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16. Abstract

This report documents a cooperative effort to gather and make available information about flexible pavement forensics methods and the valuable knowledge that has resulted from forensic studies of flexible pavements over the past several decades in Texas. The gathered information is provided to the Texas Department of Transportation (TxDOT) for placement into TxDOT's internal knowledge management system. A glossary of flexible pavement forensic-related terms was developed and used in a systematic manner to properly and consistently associate key words with the information documents being stored.

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DEVELOPMENT OF CONTENT FOR A FLEXIBLE PAVEMENT FORENSICS KNOWLEDGE MANAGEMENT SYSTEM

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Report 0-4505-2
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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permitting purposes. The engineer in charge of the project was Paul E. Krugler, P.E. #43317. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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CHAPTER 1: INTRODUCTION

This report documents the activities and findings of phase two of this research project. Phase one work included developing a knowledge management system (KMS) and collecting rigid pavement forensics information to be made available in the new system. Phase one activities and findings are documented in Technical Report 0-4505-1, *Development of a Rigid Pavement Forensics Knowledge Management System to Retain TxDOT Corporate Knowledge (1)*. Phase two of this project identified, collected, and processed flexible pavement forensics information. This information will form a second section within the KMS developed during phase one.

ORGANIZATION OF THE REPORT

This introductory chapter includes an overview of the KMS that was developed during phase one of this research project and describes how the flexible pavement forensics information will be integrated.

Chapter 2 describes the methods used by the research team to identify and capture desired flexible pavement forensics knowledge and information. Summaries of the captured information are also provided in this chapter and in Appendix A.

Chapter 3 describes the unique terms, categories of knowledge, and associated acronyms developed to facilitate storage and retrieval of flexible pavement forensics knowledge and information items.

Chapter 4 describes opportunities for the Texas Department of Transportation (TxDOT) to move forward in its initiative to capture corporate knowledge and maximize benefits from its availability.

Chapter 5 summarizes the findings and recommendations after phase two of this project.

OVERVIEW OF TXDOT'S KNOWLEDGE MANAGEMENT SYSTEM

Knowledge Management System Software

Just prior to the initiation of this research project, TxDOT selected Knowledge Centre™, a product of Meridian KSI, as the base software for their learning content management system.

TxDOT named their system i-Way. The home page of i-Way appears in Figure 1. The selected software product stores and manages both an agency's training program and corporate knowledge, thereby providing support to both training efforts and general agency operations. Therefore, i-Way was the logical choice for storing and managing the pavement forensics information being gathered. The rigid pavement forensics information gathered during phase one of this project currently resides in the i-Way database and is available to users.

Figure 1. TxDOT i-Way Home Page.

TxDOT has made i-Way available on their intranet system. In that manner, access to i-Way and the information it contains is readily available to all TxDOT employees. On the other hand, external TxDOT customers do not have access.

The Training, Quality and Development (TQD) Section of the TxDOT Human Resources Division is responsible for administering i-Way. They have developed an excellent i-Way user's manual to assist TxDOT employees in navigating i-Way.

Organization and Flow of Information

TxDOT's i-Way consists of seven major functional areas. All i-Way areas are accessible from the home page (Figure 1) by clicking on the sign representing the desired type of information or knowledge. The seven areas of i-Way are:

- Library,
- Conference Center,
- Communication Center,
- Teaming Center,
- Learning Center,
- Course & Student Management, and
- Search.

All areas of i-Way except for the Learning Center and the Course & Student Management areas play roles in the KMS that has been developed and implemented. The following discussions briefly describe the i-Way functionalities being used.

The Library, Conference Center, Communication Center, and Teaming Center of i-Way are central to the KMS. The Library, Conference Center, and Communication Center all provide knowledge storage. The Teaming Center, bulletin boards of the Communication Center, and item-rating capabilities provide the primary means for ongoing information capture. The team rooms, global and team room search capabilities, and PeerNet support knowledge location and retrieval.

In addition to information retrieval capabilities provided by the software, the research team developed glossaries of key words and acronym key word lists for the rigid pavement and the flexible pavement forensics information items. These key word lists, when used in creating the metadata files for the information items, greatly facilitate user retrieval of desired information.

Moderated and private team rooms play key roles in the KMS. Besides facilitating communications, team rooms make frequently needed and highly valued forensic pavement knowledge and resources readily available to KMS users. If desired, this information may be stored for exclusive availability to team room members by placing it in the contents sections of team rooms. Information stored outside of the team rooms can also be made readily available to team room users by hyperlink. Ready access to selected information and tools is thereby made possible for those taking advantage of available team rooms.

Moderated rigid and flexible pavement forensics team rooms are open to all department personnel, thereby providing department-wide access to selected, broadly useful information in the subject area of each team room. Some of the primary users of the rigid and flexible pavements forensics moderated team rooms are envisioned to be area engineers, maintenance foremen, and construction inspectors.

Similarly, private team rooms will offer district pavement engineers and selected division pavement engineering staff members a location to access valuable information as well as a place to share new ideas and recent lessons learned.

Figure 2 shows a graphical description of the KMS functional plan as developed by the research team. As seen, the private team rooms will serve as incubation sites for new knowledge. New ideas and experiences can be shared and discussed, merits of procedure or specification changes can be debated, and requests for assistance in unique situations can be made. New knowledge and information placed there can be migrated to the Library, Conference Center, or other portion of formal KMS item storage. When deemed appropriate by management, the new knowledge will also be made available as a content item within the moderated team room, highlighting it as a particularly valuable resource to the community of practice.

The KMS offers several mechanisms for interaction between users. User interaction is essential for sustaining flow of current information into the system. This interaction also promotes knowledge solicitation and sharing. Features of the KMS software which support user interaction are the PeerNet function, the bulletin board section, and other Teaming Center functionality. Private team rooms also offer a group email function for contacting all other team members. Another type of user interaction is the rating feature, whereby every user may rate and comment on any content item.

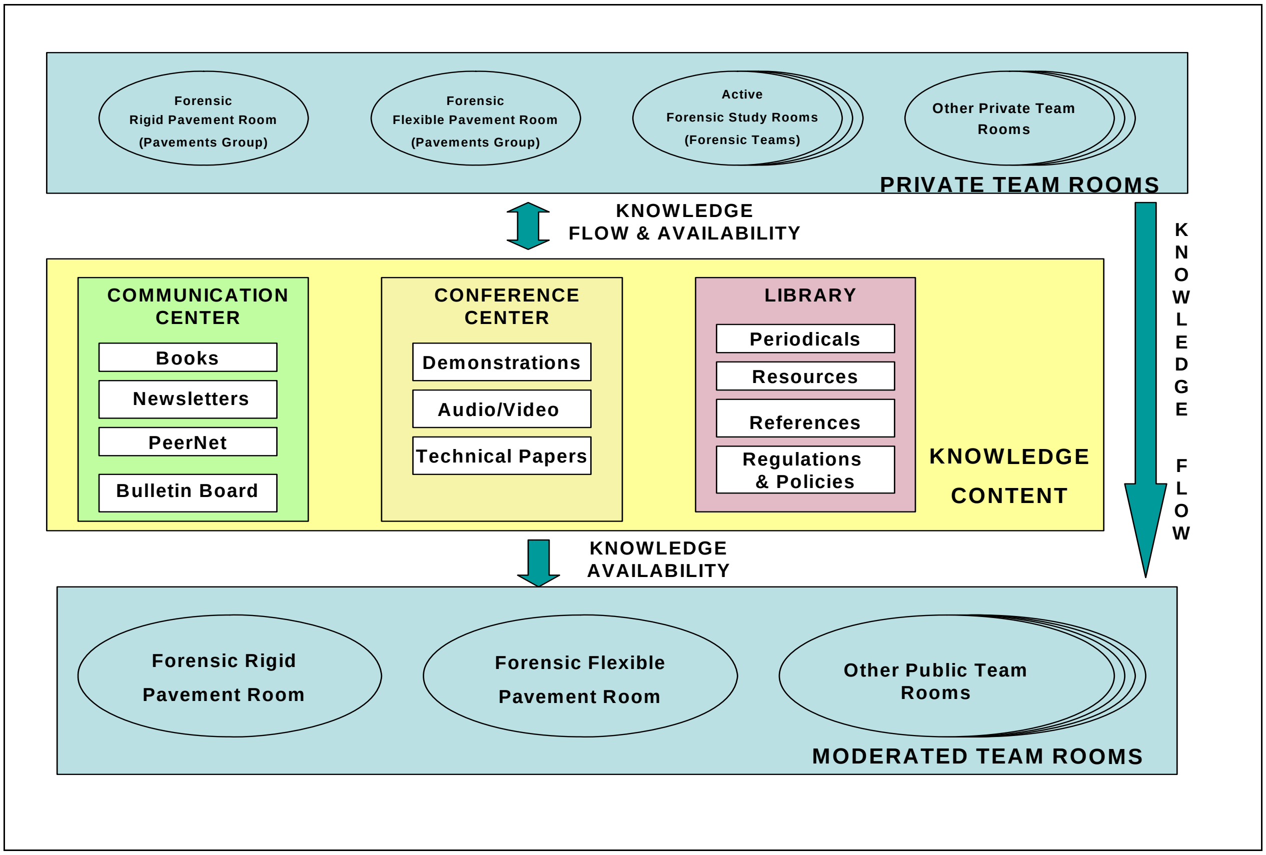

Figure 2. Knowledge Management System Functional Diagram.

The PeerNet function builds a communication network for co-workers with similar interests. Among the main applications of PeerNet is its capability to find experts in a specific topic for consulting on problems and for sharing valuable experiences. Mentoring of less-experienced members of the community is facilitated, resulting in growth in the expert network.

The bulletin board in each team room provides a discussion forum for users to post and read messages, and to comment on messages posted by other users. These bulletin boards also provide locations for district pavement engineers to request peer assistance in an environment conducive to mentoring and developing knowledge. The user can search messages in a bulletin board for key words that are used in the message subject lines and message texts. The messages retrieved through a search can then be browsed by the user, and, if desired, a thread may be converted to MS Word and saved. Like the rigid pavement forensic community of practice, the flexible pavement forensic community will have two bulletin boards to support community of practice activities, one in each of their team rooms. While all district pavement engineers and a number of individuals from TxDOT divisions will hold membership in both the rigid pavement and flexible pavement private team rooms, there will also be some uniqueness in each membership list.

The private team room content, bulletin board, and email capabilities combine to provide an efficient and effective method of gathering feedback from reviewers of draft documents. To take advantage of this, a private team room contributing member first places the draft document into the team room as a content item. A message thread is then initiated in the team room bulletin board to later harbor all team member review comments. Then an email is sent to either selected team room members or to all team room members requesting document review and comment through reply to the message thread initiated for this purpose. In this manner, any reviewer has the opportunity to read earlier reviews, if desired, without the earlier reviewer having to reply-to-all in an email, thereby cluttering everyone's email inbox. Another advantage to this method is that the individual requesting the review will find all review responses in one location instead of spread throughout an email inbox.

Private team rooms are also locations for any member to share unique experiences, lessons learned, and what they believe to be new insights or knowledge about forensic pavement investigation. These private rooms should facilitate a much increased communication level within these communities of practice.

Another helpful feature available to team room owners is the capability of deleting any thread or replies in the bulletin boards that are either inappropriate or outdated.

Knowledge Management System Administration

A recommended plan for management and administration of the knowledge management system was provided in Technical Report 0-4505-1 and is summarized here.

The KMS Central Team Room

KMS Central was created in an i-Way team room to serve as the hub for TxDOT's knowledge management system. Information available in KMS Central includes KMS Users Tips, a directory of KMS subject-specific team rooms, a directory of available key word glossaries and acronym lists, and a Welcome page. KMS Central will accommodate expansion of knowledge management into additional areas of TxDOT corporate knowledge in future years.

Site Administration

The Human Resources Division of TxDOT is the owner and site administrator of i-Way. It is recommended that this division retain these functions. Site administration roles include the following:

- providing maintenance contracts and department interface with the software vendor,
- determining potential customizations of the software,
- providing training for bulletin board moderators,
- providing second-level oversight of bulletin board use,
- assigning and managing user access, and
- loading content.

Technical Content Administration

It is recommended that responsibility for and control of the technical content in each KMS subject area be assigned to the TxDOT division having responsibility for the technology involved. For the pavement forensics knowledge management system, the Pavement and Materials Systems branch manager of the Construction Division of TxDOT is recommended to have technical content administration responsibility. It is envisioned that the technical content responsibilities described below be performed by the branch manager or be delegated, as appropriate:

- selecting moderators for team room bulletin boards in the moderated team rooms and the private team rooms created for the forensic pavement communities of practice,
- approving all new Analysis Tool Box items and Top Reference Collection materials for entry into the content sections of the moderated and private forensic pavement team rooms,
- determining appropriate use of a disclaimer statement on items related to this technical area, and
- semiannually reviewing and updating, adding, or deleting Analysis Tool Box and Top Reference Collection content.

Bulletin Board Moderators

Moderators are an essential part of an effective bulletin board. It is recommended that at least two moderators be assigned to each bulletin board to lighten the work load and to provide closer to continuous moderator availability. The moderators must be proficient in the technical subject area involved. When feasible, it is suggested that one moderator be employed in a central headquarters division and one be employed in a district office. Duties of the bulletin board moderators include the following:

- monitoring bulletin board use to limit discussions to topics pertaining to the technical subject matter of the team room;
- encouraging professional etiquette and tact in bulletin board threads;
- reporting inappropriate use of the bulletin board to the technical content administrator and the site administrator; and,
- importantly, recommending to the technical content administrator bulletin board thread information, new knowledge documents, or unique observation descriptions which should be made available to a broader audience by loading them into primary knowledge storage locations in the KMS or possibly even by including them in the Analysis Tool Box or Top Reference Collection for that technology area.

A graphical view of the system management structure is shown in Figure 3.

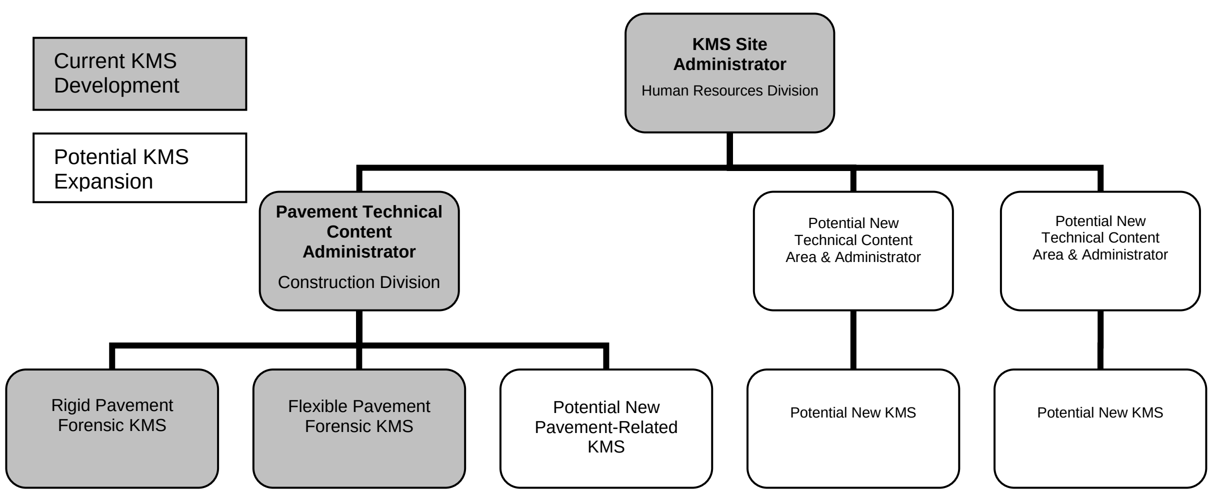

Figure 3. Knowledge Management Structure.

CHAPTER 2:
KNOWLEDGE IDENTIFICATION AND CAPTURE

KNOWLEDGE SCOPING MEETING

As during the gathering of rigid pavement forensics knowledge during phase one, a knowledge scoping meeting obtained TxDOT input for flexible pavement forensics information to be collected and prepared for placing in the KMS. This meeting was held January 12, 2006, at the Texas Transportation Institute's Austin office. Table 1 lists those attending the meeting. Considerable input was obtained from this group.

Table 1. Knowledge Scoping Meeting Attendees.

Last Name	First Name	Organization	Experience
Chang-Albitres	Carlos	Texas Transportation Institute	Associate Transportation Researcher
Claros	German	Research & Technology Implementation Office	Pavements and Construction Research Engineer
Cumby	Tracy	Lubbock District	Maintenance Foreman
Eltahan	Ahmed	Construction Division	Pavement Engineer
Fults	Kenneth	Center for Transportation Research	Research Engineer and Retired TxDOT State Pavements Engineer
Hazlett	Darren	Construction Division	Assistant Director of Materials Section, Construction Division, and Former State Asphalt Engineer
Krugler	Paul	Texas Transportation Institute	Research Engineer and Retired Pavement Materials Engineer
O'Connor	Donald	Rodriguez Engineering Consulting	Retired Assistant Materials & Tests Engineer and Former State Asphalt Engineer
Smith	Steve	Odessa District	Director of District Construction
Tahmoressi	Maghsoud	PaveTex Engineering & Testing	Former State Bituminous Engineer
Wimsatt	Andrew	Fort Worth District	Pavement Engineer
Yrigoyen	Tony	Houston District	Area Engineer

Input received from this group included specific information that would be valuable to anticipated users, sources, or locations of the identified valuable information, and an initial list of interview candidates for capturing tacit knowledge.

COLLECTED INFORMATION

The flexible pavement forensics information that was collected falls into 10 categories. These categories are shown in Table 2 along with the numbers of items collected in each. The specific items of information in each of these categories are identified in Appendix A.

Table 2. Breakdown by Information Categories.

Information Category	Number of Items
Books	8
Newsletters	11
Videos	9
Demonstrations	42
Technical Papers	52
Software	19
Web Sites	17
Databases	8
Manuals	19
Legacy Knowledge Segments	122

LEGACY KNOWLEDGE CAPTURE INTERVIEWS

Selection of Individuals for Interview

A list of 60 interview candidates was developed during the knowledge scoping meeting. A number of other excellent candidates were later added to the list as additional names occurred to either TxDOT or research team personnel. The compiled list of names was by no means an exhaustive list, however, as there are so many prior and current TxDOT personnel with knowledge worthy of sharing. It is also certain that there were many more listed candidates worthy of interviews than there was time and budget allowance within the research project. The

24 individuals who were selected and interviewed were chosen in an attempt to obtain a broad range of experiences as well as to capture information perceived to be the most valuable. Table 3 contains the names, affiliations, and backgrounds of those individuals who provided legacy knowledge capture interviews to the research team. This group includes 12 former TxDOT employees, one who left TxDOT employment later that same year.

