the 0.5-in. (12.5-mm) selected blend while Table 26 indicates the Superpave mix design properties.

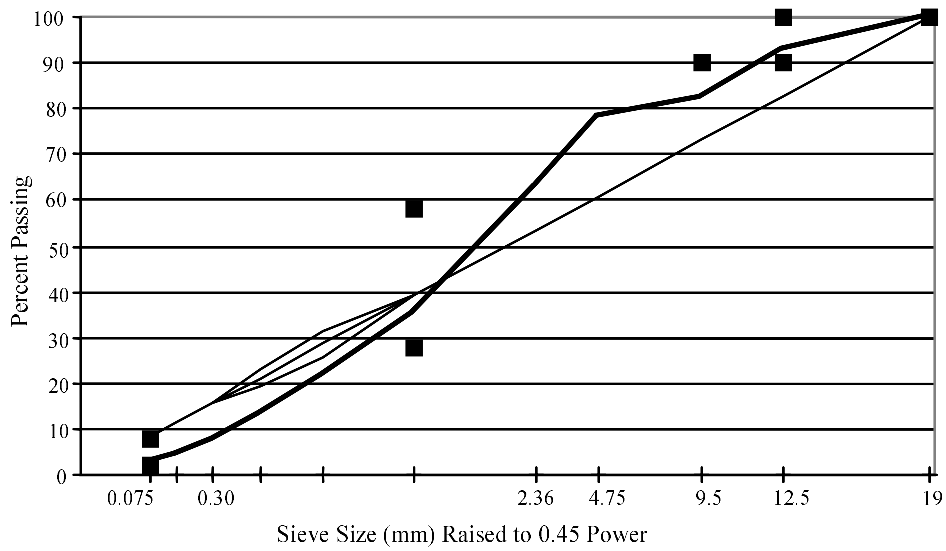

Figure 10. US 79 Superpave Gradation

Table 26. US 79 Mix Design Properties

Design Property	Value	Criteria
Design Asphalt Content, %	5.4	n/a
Air Void Content, %	4.0	3.0 – 5.0
Voids in Mineral Aggr., %	15.5	14.0 min
Voids Filled with Asphalt, %	74.2	65.0 – 75.0
$\%G_{mm}$ at N_{ini}	84.7	89.0 max
$\%G_{mm}$ at N_{max}	97.8	98.0 max
Absorbed Asph. Content, %	0.1	n/a
Dust Proportion	0.6	0.6 – 1.2
Tensile Strength Ratio	87.6	$\geq$ 0.80
Coarse Aggr. Angularity, %	100/100	85/80
Fine Aggr. Angularity, %	47	45 min
Flat and Elongated Particles, %	0	10 max
Sand Equivalent Value	85	45 min

Texas Business Interstate Highway 35

In July 1996, the San Antonio District of TxDOT requested that the SCSC develop a Superpave mix design for Business IH-35 in New Braunfels, Texas. This was an overlay consisting of a Superpave 0.75-in. (19-mm) mix. The mix was produced and placed by Colorado Materials Company of Hunter, Texas. The PG 64-22 binder was supplied by Texas Fuel and Asphalt Co. The aggregate materials used for this project consisted of the same materials selected by the SCSC for their laboratory standard materials. Figure 11 shows the gradation of the Superpave mix while Table 27 indicates the mix design properties.