Table 3. Legacy Knowledge Capture Interview List.

Last Name	First Name	Primary Experience	Experience Location	Status
Bass	David	District Laboratory Engineer	Fort Worth	Retired
Bradley	Don	District Laboratory Manager	Odessa	Retired
Epps	Jon	Pavement and Materials Research Engineer and Construction Quality Control	National	Granite Construction Inc.
Fitts	Gary	Field Engineer	Regional	Asphalt Institute
Fults	Ken	Pavement Engineer and Research Engineer	Statewide Lufkin	Retired
Garrison	Miles	District Laboratory Engineer and Pavement Engineer	Atlanta	TxDOT
Hazlett	Darren	Asphalt Laboratory Engineer	Statewide	TxDOT
Huffman	Marshall	District Engineer and Construction Engineer	Odessa	Retired
Krugler	Paul	Bituminous Laboratory Engineer and Research Engineer	Statewide	Retired
Leidy	Joe	Forensic Pavement Engineer	Statewide	TxDOT
Mikhail	Magdy	Bituminous Laboratory Engineer	Statewide Houston	TxDOT
Murphy	Mike	Pavement Design Engineer	Statewide	TxDOT
O'Connor	Donald	Asphalt Laboratory Engineer	Statewide	Retired
Peterson, Jr.	Gerald	Asphalt Laboratory Engineer	Statewide	TxDOT
Prince	Morgan	District Maintenance Engineer	Lufkin	Retired
Rand	Dale	Bituminous Laboratory Engineer	Statewide	TxDOT
Rmeili	Elias	Pavement Engineer, Design Engineer, and Transportation Planning & Development	Bryan Brownwood	TxDOT
Rudd	W. E. (Gene)	Construction Engineer	Lufkin	TxDOT
Scullion	Tom	Ground Penetrating Radar Pavement and Materials Research	Statewide	TTI
Smith	Steve	Construction Engineer, District Laboratory Engineer, and Pavement Engineer	Odessa	TxDOT
Tahmoressi	Maghsoud	Bituminous Laboratory Engineer	Statewide	Former TxDOT
Utley	Carl	District Engineer and Construction Engineer	Fort Worth Lubbock	Retired
Wimsatt	Andrew	Pavement Engineer	Statewide Fort Worth	Former TxDOT
Yrigoyen	Tony	Area Office and Project Engineer	Houston	TxDOT

Table 4 provides a breakdown of legacy knowledge content by knowledge category. A number of the legacy knowledge segments address several knowledge categories. A few legacy knowledge segments did not involve any of these information categories. An example would be a knowledge segment focused entirely on advice for new engineers in the transportation industry. Table 4 information should be considered an approximate categorical breakdown, as there is room for considerable subjectivity in determining which categories each knowledge segment addresses.

Table 4. Breakdown of Legacy Knowledge Segment Coverage.

Legacy Knowledge Category	Approximate Number of Knowledge Segments
Forensic Study Methods	18
Distress Types and Causes	39
Pavement Testing	10
Laboratory Testing	21
Innovative Field Testing	5
Materials Selection	15
Flexible Base	10
Repair/Rehab. Methods	10
Historical Forensic Studies	34
Historical Mix Design and Types	13
Historical Bases for Standard Specification Requirements	14

Legacy Knowledge Interviews

The interview process captured tacit knowledge, information contained only in the minds of experts. To elicit this knowledge, researchers prepared a set of questions to retrieve targeted knowledge based on the expertise area of the individual to be interviewed.

There were a number of questions common to all interviews. Appendix C contains a typical set of interview questions. The questions were developed to focus memory on unique experiences and observations which often are not documented in written form.

As during phase one of this research project, individuals selected for interview were contacted initially by telephone whenever possible. During phase two, every individual was quite willing to provide an interview even though no compensation was offered to retired employees.

The interviews were audio-taped so that they could be transcribed for later processing into legacy knowledge segments. One interviewee agreed to be interviewed but did not wish to have the interview recorded. That interview was also quite successful, although it took slightly longer than would have been the case otherwise. The legacy knowledge segments for this interview were immediately developed because of partial reliance on interviewer memory.

Two interviews were also given over the telephone, when distances made face-to-face interviews impractical. These were also successful.

The interviewers made an effort to approach interviews in a conversational manner, which seemed to ease occasional initial apprehensiveness. Interviews during phase two typically lasted about an hour, somewhat shorter than those during phase one of the project.

Interview Knowledge Capture Process

Each audio tape was transcribed after the interview. Researchers then analyzed each transcription for portions deemed to be the most valuable pieces of information to preserve. These portions were placed into the legacy knowledge document format designed during phase one of the project, and the information was edited to improve clarity of communication.

The legacy knowledge documents were then sent to the interviewed individual for approval to assure that no meaning was lost or changed in editing. These legacy documents average about one page in length. Photographs were added, where available. Appendix D contains several examples of legacy knowledge documents.

Evaluation of the Phase Two Legacy Knowledge Capture Interview Process

As during phase one, individuals expressed that they had found the interview process enjoyable. Retired employees were often outspoken in that regard. It seems that virtually all employees and former employees welcome the opportunity to share what they have learned over the years.

The use of a structured set of questions for the interview is essential to efficiently capture knowledge from the individuals to be interviewed. The questions used during phase two interviews were more specific in nature than those used for phase one interviews. This is believed to have both shortened the average interview length and increased the quality of information that was obtained. The quality of the set of questions provided to the interviewee in advance is considered to be the single most important factor in obtaining the type of valuable information sought from the interview process. It was also found beneficial to refine the set of questions after the first couple of interviews, after having analyzed how the interviewees apparently processed the questions by the information that they provided.

CHAPTER 3:
KNOWLEDGE STORAGE AND RETRIEVAL

KNOWLEDGE MANAGEMENT SYSTEM CONTENT AND STORAGE LOCATIONS

Information items will be stored in various subsections of the Communication Center, Conference Center, and Library following the same protocol developed and used in storing phase one knowledge and information concerning rigid pavements. Table 5 presents a list of the categories for information content items.

Table 5. Content Items for the Knowledge Management System.

Content Items	i-Way Room	i-Way Room Subsection
Books	Communication Center	Books
TxDOT Newsletters	Communication Center	Newsletters
Experts Network	Communication Center	PeerNet
Bulletin Board	Communication Center & Teaming Center	Bulletin Boards
Videos	Conference Center	Audio & Video Presentations
Presentations	Conference Center	Demonstrations
Forensic Reports	Conference Center	Technical Papers
Legacy Interview Documents	Conference Center	Technical Papers
Technical Journals	Library	Periodicals
Diagrams/Work Instructions	Library	References
Glossary & Acronym Taxonomy	Library	References
TxDOT Manuals	Library	Regulations & Policies
TxDOT Databases	Library	Resources
Web Links	Library	Resources

As with rigid pavement forensics information, stored information items that are highly recommended and/or are frequently needed for forensic studies are made available within pavement forensic team rooms in the Teaming Center.

KEY WORD GLOSSARY

A glossary of key terms related to forensic flexible pavement investigations assists users in consistently describing information content. The glossary contains categories of descriptors. The user creating an information item will be asked to select applicable key words from each of the categories. Table 6 further describes these categories. The intent is to provide a very basic, easily understood, yet sound key word structure to facilitate the most common types of information searches. Researchers anticipate that key words describing distress modes will be the most frequently used in searches. The glossary will be made available as a content item in team rooms to guide those preparing entry information for new knowledge items and to assist those preparing to do a search for database information. Appendix B provides the key word glossary used in describing flexible pavement forensics.

Table 6. Categories of Key Words and Examples.

Category	Example Key Words
Geographic Area	statewide, Abilene District, coastal, panhandle, north Texas, IH 35, Tarrant County
Information Type	legacy knowledge, reference material, analysis tool, new knowledge, unique application
Legacy Knowledge Source	Kenneth Fults, etc.
Analyses Involved	pavement tests, laboratory tests, traffic analysis, design analysis, Tex-203-F, sand equivalent test
Flexible Pavement Distress Involved	rutting, longitudinal cracking, thermal cracking, segregation, reflective cracking, alligator cracking
Other Key Words	stockpile segregation, paving machine, vibratory roller, diesel contamination, anti-stripping agent, burned asphalt

ACRONYM TAXONOMY

In addition to the use of common key words from the glossary terms, the research team developed an acronym taxonomy for the key words field. To maintain simplicity and ease of use, this taxonomy contains only a limited number of acronyms corresponding to frequently anticipated pavement forensic search needs. The value of using this acronym taxonomy is that use of subject codes will exclusively retrieve only information purposefully selected for this key word search. For instance, if a user wishes to retrieve all legacy knowledge documents pertaining to flexible pavement forensics, a search using the acronym of "lkfpf" would retrieve those items exclusively and completely. Other methods of searching may retrieve extraneous documents or could omit some desired documents. If the user desires a smaller subset of information, this information can be obtained by adding one or more additional acronyms or glossary key words to the search. An example would be a search using "lkfpf" and "rutting." This search retrieves only flexible pavement forensic legacy knowledge documents which involve rutting.

The acronym taxonomy recommended for flexible pavement forensic items is found in Tables 7 through 11. Five knowledge and information categories were selected to be applicable to a broad range of future TxDOT communities of practice as well as the pavements community. These knowledge and information categories are:

- Legacy Knowledge,
- Top Reference Collection,
- Analysis Tools and Databases (Analysis Tool Box),
- Observations and New Knowledge, and
- Unique Applications and Innovations.

While acronyms assist in managing the KMS content in a structured and organized way, it is not a requirement for the user to know and use these acronyms when searching. Generic key words from the key word glossary will also be available for searching and retrieving database items. However, the research team believes that with a rapid growth of i-Way knowledge content, these more specific acronyms will provide the user more direct access to specifically desired knowledge.

Table 7 shows the acronym taxonomy to uniquely identify the legacy knowledge documents. Note that the table has three levels of information description. The first and most general level is all legacy knowledge. The second level is a subset of the first, flexible pavement legacy knowledge. The third level has multiple options, with forensic flexible pavement legacy knowledge being the one to be used most frequently in phase two project work. The additional third-level options are provided since there will undoubtedly be knowledge captured during interviews that would be desired for other uses than forensic study applications. The research team has applied these other acronyms, as applicable, to each item of legacy knowledge to be included in the i-Way database during this project.

Table 7. Acronym Taxonomy for Legacy Knowledge.

Information to Be Retrieved	Acronym Used in Key Word Field
Legacy Knowledge – All Categories	lk
Legacy Knowledge – All Flexible Pavement Categories	lkfp
Legacy Knowledge – Flexible Pavement – Forensic	lkfpf
Legacy Knowledge – Flexible Pavement – Design	lkfpd
Legacy Knowledge – Flexible Pavement – Maintenance	lkfpm
Legacy Knowledge – Flexible Pavement – Construction	lkfpc
Legacy Knowledge – Flexible Pavement – Inspection	lkfpi
Legacy Knowledge – Flexible Pavement – Rehabilitation & Reconstruction	lkfpr
Legacy Knowledge – Flexible Pavement – Pavement Testing & Data Analysis	lkfppt
Legacy Knowledge – Flexible Pavement – Laboratory Testing & Data Analysis	lkfplt
Legacy Knowledge – Flexible Pavement – Specifications	lkfps
Legacy Knowledge – Flexible Pavement – Traffic Data & Data Analysis	lkfpt
Legacy Knowledge – Flexible Pavement – Unique Application & Innovation	lkfpu

Table 8 shows the acronym taxonomy to identify knowledge management system items that have been selected as Top Reference Collection materials. Items receiving this designation will be selected by the research team and TxDOT pavement forensic experts. A three-level category structure is also proposed in this taxonomy. More levels and item-content acronyms may be added if needed, but taxonomy brevity and simplicity are believed to be imperative.

Performing a global search from the i-Way home page using one of the Table 8 acronyms will retrieve all items in i-Way that contain that Top Reference Collection acronym in the key word field. In this manner, a user can quickly retrieve, browse, and then select from a preselected group of i-Way knowledge items that are believed to be the best sources of information currently available. Performing a search within a team room using a Table 8 acronym, on the other hand, will retrieve only Top Reference Collection materials that have been added as content items in that team room.

Table 8. Acronym Taxonomy for Items Selected as Top Reference Collection Materials.

Information to Be Retrieved	Acronym Used in Key Word Field
Top Reference Collection – All Categories	trc
Top Reference Collection – All Flexible Pavement Categories	trcfp
Top Reference Collection – All Flexible Pavement Forensic Categories	trcfpf

Table 9 shows the acronym taxonomy for knowledge management system content selected as frequently used, valuable, forensic-related tools or databases. This group of content items will provide an Analysis Tool Box for forensic flexible pavement i-Way users. Together with the Top Reference Collection, the Analysis Tool Box will provide the user with quick access to best available, frequently needed standard formats, tools, and database information sources. As for legacy knowledge documents, three levels of content acronyms are provided.

Table 9. Acronym Taxonomy for Analysis Tools and Databases.

Information to Be Retrieved	Acronym Used in Key Word Field
Analysis Tools & Databases – All Categories	atd
Analysis Tools & Databases – All Flexible Pavement Categories	atdfp
Analysis Tools & Databases – All Flexible Pavement Forensic Categories	atdfpf

Table 10 shows the acronym taxonomy to identify knowledge management system content items created by community of practice members to describe recent observations or thoughts that may represent new knowledge to the community at large. It is likely that this type of document would first be entered as a Knowledge Note *(1)* content item in the private team room of the applicable community of practice. The Knowledge Note format is shown in Figure 4. This type of information is a very important part of ongoing knowledge capture. Convenient retrieval of the items in this category will also be important, as it is envisioned that knowledgeable team members will utilize this means of sharing new and old knowledge about flexible pavement forensics, or any other pavement subject. These items will be of high interest to the rest of the community, and these items will be reviewed under this plan at least semi-annually and considered for migration to become highlighted as a Top Reference Collection material. A set of interview questions may also be provided to the individual to more completely capture the new knowledge for legacy knowledge capture and coding into i-Way.

Table 10. Acronym Taxonomy for Items Describing Observations and New Knowledge.

Information to Be Retrieved	Acronym Used in Key Word Field
Observations & New Knowledge – All Categories	onk
Observations & New Knowledge – All Flexible Pavement Categories	onkfp
Observations & New Knowledge – Flexible Pavement – Forensic Investigation Methods	onkfpf
Observations & New Knowledge – Flexible Pavement – Design	onkfpd
Observations & New Knowledge – Flexible Pavement – Maintenance	onkfpm
Observations & New Knowledge – Flexible Pavement – Construction	onkfpc
Observations & New Knowledge – Flexible Pavement – Inspection	onkfpi
Observations & New Knowledge – Flexible Pavement – Rehabilitation & Reconstruction	onkfpr
Observations & New Knowledge – Flexible Pavement – Pavement Testing & Data Analysis	onkfppt
Observations & New Knowledge – Flexible Pavement – Laboratory Testing & Data Analysis	onkfplt
Observations & New Knowledge – Flexible Pavement – Specifications	onkfps
Observations & New Knowledge – Flexible Pavement – Traffic Data & Data Analysis	onkfpt
Observations & New Knowledge – Flexible Pavement – Unique Applications & Innovations	onkfpu

Knowledge Note

Sharing Knowledge to Achieve our Mission

Name:
Date of Note:

District/Division/Office:
Position Title *(optional)*:

This note may be described as: *(check all that apply)*

- ☐ Something I learned over the years
- ☐ Description of a field observation of possible value to others
- ☐ Theory I think may be true
- ☐ Description of a somewhat unique experience or event
- ☐ Idea for possible specification, procedure or equipment change
- ☐ Simple advice being offered
- ☐ Other:

✧✧✧

Add notes here. Tips: Include location information such as highway number and county when a field observation or unique application is described. Include pictures in this section to help communicate whenever possible.

Knowledge Notes may be used or distributed in any manner desired. Its purpose is solely to promote the documentation of information that is often only observed and noted but never shared with others. It is recommended that Knowledge Notes be placed as Content Information Items in appropriate community of practice team rooms in I-Way.

Figure 4. Knowledge Note Template.

As in Table 7, a number of third-level acronym options allow retrieval of these database items by technical area.

Table 11 shows the acronym taxonomy for knowledge management content describing unique applications and innovations. For example, a document about an experimental type of asphalt concrete pavement would carry one or more of the acronyms from this table. This document could be a Knowledge Note, a published research report, or an MS Word document for the sole purpose of capturing and sharing information about a trial project. An item of this last type would carry one or more acronyms from both Table 10 and Table 11.

Table 11. Acronym Taxonomy for Items Describing Unique Applications and Innovations.

Information to Be Retrieved	Acronym Used in Key Word Field
Unique Applications & Innovations – All Categories	uai
Unique Applications & Innovations – All Flexible Pavement Categories	uaifp
Unique Applications & Innovations – Flexible Pavement – Forensic Investigation	uaifpf
Unique Applications & Innovations – Flexible Pavement – Design	uaifpd
Unique Applications & Innovations – Flexible Pavement – Maintenance	uaifpm
Unique Applications & Innovations – Flexible Pavement – Construction	uaifpc
Unique Applications & Innovations – Flexible Pavement – Inspection	uaifpi
Unique Applications & Innovations – Flexible Pavement – Rehabilitation & Reconstruction	uaifpr
Unique Applications & Innovations – Flexible Pavement – Pavement Testing & Data Analysis	uaifppt
Unique Applications & Innovations – Flexible Pavement – Laboratory Testing & Data Analysis	uaifplt
Unique Applications & Innovations – Flexible Pavement – Specifications	uaifps
Unique Applications & Innovations – Flexible Pavement – Traffic Data & Data Analysis	uaifpt

RETRIEVAL OF INFORMATION ITEMS

There are a number of options for users to access information items from i-Way. Each has certain advantages. One of the major strengths of i-Way is its searching capabilities. The user does not need to know where a document is located to find and retrieve it if the global search function is used from the home page. Therefore, the key to easily finding documents will depend heavily upon associating each document with the right key words. Great care was given to selection of key words when items were prepared by the research team for uploading into the system. Figure 5 shows the means for accessing the global search function from the home page. If a user does know the storage location for desired information, he or she can select a specific function through the "Select a Function" drop-down box in the upper right of the home page and then conduct a more refined search.

Figure 5. Home Page Icon for Accessing the i-Way Global Search Function.

It is also possible to limit a search by topic on the global search screen, as can be seen in Figure 6. However, as the topics offered by the i-Way drop-down box are necessarily broad, it is recommended that users of the flexible pavement forensic KMS leave the topic selection as "All" during searches. Additional information about search functionalities can be found in the Meridian KSI Knowledge Centre™ manuals *(2, 3)* and the i-Way user guide prepared by TxDOT *(4)*.

Figure 6. Global Search Screen with Topic Selection Option.

Searchers are advised to take advantage of the glossary and acronym taxonomy when selecting key words, particularly when first becoming familiar with the i-Way KMS.

Table 12 shows some additional key words and acronyms that the user can enter to retrieve information about knowledge management processes and philosophy. These items can be retrieved by entering the appropriate key words or acronyms either through a global search of the entire i-Way or a localized search within the Knowledge Management System – Central team room where the item is stored. The knowledge management items are grouped as knowledge management books, knowledge management software, and knowledge management web sites.

Table 12. Key Words and Acronyms to Retrieve Knowledge Management Item Types.

Room	Key Word	Abbreviated Key Term
COMMUNICATION CENTER Books	Knowledge Management Book	KMB
LIBRARY Resources	Knowledge Management Software Knowledge Management Web Site	KMS KMW

Table 13 shows the corresponding key words and acronyms to retrieve flexible pavement items stored at this site. The flexible pavement items are grouped in flexible pavement books, flexible pavement newsletters, flexible pavement video, flexible pavement demonstrations, flexible pavement technical papers, periodicals, flexible pavement software, flexible pavement web sites, pavement-related databases, and pavement manuals and specifications.

Table 13. Key Words and Acronyms to Retrieve Flexible Pavement Item Types.

Room	Key Word	Abbreviated Key Term
COMMUNICATION CENTER Books Newsletters	Flexible Pavement Book Flexible Pavement Newsletter	FPB FPN
CONFERENCE CENTER Audio Video Demonstrations Technical Papers	Flexible Pavement Video Flexible Pavement Demonstration Flexible Pavement Technical Paper	FPV FPPD FPTP
LIBRARY Periodicals Resources References Regulations & Policies	Flexible Pavement Software Flexible Pavement Web Site Pavement Database Manual	FPS FPW FDB FPM

CHAPTER 4: FUTURE KNOWLEDGE CAPTURE POTENTIAL

EXPANDING CORPORATE KNOWLEDGE CAPTURE EFFORTS

Tremendous immediate and long-term dividends appear obtainable by expanding department use of this project's findings and products. There are several ways that the department can capitalize on the developed knowledge capture and management methods, thereby gaining these benefits.

The interview knowledge capture method developed during this project offers a particularly innovative and valuable opportunity for TxDOT, as it could be used to stem corporate knowledge losses in key knowledge areas when senior, experienced personnel leave department employment. As demonstrated in this project, the interview process is also highly effective in gathering knowledge from employees who have already left TxDOT. While gathering tacit knowledge through the interview process may be a logical first step for the department in implementing this project's findings, and for some communities of practice that may be the only appropriate part of knowledge management necessary to implement, the formation of team rooms, preparation of tool boxes and top reference collections, and initiation of community discussion boards should be quite helpful to many additional communities of practices.

The information captured and made available during this research project was largely technical in nature. However, valuable corporate knowledge exists within TxDOT in both the technical and managerial realms. The methodologies developed during this research project are equally applicable to identifying and capturing technical and managerial subject matter.

There are differences in technical and managerial corporate knowledge to keep in mind as implementation is planned. One important difference is that managerial corporate knowledge may be less appropriate or even inappropriate for agency-wide accessibility. The functionality provided within i-Way, however, can easily provide desired access control through the use of private team rooms. For example, information obtained from district engineers might be established in a team room where only district engineers have access. Or this team room could also be made accessible to selected groups of individuals, such as division and office directors, primary district staff, and personnel at similar responsibility levels making them potential district engineer position applicants. Information obtained from construction engineers might similarly be made available only to district construction engineers, or access could also be provided to other district staff members, area engineers, and selected Construction Division personnel.

Based on limited TxDOT input and researcher experience, a few examples of technical knowledge areas now considered ripe for formal knowledge management are listed in Table 14.

Table 14. Additional Technical Core Knowledge Areas.

Community of Practice	Core Knowledge Area Examples
Aviation Engineers and Managers	General Aviation Airport Engineering, Construction, and Specifications General Aviation Airport Maintenance General Aviation Airport Safety
Traffic Operations	Traffic Operations Engineering and Specification Development Traffic Operations Safety
Sign Crews	Tips of the Trade – Roadside Practice
Pavement Engineers Area Engineers	Pavement Type Selection Pavement Design Rehabilitation versus Reconstruction Low-Traffic Roadway Reconstruction Techniques
Lead Construction Inspectors	Effective Use of Time at the Project Site Inspection Tricks of the Trade
District Laboratory Central Laboratory	Mixture Design – Asphalt Concrete Pavement (ACP) and Portland Cement Concrete Pavement (PCCP) Basis for Individual Texas Test Methods
Design Engineers Area Engineers	Roadway Drainage Use of Pavement Edge Drains
Special Projects Crews	Unique Problems and Innovative Solutions
Maintenance Crew Chiefs	Tips of the Trade – Roadway Maintenance Tips of the Trade – Traffic Control

Examples of managerial communities of practice and associated areas of knowledge are listed in Table 15. Pursuing knowledge management in any of these core communities of practice would allow less experienced and potential new members of these communities to learn their roles much more rapidly than currently possible. Many lessons learned over the years, some of them learned painfully through mistakes, would not have to be learned in that manner again.

Table 15. Managerial Core Knowledge Areas.

Community of Practice	Core Knowledge Area Examples
District Engineers	Building and Maintaining District Staff Teamwork Building and Maintaining High Levels of District Morale Filling Multiple District Staff Vacancies Establishing and Pursuing Objectives in District Effective Communications with Elected Officials
District Maintenance Engineers	Managing Limited Maintenance Funding Hiring Maintenance Foremen Managing Maintenance Materials Handling Weather-Related Emergencies
Maintenance Foremen	Innovative Equipment Ideas Roadway Crew Safety Handling Weather-Related Emergencies Storing Maintenance Materials – Yard and Roadside Effective Interactions with the Traveling Public
Traffic Operations	Traffic Operations Policy Development
Transportation Planning	Railroad Procurement Railroad Management
District Construction Engineers	Managing Monthly Contractor Estimates Effective Interactions with Contractors
Area Engineers	Effective Preconstruction Meetings Managing Monthly Contractor Estimates Mentoring Young Engineers Effective Communications with Locally Elected Officials Effective Interactions with Contractors
Lead Construction Inspectors	Monitoring Multiple Projects Simultaneously Effective Interactions with Contractors
District Laboratory Engineers and Managers Central Laboratory Engineers	District Laboratory Methods of Supporting Area Offices and District Staff Effective Interactions with Material Suppliers Sample Identification and Handling Methods Hiring and Training Laboratory Technicians Effective Communications with Area Engineers

ONGOING KNOWLEDGE CAPTURE

Knowledge capture was a major element of this research project. However, a significant additional challenge was to provide TxDOT with a means of ongoing knowledge capture after the project is completed. Outdated information should be removed from the knowledge repository as well.

The greatest challenge in initially creating the knowledge management system was the development of an efficient and effective process for capturing valuable tacit knowledge, that knowledge only learned through experience and that exists only in the minds of community of practice members. A structured interview process was developed and used to capture tacit knowledge.

Ongoing capture of knowledge by the TxDOT knowledge management system will rely heavily upon sustained and active use of the Teaming Center by communities of practice. Team rooms created for the rigid and flexible pavement forensics communities of practice will serve as incubators for new knowledge. It is envisioned that experts from these communities of practice will debate technical issues on the discussion boards, will share unique observations and personal theories on discussion boards and in Knowledge Notes, and will mentor less-experienced personnel within the team rooms being established. These discussions and sharing opportunities will provide a constant flow of new knowledge into the knowledge management system over time.

Not only can members of a community post documents and participate in discussions, but peer members of the community may also rate the value of documents being posted by others, and provide additional commentary as well. These ratings and comments will assist in the selection of new knowledge to be migrated into legacy knowledge, or perhaps become a new Top Reference Content material.

The process of ongoing knowledge capture is envisioned to include periodic identification of additional individuals for knowledge capture interviews.

CHAPTER 5:
FINDINGS AND RECOMMENDATIONS

FINDINGS

Phase two of this project resulted in the following findings.

- The structured interview process, as refined, was successful in capturing large quantities of valuable knowledge during an interview lasting an hour or less in most cases.
- The structured interview method provides an efficient and economical means of capturing large quantities of corporate knowledge which might otherwise be lost upon personnel leaving department employment.
- Current and former TxDOT employees are willing and, in fact, have a desire to share the knowledge gained during their transportation-related careers.
- The flexible pavement forensics community of practice is considerably larger than the rigid pavement forensics community of practice in Texas.

RECOMMENDATIONS

The following recommendations are made.

- TxDOT should take immediate advantage of the structured interview process to capture employee knowledge learned through experience in core and specialty areas of department operations. Areas of expertise that are expected to be hit hard soon by retirements should be considered first.
- TxDOT should institute a department-wide and formal knowledge management program using the full capabilities of i-Way and the methods developed during this project. This more formal and complete application of knowledge management is most appropriate in technical areas that are core to the department's mission.
- The Research Oversight Committee, as it well represents TxDOT administration, districts, and most divisions, should select the core and specialty areas of department operations where knowledge capture interviewing is most needed at this time and expedite that activity through the implementation program funding process. The Research Oversight Committee also appears to be the logical group to select the next

communities of practice for implementation of formalized knowledge management within i-Way.

- Retirees should be considered along with active TxDOT employees and other professionals for legacy knowledge capture interviews.
- The TxDOT knowledge management program should consider instituting a routine procedure for allowing staff-level and higher managers to give a legacy knowledge interview prior to retirement.
- TxDOT should include capture of managerial as well as technical knowledge from core areas of agency operations and expertise.
- TxDOT should consider developing additional legacy knowledge documents from the information-rich phase two interview transcripts.

REFERENCES

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2. *Meridian KSI Knowledge Centre™ Version 3.1.00: Baseline Documentation Part 1 — Content Administrators Guide.* Meridian Knowledge Solutions, Inc., Chantilly, Virginia, 2003.

3. *Meridian KSI Knowledge Centre™ Version 3.1.00: Baseline Documentation Part 2 — Users Guide.* Meridian Knowledge Solutions, Inc., Chantilly, Virginia, 2003.

4. *Welcome to the i-Way!* Texas Department of Transportation, Austin, Texas, 2004.

APPENDIX A:
FLEXIBLE PAVEMENT FORENSICS KNOWLEDGE SUMMARIES

Flexible Pavement Books

ID Number	Name	Description
FPB-00001	Design and Performance of Road Pavements (third edition)	This book presents the latest analytical design techniques with the results of more than 60 years of real-world pavement studies. It covers pavement design concepts and methods; specifications and procedures for construction of new road pavements; and maintenance of existing roads. Current pavement standards and specifications including American Association of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM) are explained; guidelines for increasing strength in existing roads to provide safety and longer life are also presented. Life-cycle forecasting techniques for both flexible and concrete pavements are discussed. Comparisons of U.S. and European standards are included.
FPB-00002	The Aggregate Handbook	This handbook provides a convenient reference source in a variety of areas including geophysical science, mining engineering, materials engineering, geotechnical engineering, sales, management, and business administration for the aggregate industry personnel and consulting engineers.
FPB-00003	The Science and Technology of Civil Engineering Materials	This book presents an integrative exploration of the science and technology of construction materials that begins with a section on the structure and mechanical properties of materials. It discusses the structure of materials at a microscopic level, moves through mechanical properties, and follows up with sections dealing individually with specific construction materials.
FPB-00004	Hot Mix Asphalt Materials, Mixture Design and Construction (second edition)	This book includes sections on stone matrix asphalt, Superpave performance grade (PG) asphalt binders, Superpave mix design, and asphalt modifiers. The latest information on asphalt refining; aggregates; hot mix asphalt (HMA) mix design; characterization of asphalt mixtures; equipment and construction; performance and distress; and maintenance, rehabilitation, and reconstruction of HMA are also presented.
FPB-00005	Materials for Civil and Highway Engineers (fourth edition)	This book covers the basic concepts of civil and highway engineering materials, including current environmental concerns and construction trends. An outline of laboratory test procedures for quality control and a complete list of ASTM standards are provided. It discusses the engineering performance of concrete, cements, asphalts, soil, aggregate, timber, metals, and plastics. It contains coverage of environmental concerns, emphasizing considerations regarding hazardous materials and waste disposal, contaminated soil, and remedial options. It includes a chapter on miscellaneous material which includes glass, concrete block, brick, and mortar and rounds out the coverage of materials most widely used by civil and highway engineers. The book is generally for highway engineers, test engineers, material science engineers, and materials inspectors.
FPB-00006	Design of Functional Pavements	This book deals with the philosophy of pavement construction, its functional requirements, and the factors governing operational performance. It also includes a description of mathematical models for pavement systems. A discussion on factors governing pavement operational performance is presented.

ID Number	Name	Description
FPB-00007	Pavement Management for Airports, Roads, and Parking Lots (second edition)	This book offers practical guidelines on evaluating and managing pavements for airports, roads, and parking lots. It focuses on the implementation and maintenance of successful management strategies for both network and project levels, with repair techniques. Topics covered in the chapters include: 1) step-by-step procedures for project- and network-level pavement management; 2) effective cost analysis and budget planning for pavement maintenance; 3) selection and use of nondestructive deflection, roughness measurement, and friction measurement equipment; 4) state-of-the-art pavement rehabilitation and condition prediction techniques; and 5) Pavement Condition Index (PCI) procedure for airfields and surfaced and unsurfaced roads.
FPB-00008	Modeling Flexible Pavement Response and Performance	Different analytical models, including finite element and distinct element methods, are described in this book. Strengths and weaknesses regarding validation of the analytical models are discussed. Structural and functional deterioration pavement models are described in detail. A discussion on how these deterioration pavement models may be combined with climatic variations and dynamic loading in a stochastic simulation of pavement deterioration is also addressed in the book. Topics on pavement surface characteristics, user effects, and optimization for use in pavement management are also addressed.

Flexible Pavement Newsletters

ID Number	Name	Description
FPN-00001	National Center for Asphalt Technology (NCAT) Newsletter	The NCAT newsletter, Asphalt Technology News, is published twice a year by the National Center for Asphalt Technology and has a worldwide circulation of over 6,000. Features include “Putting Research into Practice,” “Specification Corner,” and “Asphalt Forum.” The newsletter can be accessed through NCAT’s web site.
FPN-00002	Hot Mix Asphalt Technology (HMAT) Magazine	The HMAT magazine is published six times a year by the National Asphalt Pavement Association. The mission of HMAT is to educate hot mix asphalt industry members and customers through a mix of features, news, analysis, reviews, reports, and opinions. It is the voice of the hot mix asphalt industry.
FPN-00003	National Hot Mix Asphalt Newsletters	Newsletters from Superpave Centers are available including: - National Newsletter - North Central Regional Newsletter - Southeastern Regional Newsletter
FPN-00004	The Online Magazine of the Asphalt Institute	The magazine of the Asphalt Institute includes articles, news, a calendar for seminars, and links to asphalt-related organizations and events.
FPN-00005	The Asphalt Emulsion Manufacturers Association (AEMA) Newsletter	AEMA is the international organization representing the asphalt emulsion industry. AEMA’s mission is to expand the use and applications of asphalt emulsions. Asphalt emulsions are the most environmentally sound, energy-efficient, and cost-effective products used in pavement maintenance and construction.
FPN-00006	The Transport Research Laboratory (TRL) Newsletter	The UK’s Transport Research Laboratory is an internationally recognized center of excellence providing world-class research, consultancy, advice, and testing for all aspects of transport
FPN-00007	The International Slurry Surfacing Association (ISSA) Newsletter	ISSA promotes cooperation between members specializing in asphalt slurry seal and microsurfacing for roads, parking lots, and other pavements. News, articles, calendar of events, and website links are provided in the newsletters.
FPN-00008	Construction & Materials Tips – 2000-3	The newsletter is published quarterly by the Construction and Bridge Divisions of the Texas Department of Transportation. This volume corresponds to the third quarter of 2000. The main topics in this issue are: - Short, Easy-to-Read Format for TxDOT Project Summary Report - Waco District Constructs TxDOT’s First Permeable Friction Course

ID Number	Name	Description
FPN-00009	Construction & Materials Tips – 2001-1	The newsletter is published quarterly by the Construction and Bridge Divisions of the Texas Department of Transportation. This volume corresponds to the first quarter of 2001. The main topics in this issue are: - Hot Mix Certification Center - Curing Mats for Concrete Structures - Source Control – The Key to Ensuring Recycling Benefits
FPN-00010	Construction & Materials Tips – 2001-3	The newsletter is published quarterly by the Construction and Bridge Divisions of the Texas Department of Transportation. This volume corresponds to the third quarter of 2001. The main topics in this issue are: - Further Information on Nonhazardous Recyclable Materials (NRMs) and DMS-11000, Guidelines for Evaluating and Using NRMs - Does Smoothness Really Matter?
FPN-00011	Construction & Materials Tips – 2002-2	The newsletter is published quarterly by the Construction and Bridge Divisions of the Texas Department of Transportation. This volume corresponds to the second quarter of 2002. The main topics in this issue are: - Premature Failure of Asphaltic Pavement Bordering Vehicle Wire Loop - Critical Information Regarding Requests for Information

Flexible Pavement Videos

ID Number	Name	Description
FPV-00001	TAS-021 What's Hot Mix Asphalt?	This video provides a general overview of the process involved in making HMA. Audiences of all ages will enjoy this nontechnical look at the HMA industry. This video is suitable for orientation training, town meetings, classroom instruction, and a variety of other uses.
FPV-00002	Measuring Longitudinal Joints Density in HMAC Pavements	This video shows the process of measuring density in longitudinal joints in HMA concrete (HMAC) pavements. This video is part of the course "Constructing Longitudinal Joints in HMAC Pavements," developed by the Texas Transportation Institute. (Note: At the time of this report this item had not been loaded into i-Way due to its large size.)
FPV-00003	TAS-020 Handling Hot Mix Asphalt	This video program is designed for the ground crew of the paving operation, particularly those who shovel and rake HMA. It provides tips and demonstrates proper shoveling and raking techniques for handling HMA.
FPV-00004	TAS-019 Hauling Hot Mix Asphalt	This documentary-style video follows an actual truck driver working and sharing his professional views about what it takes to haul HMA. It provides invaluable tips for loading and driving safely, and being an integral part of the paving team.
FPV-00005	TAS-023 Understanding the Vibratory Roller	When it comes to providing clear instructions on how to operate and maintain a vibratory roller, this National Asphalt Pavement Association (NAPA) video fills the bill, from memorable visual illustrations of how a vibratory roller differs from a static roller and how it impacts the asphalt, to actual jobsite demonstrations of proper rolling patterns, including longitudinal and transverse joints. Concepts such as amplitude, frequency, dynamic force, and calculations needed to set up a vibratory roller for maximum efficiency are all clearly explained and illustrated.
FPV-00006	TAS-024 Lockout/Tagout, When Everyone Knows	Preventing accidents at HMA facilities is the aim of this safety training video from NAPA. In 16 minutes, this video not only explains how to comply with Occupational Safety and Health Administration (OSHA) regulations for isolating and shutting down power to equipment, but also reinforces how easily accidents can occur – especially during repair work – when proper procedures are not followed.
FPV-00007	TAS-026 Building the Notched Wedge Joint	This NAPA video explains the reasons for the superior performance of the notched wedge joint and shows the conveniences it offers to the paving crew during the construction process. Through both graphics and live action, it also offers step-by-step procedures for paving crews to follow in building the notched wedge joint. This video is a good introduction to this construction technique.
FPV-00008	TAS-028 Paving Practices for Quality	This NAPA video includes three segments designed to demonstrate the proper techniques for HMA construction and illustrate the basic principles of the subjects without being overly specific or complicated and can easily be implemented into a training program. The three 10-minute segments on each tape are titled, "Roller Operations for Quality, It's Up to You," "Paver Operations for Quality, It's Up to You," and "Paving Site Work Practices for Quality, It's Up to You."
FPV-00009	VA-26D Safe Handling of Hot Asphalt	Learn the best practices for safely loading, transporting, unloading, and storing hot asphalt. See how to safely load hot asphalt into a tanker-truck using proper safety personal protective equipment (PPE). Pick up critical tips for safely transporting hot asphalt and learn about safe storage of hot asphalt.