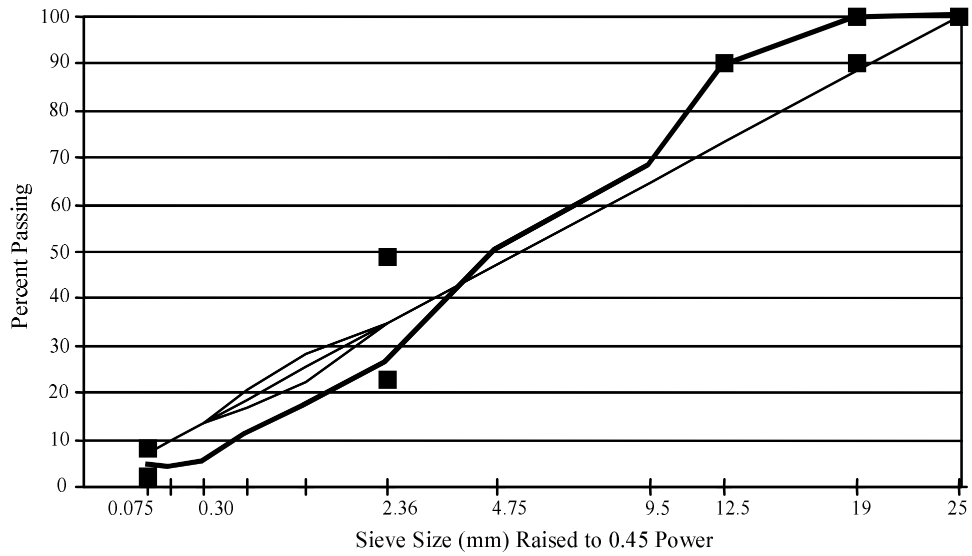

Figure 11. Business IH-35 Superpave Gradation

Table 27. Business IH-35 Mix Design Properties

Design Property	Value	Criteria
Design Asphalt Content, %	5.9	n/a
Air Void Content, %	4.0	3.0 – 5.0
Voids in Mineral Aggr., %	14.3	13.0 min
Voids Filled with Asphalt, %	72.1	65.0 – 75.0
$\%G_{mm}$ at N_{ini}	84.4	89.0 max
$\%G_{mm}$ at N_{max}	97.8	98.0 max
Absorbed Asph. Content, %	0.9	n/a
Dust Proportion	0.9	0.6 – 1.2
Tensile Strength Ratio	98.8	$\geq$ 0.80
Coarse Aggr. Angularity, %	100/100	85/80
Fine Aggr. Angularity, %	45	45 min
Flat and Elongated Particles, %	0	10 max
Sand Equivalent Value	78	45 min

COMPACTOR COMPARISON EXPERIMENTS

One of the major missions of the SCSC, as directed by the management committee, was "to evaluate and improve Superpave products through applied research." This mission was manifested in many ways — for example, by the ruggedness experiments involving the SGC and Superpave shear tester. A similar and equally significant activity was the evaluation of new SGCs.

The Federal Highway Administration (FHWA) developed a standard protocol for the systematic evaluation of new SGCs. This protocol was reviewed by the FHWA Superpave Mixtures Expert Task Group and changes were made based on this review. This protocol has now been standardized as the American Association of State Highway Transportation Officials (AASHTO) PP35-98, Standard Practice for Evaluation of SGCs. The SCSC utilized this protocol to evaluate the following six new SGCs:

- Interlaken
- Test Quip (Brovold gyratory compactor)
- Pine Model AFG1A
- Troxler Model 4141
- Rainhart
- Updated Interlaken

The AASHTO protocol was a very highly controlled experiment and involved testing four Superpave mixes (0.5 in. [12.5 mm], 0.75 in. [19 mm] fine, 0.75 in. [19 mm] coarse, and 0.98 in. [25 mm]). Two of the mixes (0.5 in. [12.5] and 0.98 in. [25 mm]) utilized SCSC laboratory standard materials. The other two mixes (0.75 in. [19 mm] coarse and fine) involved using materials from the Texas US 79 project for which the SCSC conducted the mix design. Six specimens of each mix were compacted in a candidate compactor and a referee unit. The referee units were either the Troxler Model 4140 or Pine Model AFGC125X. Thus, the experiment involved compacting a total of forty-eight specimens (four mixes × two compactors × six replicates). Specimens were individually batched and stored in plastic bags prior to use. As required by the protocol, the four mixes were designed according to AASHTO PP28 and met all the Superpave requirements.

Data were analyzed as required by AASHTO PP35. The response variable used for comparison was the bulk specific gravity of the test specimens at an initial, design, and maximum number of gyrations. Thus, for a given comparison experiment, there were twelve comparisons (four mixes × three levels of gyrations). For the two compactors to be considered comparable, the difference in their average bulk specific gravities needed to be less than 0.010. Table 28 summarizes the results in terms of comparability for the six compactor comparison experiments.