Flexible Pavement Demonstrations

ID Number	Name	Source	Description
FPD-00001	Welcome to the 2004/2005 Hot Mix Specifications Conference	Texas Department of Transportation	This presentation is an introduction to the 2004 Texas Hot Mix Specifications Conference including content of the CD, contractor and inspector roles and responsibilities, and new procedures in the specifications to improve the quality of HMA.
FPD-00002	Item 320 Equipment for Asphalt Concrete Pavement	Texas Department of Transportation	This presentation describes the requirements in Item 320 of TxDOT specifications for asphalt hot mix production equipment including drum mix plants, weigh-batch and modified weigh-batch plants, hauling equipment, placement/compaction, and laboratory tests and coring.
FPD-00003	Item 340 Dense-Graded Hot-Mix Asphalt (Method)	Texas Department of Transportation	This presentation explains the method described in Item 324 of TxDOT specifications for dense-graded HMA. It includes construction, mixture design, compaction, and ride quality control.
FPD-00004	Item 341 Dense-Graded Hot-Mix Asphalt (QC/QA)	Texas Department of Transportation	This presentation explains the quality control/quality assurance (QC/QA) in Item 341. It describes the typical used of dense-graded HMA, advantages, and disadvantages. Test methods, test responsibility, and minimum certification levels for aggregate testing mix design and verification, production testing, and placement testing are included.
FPD-00005	TxDOT's Ground Penetrating Radar Unit	Texas Department of Transportation	This presentation describes TxDOT's ground penetrating radar (GPR) unit components and applications. Examples of GPR data from a thick hot mix section with no defects and with subsurface damage are shown.
FPD-00006	Item 342 Permeable Friction Course (PFC)	Texas Department of Transportation	This presentation explains the typical use, advantages, and disadvantages of Item 342 of TxDOT specifications. Aggregate properties, aggregate quality requirements, construction procedures, test methods, mix design, and production operations are described.
FPD-00007	Item 344 QC/QA Specification for Performance Design Mixtures	Texas Department of Transportation	This presentation explains the typical use, advantages, and disadvantages of Item 344 of TxDOT specifications. Item 344 is a QC/QA specification for performance design mixtures which includes the traditional Superpave mixtures as well as the coarse matrix high binder (CMHB) mixtures.
FPD-00008	Item 346 QC/QA Specification for Stone-Matrix Asphalt (SMA) and Rubber Stone Matrix (SMAR)	Texas Department of Transportation	This presentation explains the typical use, advantages, and disadvantages of Item 346 of TxDOT specifications. Item 344 is a QC/QA specification for SMA and SMAR.
FPD-00009	Item 520 Weighing and Measuring Equipment	Texas Department of Transportation	This presentation describes procedures for weighting and measuring equipment for materials measured or proportioned by weight or volume according to Item 520 of TxDOT specifications.

ID Number	Name	Source	Description
FPD-00010	Item 585 Ride Quality for Pavement Surfaces	Texas Department of Transportation	This presentation describes ride quality specifications and presents guidelines for selecting appropriate ride quality requirements according to Item 585 of TxDOT specifications.
FPD-00011	Manual of Practice for Conducting Superpave Asphalt Binder Test	Northeast Center of Excellence for Pavement Technology (NECEPT)	An article describing the Manual of Practice for Conducting Superpave Asphalt Binder Test was developed as part of NECEPT to clarify existing AASHTO test methods and to provide supplemental information in the test methods. The manual presents a basic overview of asphalt binder properties as they relate to sampling and testing and an introduction to the Superpave specification.
FPD-00012	Network Performance Profiles	ARRB Group	This presentation gives an overview of Austroads Project AT1067: “Establish Network Performance Profiles, Identify Pavements and Establish Contributory Causes.” The overall project objective is to establish whether there was a national trend for increased performance of pavements over the last 10 years, and the likely reasons for this performance.
FPD-00013	Session 6: Advanced Laboratory Testing for Pavement Modeling Purposes	South African Pavement Technology at Transportation Research Board (TRB) 1999	This presentation gives an overview of laboratory testing for pavement modeling. Fundamental properties such as resilient response and deterioration models are explained. An overview of selected tests is also presented including the rolling wheel test, the confined impact test, the flexural strength test, the flexural fatigue test, the K-mould test, and the triaxial test. Applications for these tests are discussed.
FPD-00014	Asphalt Pavement Evaluations Houston District	Texas Department of Transportation	This presentation gives an overview of asphalt pavement evaluations in the TxDOT Houston District. It includes tests to evaluate performance of existing asphalt pavements and experimental mix designs to improve performance tests related to premature cracking and rutting. Information for pavement sections located in IH 10, US 290, US 90, and FM 529 is presented.
FPD-00015	2005 MnROAD Update	Texas Department of Transportation	This presentation gives an overview of 2005 MnROAD activities and the new testing area. Studies at MnROAD are related to smoothness, whitetopping, development of pavement-related test technology (falling weight deflectometer [FWD], dynamic cone penetrometer [DCP], GPR, and rolling wheel deflectometer [RWD]), truck safety, oil gravel, and deterioration of MnRoad sections due to thermal cracking.
FPD-00016	Dynamic Cone Penetrometer (DCP): The Development of DCP Pavement Technology in South Africa	South African Pavement Technology at TRB 1999	This presentation gives an overview of the development of DCP technology including equipment, concepts involved in data interpretation, data processing, and software. Relationships between the California bearing ratio (CBR) and DCP penetration are presented, and design master curves on layer strength diagram are shown.

ID Number	Name	Source	Description
FPD-00017	Emulsion Treated Bases: A South African Perspective	South African Pavement Technology at TRB 1999	This presentation describes emulsion-treated bases (ETB). It explains the benefits of ETB, brings a historical overview, and discusses economic considerations along with structural design, mix design, and construction.
FPD-00018	Foamed Asphalt Mix Design Procedure	RSA/US Pavement Technology Workshop 2000	This presentation describes the mix design procedure for foamed asphalt. Background and definition are presented, and benefits are discussed.
FPD-00019	RSA Design Guidelines for Hot-Mix Asphalt	RSA/US Pavement Technology Workshop 2000	This presentation describes HMA mix design challenges. It gives an overview of the design process, volumetric design issues, and new performance tests.
FPD-00020	South African Pavement Evaluation Tools and Techniques	South African Pavement Technology at TRB 1999	This presentation gives an overview of pavement evaluation tools and techniques including the DCP, the semi-automatic dynamic cone penetrometer (SA-DCP), rapid compaction control device (RCCD), laser profilometer, road surface deflectometer (RSD), multi-depth deflectometer, crack activity meter (CAM), high-speed profilometer (HSP), spray meter, dust monitor, and gravel road test kit.
FPD-00021	RSA/US Pavement Technology Workshop Opening Session	RSA/US Pavement Technology Workshop 2000	This presentation presents an introduction to the RSA/US Pavement Technology Workshop conducted in 2000. Topics include a summary of current pavement design and evaluation procedures in California, Minnesota, Texas, and Washington; mechanistic-empirical flexible pavement design, pavement nondestructive tests, and procedures; and typical four-state specification requirements.
FPD-00022	Latest Developments on Tyre Road Surface Interface Stress Measurements Using the 3-D Cell	South African Pavement Technology at TRB 1999	This presentation describes a methodology to measure stress due to tire road surface pressure using the 3-D cell.
FPD-00023	Life-Cycle Cost Analysis	Asphalt Pavement Alliance	This presentation explains the life-cycle cost analysis. Factors to be considered in life-cycle cost analysis, including initial construction and rehabilitation costs, reactive maintenance, salvage value, and user costs, are discussed.
FPD-00024	Ground Coupled GPR Equipment	Texas Department of Transportation	This presentation shows photos of ground-coupled GPR equipment and other testing devices including FWD and DCP.
FPD-00025	New Technologies for QC/QA Inspection Testing	Texas Department of Transportation	This presentation shows new technologies for QC/QA inspection testing including segregation detection, thermal imaging, and non-nuclear density gauges.
FPD-00026	What about the Pavetracker?	Texas Department of Transportation	This presentation shows photos of Pavetracker, which is a non-nuclear device to control densities in the field.

ID Number	Name	Source	Description
FPD-00027	Benefits of Seismic Methods	Texas Department of Transportation	This presentation explains the benefits of using seismic methods as an alternative to measure fundamental engineering materials properties. Photos of the equipment are provided.
FPD-00028	Pavement Instrumentation and Applications	RSA/US Pavement Technology Workshop 2000	This presentation describes the benefits of using the heavy vehicle simulator (HVS) to study pavement surface distresses. Results from pavement analysis using ELSYM5 M software are also presented.
FPD-00029	Overview of the South African Mechanistic Design Method (SAMDM)	South African Pavement Technology at TRB 1999	This presentation gives an overview of the South African mechanistic pavement design method). Components and models used in the design methods are presented.
FPD-00030	Subgrade and Base Materials	Second Annual Mn/Road Workshop 2002	This presentation gives an overview of mechanistic-based testing, compaction testing issues, and in situ testing devices for subgrade and base materials. Soil property tables are presented.
FPD-00031	Surfacing Seals	South African Pavement Technology at TRB 1999	This presentation describes the purpose of a seal, introduces reference documentation, and explains seal types and performance. Examples from South Africa are included.
FPD-00032	Asphalt Pavement Widening Consideration	Texas Asphalt Pavement Association	This presentation describes a case study on FM 1997 in Waller County for shoulder widening and asphalt concrete pavement overlay consideration. FWD and GPR testing was conducted. Cores were taken during the evaluation.
FPD-00033	Overview of South African Pavement Design Philosophy and Approach	South African Pavement Technology at TRB 1999	This presentation gives an overview of the South African pavement design philosophy and approach. It explains the managerial process and technical process. Topics are related to design strategy, pavement behavior, material and pavement optimization, accelerated pavement testing, and pavement design methods.
FPD-00034	PMIS Automated Data Collection	Texas Department of Transportation	This presentation gives an overview of automated data collection methods for the Texas Pavement Management Information System (PMIS). Photos of the TxDOT modular vehicle (TMV) are included. The vehicle is equipped with a rut-scanning laser, digital images and automated rating devices, profile lasers, and texture laser.
FPD-00035	Pavement Evaluation Using the Falling Weight Deflectometer	Texas Department of Transportation	This presentation describes pavement evaluation using the FWD. Photos and illustrations are provided.
FPD-00036	Quality Management for South African Road Construction	South African Pavement Technology at TRB 1999	This presentation introduces the general principles for attaining quality in road construction in South Africa. Concepts for QC/QA are explained. Typical pavement construction tolerances and standard methods of testing road construction materials are explained.

ID Number	Name	Source	Description
FPD-00037	RCCD: Rapid Compaction Control Device	South African Pavement Technology at TRB 1999	This presentation describes the use of the rapid compaction control device. Photos, diagrams, and comparison with other devices such as DCP are presented. Equations to estimate CBR values based on RCCD are presented.
FPD-00038	Resilient Modulus Testing and Startup Procedures	U.S. Department of Transportation Federal Highway Administration	This presentation gives an overview of resilient modulus testing and startup procedures. The usefulness of the test is emphasized. The testing protocol and equipment are explained.
FPD-00039	Mechanical System Verification	U.S. Department of Transportation Federal Highway Administration	This presentation provides guidelines for mechanical system verification prior to conducting resilient modulus testing. The laboratory proficiency testing process is explained.
FPD-00040	WSDOT's Implementation Plan for the 2002 Guide	Washington State Department of Transportation	This presentation gives an overview of National Cooperative Highway Research Program (NCHRP) 1-40 implementation plan for the Washington State Department of Transportation (WSDOT). It discusses what is needed for WSDOT to implement the mechanistic pavement design guide.
FPD-00041	Constructing Longitudinal Joints in HMAC Pavements	Texas Transportation Institute	This presentation describes the process of constructing longitudinal joints in HMAC pavements. Topics include explaining the basics of asphalt pavement compaction, summarizing the problems with longitudinal joints, presenting the challenges in constructing longitudinal joints, summarizing sound practices of longitudinal joint construction, discussing new technologies, and presenting specifications and tests.
FPD-00042	Hot Mix Compaction Problems	Texas Transportation Institute	This presentation discusses the problems related to HMA compaction. Longitudinal joints, surface segregation, and vertical segregation problems are described. Focus is on new tools to identify the problems early including non-nuclear density gauges infrared (IR) systems and GPR, as well as action regarding materials-handling devices, field compaction techniques, equipment, and mix design.

Flexible Pavement Technical Papers

ID Number	Name	Source	Description
FPTP-00001	LTPP Data Analysis: Influence of Design and Construction Features on the Response and Performance of New Flexible and Rigid Pavements	Performing Organization: Michigan State University Sponsoring Agency: National Cooperative Highway Research Program, Transportation Research Board of the National Academies	This report for the project "LTPP Data Analysis: Influence of Design and Construction Features on the Response and Performance of New Flexible and Rigid Pavements" (NCHRP 20-50 [10/16]) contains the background information, experiment status, data availability, results from analysis, and the conclusions for Specific Pavement Study-1 (SPS-1), Specific Pavement Study-2 (SPS-2), and Specific Pavement Study-8 (SPS-8) experiments of the Long-Term Pavement Performance (LTPP) program. This research was conducted to evaluate the relative influence of structural and site factors on the performance of new flexible and rigid pavements, based on LTPP NIMS data (Release 17 of DataPave) for SPS-1 and SPS-2 experiments.
FPTP-00002	Evaluation of DRM System for Reflective Crack Prevention	Performing Organization: Mississippi Department of Transportation, Research Division Sponsoring Agency: Federal Highway Administration and Mississippi Department of Transportation	Reflective cracking in asphalt pavements presents a serious problem for highway agencies worldwide. A new interlayer membrane system, DRM, which is a proprietary system consisting of a sealant and an emulsion, was constructed by the Mississippi Department of Transportation (MDOT) for evaluation as a reflective crack relief.
FPTP-00003	General Measurement Strategy to Analyze the Effects of Construction Specification Changes on Quality of HMA Surface Courses	Performing Organization: Texas Transportation Institute Sponsoring Agency: Texas Department of Transportation	The primary objective of this study was to develop a "measurement strategy" for evaluating the relative degree of success of new HMA pavement construction specifications. The specific reason for developing a measurement strategy was for comparing relative performance as a function of time of HMA pavements constructed under Item 340 (sometimes called methods and materials, recipe, or prescription specifications) with pavements constructed using the newer QC/QA specifications.
FPTP-00004	Paired Measurement Strategy to Analyze the Effects of Construction Specification Changes on Quality of HMA Surface Courses	Performing Organization: Texas Transportation Institute Sponsoring Agency: Texas Department of Transportation	The primary objective of this study was to develop a "measurement strategy" for evaluating the relative degree of success of new HMA pavement construction specifications. Researchers developed a paired analysis method, and 30 pairs of pavements were identified to test the method. A paired set of pavements is defined as an Item 340 pavement and a QC/QA pavement that have similar locations, substrates, thicknesses, mixture type, and traffic but probably were constructed at different times by different contractors.

ID Number	Name	Source	Description
FPTP-00005	Integration of Network- and Project-Level Performance Models for TxDOT PMIS	Performing Organization: Texas Transportation Institute Sponsoring Agency: Texas Department of Transportation	The main objective of Project 0-1727 was to "evaluate and recommend improvements to pavement performance prediction models" for PMIS. The secondary objective was to strive toward more integration between network and project management levels such that the models used at each level do not contradict each other and result in loss of confidence. The project evaluated models for Portland cement concrete (PCC) and asphalt concrete pavements and developed recommendations.
FPTP-00006	Laboratory and Field Procedures for Measuring the Sulfate Content of Texas Soils	Performing Organization: Texas Transportation Institute Sponsoring Agency: Texas Department of Transportation	Project 0-4240 was initiated to provide guidelines on how to effectively stabilize sulfate-rich soils. The first tasks in this project involved evaluating the various methods of measuring the sulfate content of soils both in the laboratory and in the field. In the laboratory, tow test procedures were investigated, namely TxDOT Test Method Tex-620-J gravimetric approach and the ion chromatography approach. In terms of both accuracy and repeatability, the researchers concluded that the ion chromatography approach is superior to TxDOT Test Method Tex-620-J.
FPTP-00007	Using Infrared Imaging and Ground-Penetrating Radar to Detect Segregation in Hot-Mix Overlays	Performing Organization: Texas Transportation Institute Sponsoring Agency: Texas Department of Transportation	Segregation of any type is a serious problem in HMA and typically leads to poor performance, poor durability, shorter life, and higher maintenance costs. This project focused on using both IR imaging and GPR to evaluate the uniformity of newly placed hot mix overlays. In this project IR and GPR measurements were made in test sections on four newly placed asphalt overlays. Cores were taken where anomalies were detected in the mat. These cores were returned to the laboratory to identify changes in both the volumetric and engineering properties.
FPTP-00008	In-Place Cement Stabilized Base Reconstruction Techniques Interim Report, Construction and Two Year Evaluation	Performing Organization: Louisiana Transportation Research Center	This interim report documents the construction process and two-year evaluation of 10 field test sections constructed with various crack mitigation techniques. The shrinkage crack mitigation methods being evaluated include cement content, synthetic fiber reinforcement, interlayer, curing membrane, and curing periods.

ID Number	Name	Source	Description
FPTP-00009	Predicting Hot-Mix Performance from Measured Properties: Phase I Report	Performing Organization: Texas Transportation Institute Sponsoring Agency: Texas Department of Transportation	The problem of providing pavements that perform as designed is a major concern among state transportation agencies. In the face of budget restrictions, it is imperative that the expected performance be achieved when a highway is put into service. Of importance to addressing this problem is the recognition that performance should drive not only the design process but also the construction process. This approach would necessitate the development of materials and construction specifications that are tied to pavement performance and the development of test equipment and procedures to evaluate the quality of the contractor's work on predicted performance. Project 0-1708, "Predicting Hot-Mix Performance from Measured Properties," aims to develop rational, reliable, and practical test procedures for evaluating the quality of the finished pavement based on predicted performance.
FPTP-00010	Use of Microcracking to Reduce Shrinkage Cracking in Cement Treated Bases	Transportation Research Board 2005 Annual Meeting	Shrinkage cracking occurs in cement-treated bases due to desiccation and cement hydration; eventually these cracks start to reflect through the pavement surfacing. While initially considered cosmetic in nature, these cracks open the pavement to water infiltration and increase the likelihood of accelerated pavement distress. Although numerous options exist for minimizing the amount of reflective cracks that appear, this paper focuses on the performance of controlled test sections utilizing a promising approach termed "microcracking."
FPTP-00011	Handbook of Geosynthetics	Geosynthetic Materials Association	This handbook introduces geosynthetics from the perspective of practical application. It is intended to serve as a general reference in the field for those who are building structures that include geosynthetics.
FPTP-00012	Cracking in Soil Cement – Cause, Effect, Control	American Concrete Institute (ACI)	Shrinkage of soil cement and the resulting cracking are natural characteristics related primarily to drying and its attendant volume changes. Various procedures to minimize shrinkage cracking and the resulting reflective cracking in asphalt surfaces are discussed in this paper.

ID Number	Name	Source	Description
FPTP-00013	2003 Comparison Testing of LTPP Profilers	Federal Highway Administration (FHWA)	In the LTPP program, profile data at General Pavement Studies (GPS) and Specific Pavement Studies (SPS) sections are collected by four regional contractors. Each regional support contractor (RSC) uses an International Cybernetics Corporation (ICC) MDR 4083 inertial profiler to collect profile data. These profilers are equipped with three laser sensors that collect data along the left and right wheelpaths, and along the center of the lane. Profile data are collected at 25 mm intervals along each of these paths. After completion of data collection, the ProQual software is used to compute profile data at 150 mm intervals along the left and right wheelpaths. A comparison tests between four ICC profilers used by the LTPP regional support contractors was performed and is described in the report.
FPTP-00014	Research Notes – Reflective Cracking: Year 3 Report	Oregon Department of Transportation	The effectiveness of five different geosynthetics in reducing reflective cracking is reported in this technical note. A test section was built and monitored during a three-year period to study the effectiveness in terms of percentage of reflective cracking.
FPTP-00015	Guidance on the Development, Assessment and Maintenance of Long-Life Flexible Pavements	Transport Research Laboratory, United Kingdom	This research introduces the concept of robust pavements. Robust pavements are expected to deteriorate in a similar fashion to long-life pavements. Provided that these pavements demonstrate similar characteristics to long-life pavements, these pavements can be thinner than long-life pavements. Guidelines to identify existing robust pavements and criteria are provided in the report. Visual distress, rutting, and structural condition are considered in these criteria.
FPTP-00016	Expected Service Life and Performance Characteristics of HMA Pavements in LTPP	Asphalt Pavement Alliance	In this study six distress types were used to determine the average time to various surface conditions or magnitudes of distress. These distress types are: area fatigue cracking, longitudinal cracking in the wheelpath area, longitudinal cracking outside the wheelpath, transverse cracking, rut depth, and smoothness as measured by the International Roughness Index (IRI). Key factors from the LTPP database were identified for the analysis such as traffic, climate, roughness, distress types, deflection, drainage, subgrade characteristics, HMA layer properties, and base layer properties.

ID Number	Name	Source	Description
FPTP-00017	Strategy for Modeling a Pavement Performance Analysis System at WisDOT	Transportation Research Board 2004 Annual Meeting	The objective of this study was to design a database model required for developing an effective database template that will allow analysis of pavement performance measures based on design and construction information linked by location. Information regarding year of construction, traffic, aggregate source, aggregate and materials properties for each pavement layer, distress data, performance, and maintenance records was considered relevant in the model.
FPTP-00018	Design-Build Pavement Warranties	Washington Department of Transportation	This document gives Washington Department of Transportation threshold criteria for pavement warranties. The criteria include ride quality, friction, and pavement surface condition based on HMA distresses such as alligator cracking, longitudinal cracking, and transverse cracking.
FPTP-00019	Asphaltic Pavement Warranties	Wisconsin Asphalt Pavement Association	In 1995, the Wisconsin Department of Transportation (WisDOT) and the Wisconsin Asphalt Pavement Association developed and began constructing asphaltic pavements with warranty specifications. Distress thresholds were established for alligator cracking, block cracking, edge raveling, flushing, longitudinal cracking, longitudinal distortion, rutting, surface raveling, transverse cracking, transverse distortion patching, and potholes. IRI is also considered in the criteria.
FPTP-00020	Performance-Based Specification as a Step to Performance-Based Management and Maintenance of Pavement in Japan	Public Works Research Institute, Japan	This paper proposes that successful road projects should be defined using performance indicators which should be selected in accordance with the goals and objectives of the project. Skid resistance, durability, evenness, and tire/road noise level are examples of performance indicators.
FPTP-00021	Performance Trends of Rehabilitated Asphalt Concrete (AC) Pavements	Federal Highway Administration	This study documents performance trends of GPS-6 test sections using distress data collected through 1997. Six distress types or performance indicators were used to evaluate performance trends. They include fatigue cracking, longitudinal cracking not in the wheelpaths, transverse cracking, rutting, and roughness (IRI).
FPTP-00022	Common Characteristics of Good and Poorly Performing AC Pavements	Federal Highway Administration	Data from the LTPP test sections were used to identify the site conditions and design/construction features of flexible pavements that lead to good performance and those that lead to poor performance. Four distress types were investigated: performance in roughness (IRI), rutting, transverse cracking, and fatigue cracking.

ID Number	Name	Source	Description
FPTP-00023	Engineering Application of Washington State's Pavement Management System	Transportation Research Record (TRB)	The Washington State Department of Transportation identified pavement sections that were outperforming or underperforming although constructed of similar materials and subjected to similar traffic and environmental considerations. WSDOT's Pavement Management System was used to select candidate sections for further analysis. The five performance measures considered in the selection criteria included: age of the surface course, a distress-based pavement structural condition score, annual design-lane equivalent single axle loads, roughness (IRI), and rutting.
FPTP-00024	Evaluation of the AASHTO 18-kip Load Equivalency Concept	Performing Organization: Center for Transportation Research, The University of Texas at Austin Sponsoring Agency: Texas Department of Transportation	This is an interim report for Project 0-1713, which is evaluating the 18-kip equivalency concept. This report presents the information synthesis, which includes a literature review and an evaluation of the AASHTO 18-kip equivalency concept. The results presented in this report set the stage for further evaluation of the 18-kip equivalency concept; in addition, the results can facilitate the development of mathematical models for calculating load equivalency factors, if necessary.
FPTP-00025	A Rational Pavement Type Selection Procedure	Performing Organization: Center for Transportation Research, The University of Texas at Austin Sponsoring Agency: Texas Department of Transportation	This report describes a project-level pavement type selection procedure developed for use in state departments of transportation (DOTs). This report details the overall decision framework required for making dependable pavement type selection decisions. Three important factors – agency costs, user delay costs, and performance levels associated with candidate strategies – are thoroughly evaluated and quantified for economic comparisons. The economic evaluations are primarily based on the life-cycle cost analysis and cost-effectiveness analysis. The report also describes the requirements and approach to generate candidate pavement strategies. The impact of miscellaneous factors on pavement type selection is also discussed. Some guidelines are suggested for the final strategy selection. An example case study is conducted to demonstrate the use of the computer program, Texas Pavement Type Selection (TxPTS).

ID Number	Name	Source	Description
FPTP-00026	Pavement Life-Cycle Cost Studies Using Actual Cost Data (Synthesis)	Asphalt Pavement Alliance	This synthesis presents the results of studies of interstate highways in three states which show the comparison of costs between HMA pavements and PCC pavements. The three studies were diverse in their approach to the question of which pavement type is more economical. The results of the studies show that HMA pavement was overall more economical in both initial construction cost and life-cycle costs than comparable PCC pavement.
FPTP-00027	LTPP Data Analysis: Factors Affecting Pavement Smoothness	National Cooperative Highway Research Program	Smoothness has been recognized as one of the measures of pavement performance. The research was conducted under NCHRP Project 20-50(08/13), "LTPP Data Analysis: Factors Affecting Pavement Smoothness," by soil and materials engineers. The research provided preliminary conclusions regarding the factors affecting pavement smoothness of different types of new and rehabilitated pavement structures.
FPTP-00028	LTPP Data Analysis: Effectiveness of Maintenance and Rehabilitation Options	National Cooperative Highway Research Program, Transportation Research Board, National Research Council	NCHRP Project 20-50(03/04) was conducted to assess the relative performance of different pavement maintenance and rehabilitation treatments, including the influence of pretreatment condition and other factors on treatment effectiveness. The data used in this study were drawn from the LTPP SPS-3 (flexible pavement maintenance), SPS-5 and GPS-6B (flexible pavement rehabilitation), and SPS-6 and GPS-7B (rigid pavement rehabilitation) experiments.
FPTP-00029	Recommended Mechanistic-Empirical Pavement Section Design Guide and Software	National Cooperative Highway Research Program	This document describes key products from NCHRP Project 1-37A, "Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II," for evaluation. Project 1-37A includes 1) a guide for mechanistic-empirical design and analysis, 2) companion software with documentation and a user manual, 3) an extensive series of supporting technical documents, and 4) implementation and training materials.

ID Number	Name	Source	Description
FPTP-00030	Pavement Type Selection Processes	Asphalt Pavement Alliance	Pavement type selection processes are used by pavement authorities such as state highway agencies to identify the most beneficial type of pavement structure for a given set of traffic, soils, climate, and other factors. This document was prepared in order to discuss the primary considerations in pavement type selection as presented in the AASHTO guide in detail, and to present the advantages available from HMA pavements in each of these. Additional considerations include the issue of tire-pavement noise generation, ride quality, and safety, and the advantages asphalt offers in these characteristics.
FPTP-00031	Chemical Binders Used in Australia	Australian Stabilization Industry Association (AustStab)	Australia, like many other countries around the world, is gaining access to a wave of new chemical binders on the market. So how do these binders work? And is there a way of characterizing them in the laboratory with a rational design approach to establish binder content and stabilization depth? This paper covers the different types of chemical binders in Australia, the difference between stabilization binders and dust suppressants, common laboratory testing, their performance, and future research for these binders.
FPTP-00032	Traffic Data Collection, Analysis, and Forecasting for Mechanistic Pavement Design	National Cooperative Highway Research Program	This report includes guidelines for collecting traffic data to be used in pavement design, and software for analyzing traffic data and producing traffic data inputs required for mechanistic pavement analysis and design. The report also describes the actions required at both the state and national levels to promote successful implementation of the software. The report is a useful resource for state personnel and others involved in planning and designing highway pavements.

ID Number	Name	Source	Description
FPTP-00033	A Methodology for Bump Detection Using Inertial Profile Measurements	The University of Texas at Arlington, Transportation Instrumentation Laboratory	TxDOT started implementing its new ride quality specification in 2002. This specification requires the use of inertial profilers in lieu of profilographs for quality assurance testing of surface smoothness on new construction and rehabilitation projects. The profilograph-based ride specification that it replaced includes criteria on both section-wide and localized roughness. The new ride specification identifies defects based on an allowable difference between the average measured profile and its moving average, and assesses section-wide roughness using IRI. TxDOT initiated Project 0-4479 to investigate the application of the new equation for detecting defects in a smoothness specification. Its objectives are to determine methods for defining localized roughness characteristics that are objectionable to ride, and establish how these characteristics can be measured in an effective way for construction quality control and assurance using inertial reference profile data.
FPTP-00034	Development and Validation of Performance Prediction Models and Specifications for Asphalt Binders and Paving Mixes	Strategic Highway Research Program (SHRP)	This report documents the findings of SHRP A-005 to develop detailed performance-based specifications for asphalt binders and mixtures to control three distress modes: rutting, fatigue cracking, and thermal cracking.
FPTP-00035	Stiffness of Asphalt-Aggregate Mixes	Strategic Highway Research Program	The primary objective of this research contract was to develop a series of accelerated performance tests for asphalt-aggregate mixes and methods for analyzing asphalt-aggregate interactions that significantly affect pavement performance. All of the stiffness test systems were found to be sensitive to mix and test variables, especially to asphalt source, asphalt content, aggregate type, and air-void content. Temperature had the greatest effect on stiffness for axial, diametral, and flexural stiffnesses.
FPTP-00036	Development of a Procedure to Rate the Application of Pavement Maintenance Treatments	Strategic Highway Research Program	Some of the factors that affect the life of preventive maintenance treatments are the quality of the materials used, the environmental conditions during which the treatments are placed, the type of equipment used, and the quality of the treatment application. Quantifying these factors is difficult. This report describes an approach which has the potential of quantifying this set of diverse factors into a single rating, in the possibility that this can be related to the performance of the treatments.

ID Number	Name	Source	Description
FPTP-00037	Innovative Materials Development and Testing Volume 1: Project Overview	Strategic Highway Research Program	SHRP Project H-106 initiated an investigation of the cost-effectiveness of materials, equipment, and procedures used to perform several routine pavement maintenance activities: pothole repair in asphalt pavement, crack treatment (sealing and filling) in asphalt pavements, joint resealing in PCC pavements, and partial-depth repair in PCC pavements.
FPTP-00038	Innovative Materials Development and Testing Volume 2: Pothole Repair	Strategic Highway Research Program	This report describes pothole repair techniques in asphalt concrete pavements. Potholes are one of the most commonly performed maintenance operations for most agencies, especially in areas where cold winters and warm, wet springs contribute to accelerated pavement breakup every year. The SHRP H-106 project was the first major effort undertaken to test cold-mix asphalt patching materials, those most commonly used for winter and springtime pothole repairs. The primary goal of this project was to identify those materials and techniques that are potentially the most cost-effective.
FPTP-00039	Innovative Materials Development and Testing Volume 3: Treatment of Cracks in Asphalt Concrete-Surfaced Pavements	Strategic Highway Research Program	This document presents results from the SHRP H-106 experiment. The primary objective of the H-106 experiment was to determine the most effective and economical materials and methods for conducting crack-sealing and crack-filling operations. Secondary objectives included the identification of both performance-related material tests and quicker, safer installation practices.
FPTP-00040	Innovative Materials Development and Testing Volume 4: Joint Seal Repair	Strategic Highway Research Program	Under SHRP contract H-106, a full-scale investigation of the performance of materials and methods for resealing joints in concrete pavement has been initiated. Over 1,600 joints were installed employing four different installation methods and twelve sealant materials, including rubberized asphalt, silicone, and polysulfide, at five sites across the United States. Laboratory analysis of the sealant material properties and evaluation of field performance have been conducted and the results analyzed.

ID Number	Name	Source	Description
FPTP-00041	Pavement Maintenance Effectiveness	Strategic Highway Research Program	This report documents SHRP Project H-101, "Pavement Maintenance Effectiveness." The purpose of Project H-101 was to develop a database that permits increased understanding of selected maintenance treatments in extending pavement service life or reducing the development of pavement distress. This includes an evaluation of the cost-effectiveness of the pavement maintenance treatments. An experimental design was developed to help determine the impact of important variables on the performance of pavement maintenance treatments. Major factors considered include environment, traffic, subgrade type, structural capacity, and condition prior to treatment for the test sections applied to flexible pavements.
FPTP-00042	Making Pavement Maintenance More Effective	Strategic Highway Research Program	This document is intended to be a training supplement for material contained in *"Pavement Maintenance Effectiveness"* (SHRP H-358) and *"Development of a Procedure to Rate the Application of Pavement Maintenance Treatments"* (SHRP H-322). The major topic discussed in this report is the "lessons learned" about the maintenance treatments. The second section of this report presents important considerations for continuing the development of a strong pavement maintenance database that was begun in SHRP H-101.
FPTP-00043	Sensitivity Analyses for Selected Pavement Distresses	Strategic Highway Research Program	This document presents the results of a research effort on the effects of loading, environment, materials property and variability, construction quality, and maintenance level on pavement distress and performance. A sensitivity analysis on the National Information Management System was conducted. In order to conduct the sensitivity analysis, it was first necessary to develop statistically linear regression equations to predict the occurrence of distresses. Once a predictive equation was available, the effects of variations in significant independent variables were quantified by calculating the change in the predicted distress as each significant variable was varied from one standard deviation above its mean to one standard deviation below its mean, with all other variables held at their mean values.