Table 28. Summary of SGC Comparability

Compactor		
Candidate	Referee	Comparability
Interlaken	Pine Model AFGC125X	9/12
Test Quip	Pine Model AFGC125X	11/12
Pine Model AFG1A	Pine Model AFGC125X	11/12
Troxler Model 4141	Troxler Model 4140	12/12
Rainhart	Pine Model AFGC125X	12/12
Updated Interlaken	Pine Model AFGC125X	12/12

SUMMARY AND CONCLUSIONS

Like the other Superpave Centers, the South Central Superpave Center (SCSC) represented a new and innovative approach to implementing new technology. It effectively began in June 1995 and operated out of the transportation materials laboratory at The University of Texas at Austin. In 1996, the Center developed an entirely new research and training facility at an off-campus location. Its host agency was the Texas Department of Transportation (TxDOT), and a uniquely strong partnership developed between the SCSC and the Bituminous and Asphalt Sections of TxDOT. Cooperating partners included the state highway agencies in Arizona, New Mexico, Oklahoma, Arkansas, and Louisiana, the Federal Highway Administration (FHWA), and the Texas Hot Mix Asphalt Pavement Association. It largely realized its role as a center of expertise to facilitate the implementation of Superpave.

Specialized Superpave training was a major activity of the Center: By November 1998, Center staff had organized and provided such training to 2,000 individuals representing all facets of the asphalt materials community. Included in these efforts were numerous on-site mix design training symposia for the state highway agencies of Arizona, New Mexico, Louisiana, Texas, Wyoming, and Illinois. Approximately 1,000 more individuals were reached through miscellaneous symposia.

In addition to organized training, SCSC transmitted Superpave technology through its presence on the Internet. The SCSC Web site is a very successful endeavor, with over 2,300 hits per week. A Superpave-related e-mail group was established that now contains over 250 subscribers.

The fact that SCSC was organized through The University of Texas at Austin necessitated that the Center support graduate students. Through this activity, five master's degree students and one doctoral student were supported. Two of the students awarded master's degrees were employees of TxDOT who conducted thesis research on topics pertaining to Superpave.

Applied research was also a function of the Center. This activity was dominated by evaluation of new test equipment and procedures that are part of the Superpave system. SCSC efforts lead directly to an increase in the availability and suitability of new models of SGCs through standardized compactor comparison experiments. In addition, SCSC efforts in cooperation with other organizations allowed the gyratory compaction protocol to be updated and improved. Through research sponsored by the FHWA, SCSC was able to make use of the Superpave shear tester to evaluate the sensitivity of engineering properties to a number of gyrations. In combination with the National Cooperative Highway Research Program

(NCHRP) 9-9 project, this experiment led to a vastly improved N-design table, which is an important feature in Superpave mix design.

While the Center largely accomplished its intended purpose, one factor that impeded the Center's support was the fact that it was not affiliated with one of the five asphalt user producer groups (UPGs). The SCSC's cooperating state highway agencies were members of the Pacific Coast UPG (Arizona), the Rocky Mountain Asphalt UPG (New Mexico), the North Central UPG (Oklahoma), and the Southeast UPG (Arkansas, Louisiana, and Texas). Consequently, there was no central forum for the SCSC to use for management committee meetings, activity updates, and other items of business. Through their UPG activity, SCSC cooperating partners were often placed in the confusing role of supporting other centers because of their UPG affiliations.

It is likely that the SCSC was the most well-financed Center over its period of operation. This clearly enabled the SCSC to achieve its intended purpose without a need to pursue funding from outside contract research efforts. Yet most of the SCSC's funding came not from a wide range of cooperating partners, but rather from TxDOT and, to a lesser extent, from the FHWA. By the end of August 1999, TxDOT will have provided funding approaching $1.6 million, with another $325,000 provided by the FHWA. The state highway agencies of Arkansas and Oklahoma also provided $50,000, although only $20,000 of these funds were directly accessible to the Center (the remaining $30,000 was held to fund travel costs of state personnel). In effect, TxDOT and the FHWA built the team that made up the Center and a wide array of organizations and individuals benefited from the resources of the SCSC. But without a more widely dispersed funding base from other agencies, the activities of the Center will likely cease in August 1999.

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