ID Number	Name	Source	Description
FPTP-00044	Mechanistic Evaluation and Calibration of the AASHTO Design Equations and Mechanistic Analysis of the SHRP Asphalt Surfaced Pavement Sections	Strategic Highway Research Program	Mechanistic evaluation of the AASHTO flexible design equations was conducted by using 243 artificial pavement sections with various layer properties, roadbed soil modulus, and traffic volumes. Throughout the analyses it is assumed that the mechanistic responses (stresses, strains, and deflections) of the pavement sections due to an applied 9000 pounds of load are indicative of the level of damage delivered to these sections. Results of the analyses indicated that while the AASHTO design method produces pavement sections with an almost equal level of protection, the damage delivered to the various layers varies from one section to another.
FPTP-00045	Round 1 Hot Mix Asphalt Laboratory Molded Proficiency Sample Program	Strategic Highway Research Program	Round 1 testing provided within- and among-laboratory diametral resilient modulus data for tests performed in accordance with SHRP Test Protocol P07. The objectives included drafting single operator and multi-laboratory test precision statements in testing proficiency status for SHRP laboratories, and preserving test sample information for future analysis. Worksheets, supporting data, analyses, final comments, and conclusions are presented. A complete set of proficiency sample statements in AASHTO and ASTM format are provided.
FPTP-00046	Type II Unbound Cohesive Subgrade Soil Synthetic Reference Sample Program	Strategic Highway Research Program	SHRP Protocol 46, "Resilient Modulus of Unbound Granular Base/Subbase Materials and Subgrade Soils," was the specified procedure for laboratories performing resilient modulus tests on research samples of unbound cohesive subgrade soil obtained from LTPP field sites. All laboratories conducting tests for the LTPP program were required to be accredited by the AASHTO Accreditation Program (AAP). A set of three reference specimens was rotated to all participating laboratories for testing in accordance with certain specified parameters. The final comments, analyses, conclusions, and recommendations resulting from the Type II Unbound Cohesive Subgrade Soil Synthetic Reference Sample Program are contained in this report.

ID Number	Name	Source	Description
FPTP-00047	Type I Unbound Granular Base Synthetic Reference Sample Program	Strategic Highway Research Program	SHRP Protocol 46, "Resilient Modulus of Unbound Granular Base/Subbase Materials and Subgrade Soils," was the specified procedure for laboratories performing resilient modulus tests on research samples of unbound cohesive subgrade soil obtained from LTPP field sites. All laboratories conducting tests for the LTPP program were required to be accredited by the AASHTO Accreditation Program. The Type 1 Unbound Granular Base Synthetic Reference Sample Program was approved for implementation as one such supplement testing program. P46 requires a test system which includes a triaxial pressure cell component, a closed loop electro-hydraulic, repeated load component, and certain load and specimen response control, measurement, and recording components.
FPTP-00048	Round 1 Type II Unbound Cohesive Subgrade Soil Proficiency Sample Program	Strategic Highway Research Program	SHRP Protocol 46, "Resilient Modulus of Unbound Granular Base/Subbase Materials and Subgrade Soils," was the specified procedure for laboratories performing resilient modulus tests on research samples of unbound cohesive subgrade soil obtained from LTPP field sites. All laboratories conducting tests for the LTPP program were required to be accredited by the AASHTO Accreditation Program. In the round 1 proficiency sample research, a set of eight samples was shipped to each participant for testing.
FPTP-00049	SHRP-LTPP Monitoring Data: Five-Year Report	Strategic Highway Research Program	The overall objective of the SHRP-LTPP study was to increase pavement life by investigation of various designs of pavement structures and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soil, and maintenance practices. This report summarizes the LTPP monitoring data collection five-year activities for inclusion in the National Pavement Performance Database.

ID Number	Name	Source	Description
FPTP-00050	Use of Microcracking to Reduce Shrinkage Cracking in Cement Treated Bases	Transportation Research Board 2005 Annual Meeting	The microcracking concept can be defined as the application of several vibratory roller passes to the cement-treated base at a short curing stage, typically after one to three days, to create a fine network of cracks. In addition to the microcracked test sites, the contractor constructed moist-cured, dry-cured, and asphalt-curing membrane sites for comparison. Researchers used FWD tests to control the microcracking process, periodic crack surveys to monitor crack performance, and FWD tests through time to track base moduli. Microcracking proved quite effective at reducing shrinkage cracking problems in the base; applying the procedure with three passes of the roller after two to three days curing resulted in the best performance.
FPTP-00051	Assessing Pavement Layer Condition Using Deflection Data	National Cooperative Highway Research Program	A method for assessing pavement layer condition on the basis of layer condition indicators estimated from FWD deflection data is presented in this report. The research was conducted under NCHRP Project 10-48, "Assessing Pavement Layer Condition Using Deflection Data." This document provides a summary of the work performed in this research.
FPTP-00052	The Restricted Zone in the Superpave Aggregate Gradation Specification	Transportation Research Board	This report presents the findings of a research project to determine whether the restricted zone requirement is necessary for aggregate gradations designed in accordance with AASHTO MP2 and PP28 if mix volumetric and fine aggregate angularity criteria are met. Its main finding is that, based on an evaluation of the performance properties of HMA, the restricted zone requirement is redundant in these circumstances.

Flexible Pavement Software

ID Number	Name	Source	Description
FPS-00001	Flexible Pavement Design System FPS 19W: User's Manual (2001)	Texas Department of Transportation	FPS 19W is the approved flexible pavement thickness design system used by TxDOT.
FPS-00002	MODULUS 6.0 for Windows: User's Manual (2001)	Texas Department of Transportation	MODULUS is used by TxDOT to process FWD data. This system has been used since the early 1990s to perform structural evaluation of pavements and to provide layer moduli values for structural design.
FPS-00003	The Texas Modified Triaxial (MTRX) Design Program (2001)	Texas Department of Transportation	The Texas Modified Triaxial design program checks the adequacy of the thickness design from FPS based on the Mohr-Coulomb yield criterion. MTRX incorporates the following features: 1) characterization of pavement materials using layer moduli backcalculated from FWD deflection and strength properties determined from Texas triaxial tests, 2) modeling of single and tandem axles to evaluate pavement damage potential under different axle configurations, 3) application of layered elastic theory to predict stresses under applied wheel loads, and 4) application of Mohr-Coulomb failure criterion to check pavement damage potential.
FPS-00004	PerRoad Background	Asphalt Pavement Alliance	Background information is provided about PerRoad. PerRoad is a mechanistic-based procedure for the design of flexible long-life or perpetual pavement structures. The procedure was develops at Auburn University (AU) in conjunction with the Asphalt Pavement Alliance (APA).
FPS-00005	PerRoad Software	Asphalt Pavement Alliance	This software is the PerRoad 2.4 installation file. PerRoad is a mechanistic-based procedure for the design of flexible long-life or perpetual pavement structures. The procedure was develops at Auburn University in conjunction with the Asphalt Pavement Alliance.
FPS-00006	1-37A NCHRP Design Guide Mechanistic-Empirical Design of New Software	National Cooperative Highway Research Program	The mechanistic-empirical (M-E) pavement design guide uses mechanistic-empirical models to analyze and input data for traffic, climate, materials, and proposed structure in order to estimate pavement service life damage. The software is available to allow for independent testing and evaluation by interested users in the public and private sectors. The software can be downloaded for installation on a local drive in executable form, but its copy-protection feature requires access to the Internet to check for a specific file on the Transportation Research Board web server at each use. The installation file can be downloaded from http://www.trb.org/mepdg/software.htm (accessed March 22, 2006).

ID Number	Name	Source	Description
FPS-00007	Life-Cycle Cost Analysis (LCCA) Program Description	Asphalt Pavement Alliance	The LCCA program calculates the net present value of different pavement alternatives using either deterministic or probabilistic methods.
FPS-00008	Life-Cycle Cost Analysis (LCCA) Program Description	Asphalt Pavement Alliance	The LCCA program calculates the net present value of different pavement alternatives using either deterministic or probabilistic methods.
FPS-00009	DARWin	AASHTOWare	DARWin is a metric-compliant AASHTOWare computer software product that conforms to and is compliant with the pavement design models presented in the respective design guide documents. However, DARWin allows the pavement design engineer to accomplish much more. For example, in flexible pavement design, DARWin allows the calculation of layer thickness by three user-selected methods, including an optimization scheme. Rigid pavement design is enhanced by the addition of the steel design equations for jointed reinforced concrete pavement (JRCP) and continuously reinforced concrete pavement (CRCP) and by the inclusion of in-depth guidance on many of the inputs to the rigid pavement design equation. The overlay design module incorporates the revised approach to pavement overlay design developed under NCHRP Project 20-7. The overlay design module provides a fully automated means of performing all of the different overlay design calculations, including automated FWD file processing and backcalculation.
FPS-00010	PaveCool	Minnesota Department of Transportation	The Minnesota Department of Transportation has developed a computer tool (PaveCool) to assist contractors, inspectors, and engineers in making rapid decisions regarding cool-weather paving. The user enters the time of day, the date, and the latitude of the paving job. Next, the type of mixture is entered along with the type of surface being paved. Data input includes the surface temperature, air temperature, wind speed, lift thickness, and mixture delivery temperature. The final input is the amount of cloud cover. A heat flow model is used to compute the temperature drop in the mat and the time it takes for the asphalt mix to cool from its delivery temperature to 175 °F (80 °C). If the user feels that there is an inadequate amount of time available to compact the mixture, options can be explored to extend the time. For instance, increasing the lift thickness or mix temperature will increase the window of time for effective compaction of the pavement.
FPS-00011	SW-1 Asphalt Thickness Design Software	Asphalt Institute	The SW-1 Asphalt Thickness Design program is a mechanistic-empirical pavement thickness design program based on Asphalt Institute methods. It includes an integrated pavement design suite for highways, streets, parking lots, airports, and industrial facilities supporting heavy wheel loads.

ID Number	Name	Source	Description
FPS-00012	SW-2 Mix Design Program CD	Asphalt Institute	The SW-2 Asphalt Institute's Mix Design Program addresses the Superpave Mix Design, Superpave Trial Blending, Marshall Mix Design, and Marshall Trial Blending. It was designed in conformance with MS-2 Mix Design Methods for Asphalt and SP-2 Superpave Mix Design.
FPS-00013	Data Readability and Completeness FWDSCAN Version 1.3 Program Background and User's Guide	Strategic Highway Research Program	FWDSCAN is a computer program developed to verify the integrity, completeness, and compliance with the established test pattern of field data of nondestructive deflection testing under SHRP for the LTPP study.
FPS-00014	Layer Moduli Backcalculation Procedure: Software Selection	Strategic Highway Research Program	Backcalculation software used to estimate the in situ elastic moduli of the pavement layer materials was evaluated. Six programs were selected for detailed evaluation: ELCON and ILLI-BACK for rigid pavement, and ISSEM4, MODCOMP3, MODULUS, and WESDEF for flexible pavements. Using deflection data and other pertinent information obtained from SHRP pavement test sections, the selected software was exercised. Backcalculation results were evaluated on the basis of reasonableness, robustness and stability, goodness of fit, and general suitability for SHRP's purposes.
FPS-00015	Windows-Based Flexible Pavement Design Tools	Texas Department of Transportation	The existing flexible pavement design and analysis programs used by TxDOT are FPS 19, Modulus 6.0, and MTRX. FPS 19 is used for pavement analysis and design. Modulus is used to process FWD, and MTRX is used to check the adequacy of the FPS 19 design.
FPS-00016	Introducing ProVal 2.0	U.S. Department of Transportation Federal Highway Administration	The Profile Viewer and Analyzer (ProVal) software was developed to provide a means to view and analyze pavement profiles efficiently and robustly. Profile data analyses include ride indexes, power spectral density, butterworth filtering, profilograph simulation, and rolling straightedge simulation.
FPS-00017	McLeod Design Method Spreadsheet	Texas Department of Transportation	This spreadsheet in Excel assists with the design of seal coats using the McLeod Design Method.
FPS-00018	Modified Kearby Design Method Spreadsheet	Texas Department of Transportation	This spreadsheet in Excel assists with the design of seal coats using the Modified Kearby Design Method.
FPS-00019	Tex-207-F, Part VII, Longitudinal Joint Density	Texas Department of Transportation	This spreadsheet in Excel assists with quality control of longitudinal joint density.

Flexible Pavement Web Sites

ID Number	Name	Source	Description
FPWS-00001	Asphalt Institute (AI)	Asphalt Institute	The Asphalt Institute is a U.S. based association of international petroleum asphalt procedures, manufacturers, and affiliated businesses.
FPWS-00002	Asphalt Emulsion Manufacturers Association (AEMA)	Asphalt Emulsion Manufacturers Association	AEMA is the international organization representing the asphalt emulsion industry. AEMA's mission is to expand the use and applications of asphalt emulsions. Asphalt emulsions are the most environmentally sound, energy-efficient, and cost-effective products used in pavement maintenance and construction.
FPWS-00003	ARRB Group	ARRB Group	ARRB Group (formerly ARRB Transport Research) is a provider of value-added research, consulting, and technology addressing transport problems. Its customers include international aid agencies, national governments, state road authorities, local governments, major construction firms, and transport and mining companies.
FPWS-00004	American Association of State Highway and Transportation Officials (AASHTO)	American Association of State Highway and Transportation Officials	AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.
FPWS-00005	National Highway Institute (NHI)	National Highway Institute	NHI is a training arm of FHWA. NHI provides leadership and resources for the development and delivery of training and education programs to improve the quality of our nation's highway system and its intermodal connections. Established by Congress in 1970, NHI provides training, resource materials, and educational opportunities to the surface transportation community. NHI courses are instrumental in developing core competencies and new skills of the surface transportation workforce and in transferring leading technology and current policies in the United States and abroad.
FPWS-00006	National Asphalt Pavement Association (NAPA)	National Asphalt Pavement Association	NAPA is the only trade association that exclusively represents the interests of the HMA producer and paving contractor on the national level with Congress, government agencies, and other national trade and business organizations. NAPA supports an active research program designed to answer questions about environmental issues and to improve the quality of HMA pavements and paving techniques used in the construction of roads, streets, highways, parking lots, airports, and environmental and recreational facilities. The association provides technical, educational, and marketing materials and information to its members, and supplies technical information to users and specifiers of paving materials. The association, which counts more than 1,100 companies as its members, was founded in 1955.

ID Number	Name	Source	Description
FPWS-00007	The Road Engineering Association of Asia and Australasia (REAAA)	The Road Engineering Association of Asia and Australasia	REAAA was established on June 15, 1973, with objectives to promote and advance the science and practice of road engineering and related professions, and to educate and seek to improve, extend, and elevate the technical and general knowledge of persons concerned with road engineering.
FPWS-00008	Transport Research Laboratory (TRL)	Transport Research Laboratory	TRL, the UK's Transport Research Laboratory, is an internationally recognized center of excellence providing world-class research, consultancy, advice, and testing for all aspects of transport. TRL works at the leading edge of transport, generating and applying science, knowledge, and understanding to develop innovative solutions delivered to customers around the world. TRL works with customers from public and private sectors on all aspects of transportation, safety, vehicles, environment, sustainability, and transport infrastructure.
FPWS-00009	Publications of the Headquarters, United States Army Corps of Engineers (USACE)	United States Army Corps of Engineers	This web site contains a collection of publications and is the only repository for all official USACE engineering regulations, circulars, manuals, and other documents originating from USACE headquarters.
FPWS-00010	Northeast Center of Excellence for Pavement Technology (NECEPT)	Northeast Center of Excellence for Pavement Technology	The NECEPT website contains information about Superpave including regional centers, publications, workshops, and a certification program for asphalt technicians.
FPWS-00011	Welcome to the National Center for Asphalt Technology (NCAT) Hot-Mix Asphalt (HMA) Reference Collection	The National Center for Asphalt Technology	This website lists relevant items recommended by the National Center for Asphalt Technology related to aggregates, asphalt cement, and HMA mixes.
FPWS-00012	International Slurry Surfacing Association (ISSA)	International Slurry Surfacing Association	ISSA promotes cooperation between members specializing in asphalt slurry seal and microsurfacing for roads, parking lots, and other pavements. Members represent the slurry and microsurfacing industry in 36 countries. ISSA was formerly known as the International Slurry Seal Association.

ID Number	Name	Source	Description
FPWS-00013	Texas Pavement Preservation Center (TPPC)	Texas Pavement Preservation Center	TPPC, in joint collaboration with the Center for Transportation Research (CTR) of The University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, promotes the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. TPPC serves a broad range of needs for TxDOT, industry, and agencies within the highway community.
FPWS-00014	Superpave Asphalt Technology Program	The University of Texas at Austin Superpave Asphalt Technology Program	The Superpave Asphalt Technology Program: 1) evaluates Superpave products through applied research, 2) is an information resource for management-level personnel, 3) provides training in Superpave technology, and 4) provides testing and technical assistance related to the Superpave system.
FPWS-00015	Texas Engineering Extension Services (TEEX)	Texas Engineering Extension Services	The TEEX web site features a course catalog offered by TEEX. There are some online courses open.
FPWS-00016	Minnesota Road Research Section	Minnesota Department of Transportation	The Minnesota Road Research website features a description of products and testing facilities. Testing facilities involve an electronic sensor network embedded within 6 miles of test pavements located 40 miles from Minneapolis/St. Paul.
FPWS-00017	WSDOT Pavement Guide	Washington Department of Transportation	This web site offers technical information about pavement types, materials, design parameters, mix design, structural design, construction, quality assurance and specifications, pavement evaluation, maintenance and rehabilitation, and pavement management.

Pavement-Related Databases

ID Number	Name	Source	Description
PDB-00001	LTPP Pavement Performance Database Release Notes	U.S. Department of Transportation Federal Highway Administration	The LTPP database release notes contain notes on the contents, changes, and updates made to each version of the Standard Data Release (DSR) of the database. The LTPP program has collected a large quantity of data and information on the performance of selected in-service pavement test sections in North America. These data are designed to serve a broad range of research needs related to pavement performance engineering, pavement materials engineering, and pavement management. To serve this mission, LTPP developed a Standard Data Release that provides access to its data.
PDB-00002	LTPP Information Management System (IMS) Quality Control Checks (Revised 2003)	U.S. Department of Transportation Federal Highway Administration	The LTPP Information Management System Quality Control Checks report documents the QC/QA of the software programs. The LTPP program has collected a large quantity of data and information on the performance of selected in-service pavement test sections in North America. These data are designed to serve a broad range of research needs related to pavement performance engineering, pavement materials engineering, and pavement management. Data types in the IMS are inventory, materials testing, maintenance, rehabilitation, traffic, climatic, monitoring, longitudinal profile, deflection, cross profile, manual distress, automated distress, friction, SPS construction, Seasonal Monitoring Program (SMP), and automated weather station.
PDB-00003	Long-Term Pavement Performance Information Management System: Pavement Performance Database User Reference Guide	U.S. Department of Transportation Federal Highway Administration	This user reference guide provides information to aid in the understanding and use of the LTPP database. This document provides an introduction to the structure of the LTPP program, the relational structural of the LTPP database, a description of the location of various data elements, contents of the data tables, tips on efficient means of manipulating data for specific types of investigation, and examples of Structured Query Language (SQL) scripts that can be used to build user-defined custom extractions.

ID Number	Name	Source	Description
PDB-00004	Minnesota Research Test Section Tracking	Minnesota Department of Transportation	The Minnesota Department of Transportation along with Minnesota cities and counties have developed hundreds of test sections and projects relating to every aspect of roadway design. These projects typically have a local champion who sees the value in field validation of both new designs and materials. The problem with their past system is that projects tended to be forgotten before the benefits of research were learned. The Office of Materials, Road Research Section, is developing this system with the help of the Local Road Research Board that will allow each individual champion to collectively enter a project name, purpose, locations, and comments for each test section developed. The system archives information for others to build upon with the use of other test sections or performance or material testing databases being developed within the state.
PDB-00005	Accelerated Loading Facility (ALF)	U.S. Department of Transportation Federal Highway Administration	The ALF is located on the grounds of the Turner Fairbank Highway Research Center. The facility was originally established in 1986 with space available for the construction of eight full-scale test pavement sections. It was expanded to 12 test pavement sections in 1989 and to 24 in 1993. As the first of its kind in North America, the ALF has the capability of simulating 20 years of traffic loading in six months or less. The ALF is a 29 m long structural frame containing a moving wheel assembly. The wheel assembly models one-half of a single axle and can apply loads ranging from 44.5 to 100.1 kN. It travels 18.5 km/h over a 9.8 m test pavement section. To simulate highway traffic, the ALF loads pavement in one direction, and the loads are laterally distributed to simulate the side-to-side wander of trucks. The ALF is computer controlled, permitting operation 24 hours per day, seven days a week.
PDB-00006	Development of the LTPP Climatic Database	Strategic Highway Research Program, National Research Council	SHRP's LTPP research is a 20-year study of pavement performance, and the factors which affect it. The SHRP climatic database contains the weather and climatic information needed to characterize the environment in which the General Pavement Studies test sections from the time of construction through the LTPP monitoring period.

ID Number	Name	Source	Description
PDB-00007	Analysis and Treatment Recommendations from the Supplemental Maintenance Effectiveness Research Program (SMERP)	Texas Department of Transportation	SMERP was designed to study the effectiveness of maintenance treatments typically used in Texas. Six maintenance treatments and a control section were applied at 20 locations throughout the state. Treatments included: asphalt rubber chip seal, polymer-modified emulsion chip seal, latex-modified asphalt chip seal, asphalt chip seal, microsurfacing treatment, and a fog seal section. Researchers inspected the sites annually for eight years storing this information in a database.
PDB-00008	Laboratory Information Management System (LIMS)	Texas Department of Transportation	The LIMS project defines, analyzes, and develops an application to streamline the materials testing laboratory operation process, making it efficient with minimized errors. For additional information please contact the Materials and Pavements Section of the Construction Division at the following phone numbers: For asphalt concrete questions: 512-506-5832 For asphalt binder questions: 512-506-5821 For soils and aggregates questions: 512-506-5903 For hydraulic cement concrete questions: 512-506-5850

Pavement Manuals

ID Number	Name	Source	Description
FPM-0001	Standard Specification for Construction and Maintenance of Highways, Streets, and Bridges (2004)	Texas Department of Transportation	TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets and Bridges (June 2004) are the department-wide specifications of TxDOT.
FPM-0002	Guide Schedule for Sampling and Testing (2005)	Texas Department of Transportation	This manual contains TxDOT guidelines for sampling and testing materials.
FPM-0003	200-F, Bituminous Test Procedures (2006)	Texas Department of Transportation	The chapters in this manual cover the testing methods for HMA concrete, black base, cold-mix, patching mix, recycled asphalt pavement (RAP), and crumb rubber; and in-plant inspection of limestone rock asphalt aggregates and mixes, aggregates and bituminous materials, and surfacing aggregates.
FPM-0004	100-E, Soils & Aggregates Test Procedures (2005)	Texas Department of Transportation	This pavement manual gives information on material, specifications, aggregate, bank gravel, blast furnace slag, bottom ash, clay, clay size, coarse aggregate, concrete, conglomerate, crushed face, crushed gravel, crushed stone, detrital, fine aggregate, fly ash, granite, gravel, lightweight aggregate, limestone rock asphalt, lithification, mineral filler, quarry riprap, rock, sand, sandstone, silt, silt size, slag, soil, source, stone, trap rock, and virgin material.
FPM-0005	500-C, Asphalt Test Procedures	Texas Department of Transportation	This manual covers the testing methods for asphalt cements, asphalt cutbacks, asphalt emulsions, performance grade binders, bituminous adhesives, waterproofing and joint materials, crack sealers, rejuvenating agents, and additives.
FPM-0006	LTTP Manual for Profile Measurements and Processing (2004)	Federal Highway Administration	This manual describes operational procedures to be followed when measuring pavement profiles for the LTPP program using the International Cybernetics road profiler, the Dipstick®, and the rod and level. Field testing procedures, data collection procedures, calibration of equipment, record keeping, and maintenance of equipment for each of the profiling methods are described in this manual. This manual also describes procedures to be followed in the office when processing the profile data that were collected in the field.
FPM-0007	Operations Manual (2001)	Texas Department of Transportation	The operations manual contains information describing the purpose and functions of the Materials Section and the various programs administered by the section. The manual also provides links to information in other manuals contained in the TxDOT manual system.

ID Number	Name	Source	Description
FPM-0008	Material Inspection Guide (2003)		This guide includes sampling, testing, and inspecting procedures and instructions for specific roadway materials. These procedures and instructions guide the project engineer as well as the Construction Division, Materials & Pavements Section (CST/M&P) personnel in performing sampling, testing, inspecting, and related functions.
FPM-0009	Quality Assurance Program (2005)	Texas Department of Transportation	TxDOT established the Quality Assurance Program (QAP) to ensure that materials and workmanship incorporated into any highway construction project are in reasonable conformity with the requirements of the approved plans and specifications, including any approved changes.
FPM-0010	The Asphalt Handbook (Manual Series No. 4, MS-4)	Asphalt Institute	This manual presents an overview of the field of asphalt technology and construction. Chapters include types of asphalts, mix designs, mixing facilities, paving, compaction, surface treatments, recycling, maintenance, structural design, and various miscellaneous uses and tables.
FPM-00011	Manual of Practice for Conducting Superpave Asphalt Binder Test	Northeast Center of Excellence for Pavement Technology	An article describes the manual that was developed as part of NECEPT to clarify existing AASHTO test methods and to provide supplemental information in the test methods. The manual presents a basic overview of asphalt binder properties as they relate to sampling and testing and an introduction to the Superpave specification.
FPM-00012	AASHTO Guide for Design of Pavement Structures (fourth edition, 1993)	The American Association of State Highway and Transportation Officials	The guide presents state-of-the-art approaches to pavement design including design and management principles, procedures for new construction or reconstruction, procedures for rehabilitation of existing pavements, and mechanistic-empirical design procedures. It provides new material on overlay design methodology and rehabilitation, including seven overlay procedures and associated options. This edition supersedes Volume 1 of the same title published in 1986.
FPM-00013	Manuals Provide Information for Pavement Maintenance and Repair	Strategic Highway Research Program	This is a short description of the manuals available from the Strategic Highway Research Program (SHRP) H-106, “Innovative Testing,” and the Federal Highway Administration project “Long-Term Monitoring of Pavement Maintenance Materials Test Sites.”
FPM-00014	Transportation Asset Management Guide (2002)	American Association of State Highway and Transportation Officials	Transportation asset management represents a strategic approach to managing transportation infrastructure assets. It focuses on a DOT’s business processes for resource allocation and utilization with the objective of better decision making based upon quality information and well-defined objectives. This guide was developed by AASHTO under NCHRP Project 20-24.

ID Number	Name	Source	Description
FPM-00015	Manuals of Practice: Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements Materials and Procedures for the Repair of Potholes in Asphalt-Surfaced Pavements	Strategic Highway Research Program	These maintenance manuals were developed under the SHRP studies. They are for use by highway maintenance agencies and contracted maintenance firms in the field and in the office. They are a compendium of good practices for AC crack sealing and filling and pothole repair.
FPM-00016	Concrete Pavement Repair Manuals of Practice Materials and Procedures for the Repair of Joint Seals in Concrete Pavements Materials and Procedures for Rapid Repair of Partial-Depth Spalls in Concrete Pavements	Strategic Highway Research Program	These maintenance manuals were developed under the SHRP studies. They are for use by highway maintenance agencies and contracted maintenance firms in the field and in the office. They are a compendium of good practices for PCC joint resealing and partial depth spall repair.
FPM-00017	Manual for Profile Measurement: Operational Field Guidelines	Strategic Highway Research Program	The LTPP program is a study of pavement performance at about 1,000 in-service pavement sections. The data collected at the test sections are stored in LTPP Information Management System data. This manual describes procedures to be followed when measuring pavement profiles for LTPP using the K. J. Law Profilometer, Face Technologies Dipstick, and the rod and level.
FPM-00018	Manual for FWD Testing in the Long-Term Pavement Performance Program	Strategic Highway Research Program	Nondestructive testing with FWD is a critical element of the pavement-monitoring effort for the LTPP test sections of the SHRP. Data obtained through this testing serve as the primary mechanism for assessing structural conditions within each LTPP test section.

ID Number	Name	Source	Description
FPM-00019	A Mix Design Manual for Hot Mix Asphalt (2005)	National Cooperative Highway Research Program	The purpose of this manual is to present an improved mix design procedure for HMA (including dense-graded, open-graded, and gap-graded mixes) for use by engineers and technicians in the public and private sectors. The mix design procedure will make use of the best-available materials-testing and performance-prediction technology to produce durable, distress-resistant mix designs tailored to the requirements of specific pavement layers. At a minimum, development of the design procedure shall consider: 1) the volumetric design method in AASHTO MP 2 and PP 28; 2) the simple performance test(s) (SPT) and equipment recommended by NCHRP Projects 9-19 and 9-29; 3) the HMA materials characterization tests and performance models developed in NCHRP Project 1-37A; 4) any improved method for measuring moisture susceptibility developed through NCHRP Projects 9-34 and 9-37; and 5) any other sound, applicable research products from, for example, NCHRP Projects 1-42, 9-9(1), 9-16, 9-17, 9-22, 9-25, 9-27, 9-31, 9-36, and 9-38. The mix design manual follows the general format of Asphalt Institute Manual SP-02, *Superpave Mix Design.*

APPENDIX B:
KEY WORD GLOSSARY
FOR FLEXIBLE PAVEMENT FORENSICS

Key Word Glossary for Flexible Pavement Forensics

A. Flexible Pavement Surface Course Types

Dense-Graded Hot-Mix Asphalt Concrete Pavement (ACP) (Items 340 and 341)
Hot Asphalt-Rubber Surface Treatment (A-RST) (Item 318)
Hot-Mix Cold-Laid Asphalt Concrete (HMCL) (Item 334)
Limestone Rock Asphalt (LRA) (Item 330)
Microsurfacing (MS) (Item 350)
Performance-Designed Mixture – Coarse-Matrix High Binder (CMHB) (Item 344)
Performance-Designed Mixture – Superpave (SP) (Item 344)
Permeable Friction Course (PFC) (Item 342)
Stone-Matrix Asphalt (SMA) (Item 346)
Surface Treatment or Seal Coat (ST) (Item 316)

B. Material Sampling and Testing Terms

Aging Ratio (Tex-211-F)
Binder Content (Tex-210-F or Tex-236-F)
Boiling Water Stripping Test (Tex-530-C)
Cantabro Loss (Tex-245-F)
Coarse Aggregate Angularity Test (Tex-460-A, Part I))
Core Bulk Specific Gravity (Tex-207-F)
Decantation Test (Tex-217-F, Part II)
Deleterious Material (Tex-217-F, Part I)
Drain Down Test (Tex-235-F)
Dry Sieve Analysis (Tex-200-F, Part I)
Dynamic Cone Penetrometer (DCP)
Dynamic Shear Rheometer Test (DSR) (AASHTO T 315)
Extraction Test (Tex-210-F)
Falling Weight Deflectometer (FWD)
Flat and Elongated Particles Test (Tex-280-F)
Gradation Test (Tex-200-F or Tex-236-F)
Ground Penetrating Radar (GPR)
Hamburg Wheel Test (Tex-242-F)
Ignition Oven Test (Tex-236-F)
In-Place Air Voids (Tex-207-F)
Indirect Tensile Strength (Tex-226-F)

Laboratory-Molded Bulk Specific Gravity (Tex-207-F)
Laboratory-Molded Density (Tex-207-F)
Layer Thickness
Longitudinal Joint Density (Tex-207-F, Part VII)
Magnesium Sulfate Soundness Test (Tex-411-A)
Maximum Theoretical Specific Gravity (Rice Gravity) (Tex-227-F)
Micro-Deval Abrasion Test (Tex-461-A)
Mixture Temperature
Modified Texas Triaxial
Modulus of Elasticity
Moisture Content (Tex-212-F)
Organic Impurities Test
Penetration Test (AASHTO T 49)
Polymer Content (Tex-533-C)
Roadway Surface Temperature
Ride Quality Test (Tex-1001-S)
Sampling (Tex-400-A or Tex-225-F or Tex-222-F)
Sand Equivalent Test (Tex-203-F)
Sawed Pavement Cross Section
Segregation Test (Density Profile) (Tex-207-F, Part V)
Skid Testing
Surface Aggregate Classification (SAC)
Tack Coat Adhesion (Tex-243-F)
Texas Gyratory Compaction (TGC) (Tex-206-F)
Thermal Coefficient of Expansion (TCE)
Thermal Profile (Tex-244-F)
Stripping Test (Tex-531-C)
Superpave Compaction (SPC)
Viscosity Test (AASHTO T 202)
Voids in Mineral Aggregates (VMA) (Tex-207-F)
Washed Sieve Analysis (Tex-200-F, Part II)

C. Flexible Pavement Distress Terms

I. General Conditions

Aging (Materials)
Construction Defects
Fatigue Failure
Joint Failure
Materials-Related Distress
Moisture Damage or Stripping
Premature Flexible Pavement Distress
Structural Defects
Structural Deterioration
Surface Deterioration

II. Cracking

Alligator Cracking
Heat Checking
Longitudinal Cracking
Reflective Cracking
Transverse Cracking

III. Layer Interface and Surface Issues

Blistering
Debonding
Delamination
Stripping or Moisture Damage
Tearing
Raveling

IV. Deformation

Deformation
Heaving
Rutting

V. Surface Course Irregularities

Bleeding
Flushing
Patches or Patch Deterioration
Permeability
Potholes
Raveling
Ride Quality
Skid Resistance
Surface Course Irregularities

VI. Subgrade Swelling, Movement, and Conditions

Differential Settlement
Heaving
Lane-to-Shoulder Dropoff
Lane-to-Shoulder Separation
Pumping

VII. Aggregate Issues

Polished Aggregate
Segregation (Aggregates)

VIII. Construction Joint Issues

Cracking at Longitudinal Construction Joints
Cracking at Transverse Construction Joints
Joint Damage
Raveling at Longitudinal Construction Joints
Raveling at Transverse Construction Joints

D. Distress Causes and Manifestations

Overweight Loads:
Rutting, cracking
Construction Errors:
Compaction, paving machine operation, mixture storage, temperature, paving mixture composition, quality of materials
Inadequate Structural Design:
Cracking
Miscellaneous Chemical Attack:
Softening
Moisture Damage:
Flushing, rutting
Settlement and Movement:
Subgrade expansion and contraction

APPENDIX C:
EXAMPLE OF LEGACY KNOWLEDGE INTERVIEW QUESTIONS FOR FLEXIBLE PAVEMENT FORENSICS

Legacy Knowledge Interview Questions – Flexible Pavement Forensics

1. Please tell us about one or two flexible pavement forensic studies (they may be official or unofficial forensic studies, documented or undocumented in the literature) that you did or were involved with that taught you something important about why pavements perform the way they do. Some of the information we would like to know, to the best of your recollection, is:

- Highway number, county, district.
- Types and approximate thicknesses of pavement layers, if you recall.
- Description of the premature failure as seen from the surface (photo if available would be fantastic).
- Description of the method used to determine what had caused the failure:
  - What field pavement tests (FWD, GPR, etc.) were performed, if any?
  - If cores were taken, how often and their locations across pavement width?
  - What tests were performed on cores?
  - How were the pavement and/or core test data analyzed?
  - Was there an analysis of traffic volume/type in the investigation?
  - What construction records, if any, were helpful to the failure investigation?
  - Other aspects of investigation possibly of interest.
- What was the cause of the pavement performance problem or failure, if determined?
- Were any specification changes made based on what was learned?
- Were pavement design methods or guidance changed as a result of findings?
- If you, personally, learned something new about pavement performance, construction, importance of construction inspection or maintenance, what was it?

2. Please describe typical steps you take after you are asked to investigate a flexible pavement performance problem (i.e., what do you do or look at first, second, third, etc.).

3. Are there any manuals, research reports, web sites, or other sources of information about performing flexible pavement forensic investigations that you would recommend as excellent resources for a new district pavement engineer?

4. From experiences over your career, what are the most common causes if the following distresses are seen prematurely in a flexible pavement surface course?

- Rutting
- Transverse cracking
- Longitudinal cracking
- Random cracking
- Alligator cracking
- Tearing where vehicles often change speeds
- Raveling (asphaltic concrete)
- Stripping
- Potholes

5. Do you have any other advice gained from your years involved with flexible pavements for TxDOT personnel in the districts or divisions?

APPENDIX D:
EXAMPLES OF LEGACY KNOWLEDGE INTERVIEW SEGMENTS FOR FLEXIBLE PAVEMENT FORENSICS

Legacy Knowledge

Paul Krugler: July - 2006

Paul Krugler's Thoughts on ….

Studying Trends in QC Data and Tex-233-F
Selecting Coring Locations
Migrating Asphalt Cement

Since we went out and looked at a fair number of rutted pavements in the 1980's, we came up with some practical techniques to analyze what had caused the problem. One of the things that we learned was to plot job control test results as part of our investigation.

The first thing to do, though, was always to go out and drive the project, see if the problem was everywhere, or just in certain locations. If it was just in certain locations, or if it was much worse in some locations than in others, it made figuring the situation out much easier.

If the job was still going on, or if the construction records were still available for an older pavement, I always wanted to look at the field laboratory's test results next. If there were three things that I would look at from the plant laboratory results, they would be the lab-molded densities, the amount of passing No. 200 sieve material, and the extracted asphalt contents. I would be looking for trends in the data over the course of the job. Individual aggregate materials being brought to the hot mix plant have a tendency to change over the course of the project. They may get coarser or finer. They may get cleaner or dirtier. It's hard to notice this incremental change. But if you plot the test results on a chart versus calendar days, you can clearly see any trends if they are happening. Then you find out where they laid mix on which days, and you looked for a correlation between changing hot mix properties and changes in the rutting that you saw on the road. If you found some uniqueness or trends in test results that corresponded to problems on the road, that uniqueness was probably one of the factors involved. A typical trend we would see which would contribute to rutting would be increasing passing No. 200 material in the mix. As this fine material increased, the lab-molded job control densities usually climbed in direct proportion. And the higher the lab-molded densities, the greater likelihood that the pavement was rutting in those locations on the road. We saw that kind of trend a lot of times. It was actually this forensic use of plotting job control tests, and our success in linking the test results to problems on the road, that led us to require plotting of job control test data as a normal job control activity. We figured that maybe we could catch problems earlier doing that, while the project was still underway.

Another thing that is important to do while you're out on the road is to find the best locations to take some cores. I would look for the worst performing location. If it's rutting, it's where the ruts are deepest. If it's cracking, it's where the cracks are the widest or densest. Then I would look for the best performing part of that same project. Maybe there's one place that has a rut depth that's only a third as deep as it is elsewhere. Look for the best area and the worst area and you core both. Preferably what we would do is core in the wheel path, between the wheel path and then often times in the other wheel path as well. What we wanted to do was to see the difference in test results between those core locations. The difference in density or air voids in the wheel path and between the wheel paths would tell you how much effect the traffic has had in further compacting the pavement. It might also indicate that the contractor had done a poor job of compaction on the job. And then you compared asphalt contents, gradations, and densities between the best and worst performing pavement sections. You were looking for significant differences, which would indicate a contributing factor if you found any.

Occasionally rutting would happen very quickly after construction, or even during construction. More typically it would be within a year or so after construction. It didn't commonly just show up for the first time eight years later. There is a reason why some pavements do rut later after construction. When that happens, I suspect stripping down below, or there may be a layer down underneath that just had too much asphalt in it from the start. In either of those cases, the extra asphalt down there begins to migrate up, which can take some time, and cause the upper pavement layers to become over asphalted. When that happens, the upper layers typically rut and flush. I think that even with a seal coat that lost its rock, if you come in and put a thin overlay right on top of that, it's possible for that asphalt to migrate upward and have enough of an effect to cause performance problems.

Key Words, by Category:

Geographic Area – Statewide

Information Type – Legacy knowledge

Legacy Knowledge Source – Paul Krugler, July 2006 interview

Analyses Involved – Extraction test (Tex-210-F) (Tex-236-F), sieve analysis (Tex-200-F), plotting control charts (Tex-233-F), in-place air voids (Tex-207-F), laboratory compacted density (Tex-206-F)

Flexible Pavement Distresses Involved – Rutting, stripping, flushing

Other Descriptors – Asphalt concrete pavement, ACP, traffic compaction, wheel path ruts, data trends, job control test, QC, interpreting quality control test results, coring location

Search Acronyms: Legacy Knowledge – Flexible Pavement – Forensics, lkfpf, Legacy Knowledge – Flexible Pavement – Mix Design, lkfpmd, Legacy Knowledge – Flexible Pavement – Construction, lkfpc, Legacy Knowledge – Flexible Pavement – Materials, lkfpmat, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Laboratory Testing & Data Analysis, lkfplt

Tom Scullion's Thoughts on ....

Causes of Asphalt Pavement Distresses
Problems from Underneath the Pavement Surface

One of the important things to remember about flexible pavements is that whatever distresses you see on the surface, they are not necessarily the result of problems with the top pavement layer. The top asphalt layer or two can be perfectly good, with the problem being below them.

The pavement problems I have seen are usually related to materials problems and construction problems. The main thing about asphalt pavements as opposed to concrete pavements is that all the layers in an asphalt pavement have to work together. They are all important. If the subgrade goes bad, the base goes bad, and if the base goes bad, everything goes bad. When you go out to do a forensic investigation, you really need to be careful not to jump to conclusions.

Here is one example. This is a four-year old pavement section located on SH 47. The pavement structure is composed of 3 inches of asphalt mixture, 15 inches of base, and 8 inches of lime stabilized subgrade.

Figure 1. Alligator Cracking in the Wheel Path of SH 47

When we conducted non-destructive tests, we observed that the Falling Weight Deflectometer (FWD) and the Ground Penetrating Radar (GPR) data showed some apparent problems.

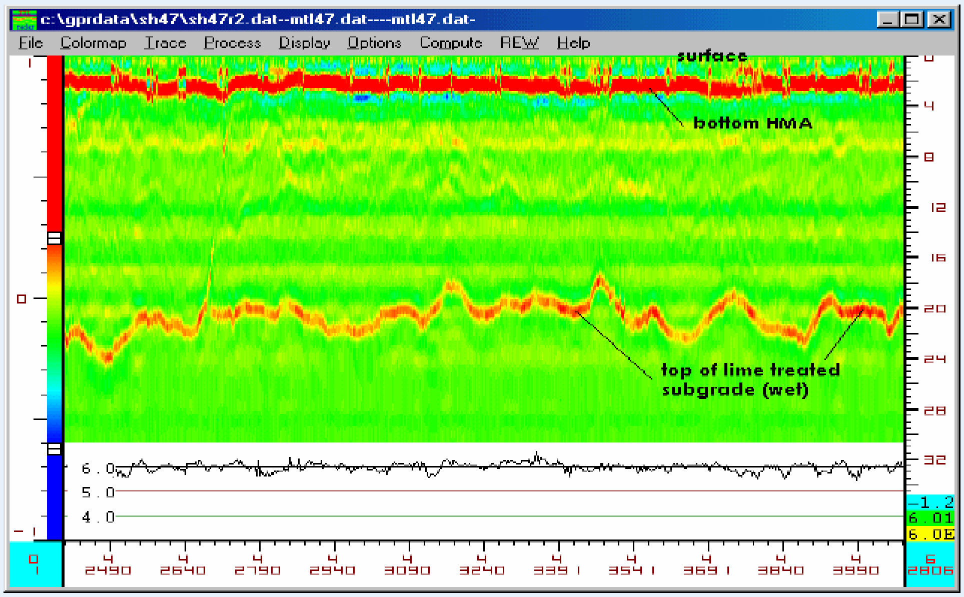

Figure 2. Ground Penetrating Radar Analysis SH 47

The GPR graph in Figure 2 shows the 3 inches of asphalt mixture on top, then the thick base below that, and finally the red line toward the bottom indicates the top of the lime stabilized layer. As seen, this layer is a long way down. The lime stabilized layer was almost 20 inches below the surface. As the GPR signal went through this pavement structure we were getting a strong reflection back from that layer. When you get a strong reflection back like that, the layer is saturated, completely wet. After looking at the FWD data we suspected that the lime stabilized layer was where the problem was coming from. So, we went in and proved this hypothesis with the Dynamic Cone Penetrometer (DCP).

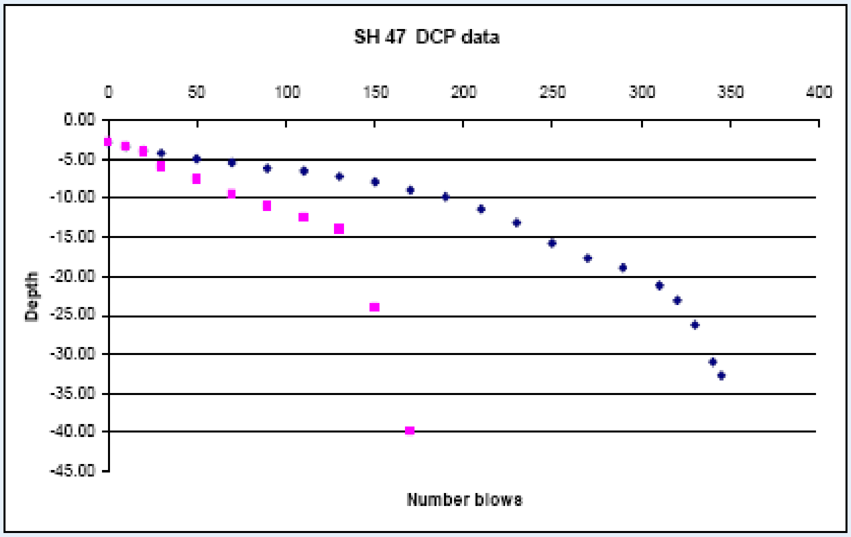

Figure 3. Dynamic Cone Penetration Analysis SH 47

Figure 3 shows a plot of DCP test results from two locations along this pavement. One test was run at a location where we didn't see any distresses in the pavement. The other location was a distressed area. Where we didn't see pavement distress on the surface, the DCP data showed a fairly normal penetration rate through all the pavement layers. These are the blue, diamond-shaped points. The test data from the distressed area, on the other hand, show rapidly increasing penetration per drop once the top of the lime stabilized layer was reached.

We went out again three or four years later and did some test holes to verify if the lime layers were there or not. So, in the final analysis we decided that the cause of the pavement problem came down to a couple of things. I think the problem here was that the soils that we were using were imported from a burned area. Our feeling is that those soils were high in organic material, which could be any kind of living matter. The conclusion was that the cracking observed on the surface unfortunately came from the layers underneath. And there would be no easy way of fixing it.

We need to ponder what can be done to extend the pavement service life for another 10 years against what needs to be done to really fix the problem. To really fix the problem, the entire pavement structure needed to be removed so that the subgrade layer could be reworked. That was an unacceptable solution from the economical point of view. What they actually did on this pavement section was full-depth reclamation on the six worst areas identified by the FWD tests. We came in and cement stabilized the top 10 inches of the pavement structure, mixed everything together with the cement to bridge over the bad material down below, and then we put three inches of asphalt back on the surface. We did that in 2003, and we haven't seen any more problems.

Key Words, by Category:

Geographic Area – Central Texas, SH 47

Information Type – Legacy knowledge

Legacy Knowledge Source – Tom Scullion, April 2006 interview

Analyses Involved – Falling Weight Deflectometer (FWD), Ground Penetrating Radar (GPR), Dynamic Cone Penetrometer (DCP) (Tex-132-E)

Flexible Pavement Distresses Involved – Alligator cracking

Other Descriptors – Asphalt concrete pavement, ACP, organic material, lime stabilized layer, full depth reclamation, photos

Search Acronyms: Legacy Knowledge – Flexible Pavement – Forensics, lkfpf, Legacy Knowledge – Flexible Pavement – Pavement Testing and Data Analysis, lkfppt , Legacy Knowledge – Flexible Pavement – Rehabilitation and Reconstruction, lkfpr

Legacy Knowledge

Joe Leidy: June - 2006

Joe Leidy's Thoughts on ….

Causes of Various Failure Types

Rutting. In general, rutting causes come down to one of three different things; poor mixture design mechanical properties, stripping, and high pavement air voids. You know, rutting has pretty much been eliminated since we now have the Hamburg test that we use during mixture design. Using the Hamburg test will take care of the first two causes. It won't let you use a stripping susceptible mix or a mix with poor strength properties. But it can't really predict how well you'll compact the mix in the field. So you may still have the air void issue occur.

Transverse Cracking. I would say that in this day most transverse cracking is either reflection cracking from underlying jointed concrete sections or reflection cracking from shrinkage of cement stabilized bases. Through research, we are trying to come up with an appropriate solution for the problem of not having so much cement stabilization in there. One thing that has been recommended is the use of a vibratory roller to pre-crack the stabilized base within 24 to 48 hours after placement. For a short time the base will have a lower modulus, but then within another 48 hours it seems to bind itself back up. It just doesn't get back to the point where it's going to have enough shrinkage cracking to cause a problem in the future. This has been tried, but I don't know how good the documentation is so far on how well it's worked. I believe the Bryan district did actually document better performance out of bases constructed that way.

Alligator Cracking. The issue here is usually too thin of a pavement structure for the predicted traffic. The pavement is failing in fatigue. The cause can be complicated if you have oxidized or aged or very stiff mixes that are fairly thin and are on top of flexible substructures. This problem can also manifest itself when the surface hot mix mat is not bonded to the underlying base hot mix, or when lower hot mix lifts have stripped out and no longer provide uniform support for the surface course.

Longitudinal Cracking. If the longitudinal cracking is in the wheel path, it is usually a precursor to alligator cracking and pavement structure failure. But most of the longitudinal cracking we have here in the state is probably related to desiccation or drying out of the underlying soils. Both of these causes are usually associated with multi-year cycles of very dry weather followed by wet weather and back again. These weather cycles particularly affect the pavement edges, where longitudinal cracking often shows up. Then, if the maintenance section is not Johnny-on-the-spot with crack sealing, then the longitudinal crack acts essentially like a new pavement edge, so more longitudinal cracks work their way in from that edge.

Random Cracking. I would say that random cracking is basically an issue with oxidized or aged asphalt in the hot mix. We are developing an overlay tester to help us evaluate if a hot mix will withstand the movement of jointed concrete slabs. But it's a good test over all for evaluating the resiliency of a hot mix and determining how well it retains its resilient properties. So there might be some hope for developing more oxidization-resistant type mixes with that particular device. But it's not developed to a mature state.

Tearing. Pavement tearing happens where vehicles often change speeds; and there is usually a poor tack coat or adhesion issue involved. There are a lot of braking, acceleration, and deceleration types of situations. Even though the adhesion problems between layers may exist broadly, places where there are frequent changes in vehicle speed will develop a pavement tear much earlier than in other locations. We have research now on how to evaluate tack coats for proper stickiness, but I don't know if we've really come up with the best solution yet at this point. We now have a tack coat pull-off device that was developed under a research project. It's a little bit cumbersome to use, and the old boot heel test may still be sufficient from my experience. What I have seen is that the contractor sometimes puts down a tack coat, but then lets too much time elapse before placing the mix. The wind can blow dust and stuff on there, and it's no longer tacky. So it's one of those things where the inspector could really play a key role in ensuring better pavement performance by just being there at this key juncture and holding the contractor accountable.

Raveling. I would say that almost all raveling is a result of segregation that occurred at the time of placement. Either it's from thermal segregation, or an actual physical segregation of aggregate sizes occurred. Those areas of the pavement tend to oxidize more quickly and the fines get pulled out faster. So raveling is a problem that was built into the pavement from the start by segregation.

Stripping. Stripping is not so much a problem anymore. In the past, it seemed like it was a pretty frequent issue. Generally the problem was that they weren't using lime to ensure a good bond between the asphalt and the stone. But there again, the Hamburg wheel-tracking test will pretty well call out whether a mix is stripping susceptible.

Pot Holes. I guess the biggest issue here is whether or not you have sufficient structure under the surface layer. Pot holes could develop, for example, if you have localized segregation. Water gets through the pavement, softens up the base, and then once the base is soft there is not enough structure there anymore to support wheel loads, so the top pavement layer breaks up and pops out. The other issue is when you have an area where the surface hot mix has debonded from an underlying lift of hot mix. You can have a similar kind of situation develop there. Although you won't have exposed the base in that type of situation, you will have exposed the underlying hot mix when the surface material pops out.

Key Words, by Category:

Geographic Area – Statewide

Information Type – Legacy knowledge

Legacy Knowledge Source – Joe Leidy, June 2006 interview

Analyses Involved – Hamburg wheel-tracking test (Tex-242-F), overlay tester, tack coat pull-off device (Tex-243-F), boot heel test

Flexible Pavement Distresses Involved – Rutting, transverse cracking, longitudinal cracking, random cracking, alligator cracking, pavement tearing, raveling, segregation, stripping, potholes

Other Descriptors – Asphalt concrete pavement, ACP, mixture design, pavement design, pavement compaction, air voids, reflection cracking, jointed concrete pavement overlay, JCP overlay, stabilization, vibratory roller, oxidation, causes of failures, fatigue cracking, thermal segregation, physical segregation, debonding, tack coat, mechanical properties

Search Acronyms: Legacy Knowledge – Flexible Pavement – Forensics, lkfpf, Legacy Knowledge – Flexible Pavement – Mix Design, lkfpmd, Legacy Knowledge – Flexible Pavement – Construction, lkfpc, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Unique Application & Innovation, lkfpu, Legacy Knowledge – Flexible Pavement – Maintenance, lkfpm, Top Reference Collection – Flexible Pavement Forensics - trcfpf

Legacy Knowledge

Marshall Huffman: May - 2006

Marshall Huffman's Thoughts on ….

Flexible Base Failures
Career Reflection and Advice

The early base failures or the failures in pavement will generally be because of wet spots, or a spot that was wet and covered up. What can happen is that some of the base may be a little wetter than other parts, and if everybody is in a rush, all of it may not be dried out before they move on to the next layer. Sometimes the moisture may be down deeper in your subgrade or embankment.

I can tell you about a construction job that happened after I left the department. It's a highway that I sometimes drive. I know exactly why it rutted and failed. The base was also not a higher quality base, so that was some of the problem, but I know that it was moisture in it that caused the failure.

When it comes down to it, quality in the construction process is a hard thing to achieve and achieve consistently. It depends on the contractor's personnel, the contractor's equipment, highway department personnel, experience, work ethics, and a whole host of things that could cause quality to break down. All these things have to work for you to get good quality consistently. And so it's hard then to blame a pavement that fails on just a material or the environment or the design. It's hard to blame that on those things unless you are absolutely sure of the quality of the construction.

Well, it was a very satisfying life achievement to be able to build roads, good roads. And, you just need to be conscientious about what you do, interested in what you do, and learn as much as you can about what you are trying to do. Always be able to see the larger picture. I think that was probably one conflict I always saw between say the district laboratory and the chief inspector and the contractor. They each had a little bit of a narrow focus on what their job was. They didn't necessarily see the big picture all the time.

Key Words, by Category:

Geographic Area - Odessa district, west Texas

Information Type - Legacy knowledge

Legacy Knowledge Source – Marshall Huffman, May 2006 interview

Analyses Involved – Moisture content (Tex-103-E)

Flexible Pavement Distresses Involved – Rutting, base failure

Other Descriptors – Flexible base, subgrade, embankment, job control, career advice

Search Acronyms: Legacy Knowledge – Flexible Pavement – Materials, lkfpmat, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Construction, lkfpc

Paul Krugler's Thoughts on ….

ACP Rutting Prevalence in the 1980's
Historical Texas Mix Preferences and Practices

I would like to talk about some of what I saw and learned during my early and middle years with TxDOT. I moved over to the bituminous section of the Materials and Tests Division in 1979, became responsible for the section in 1982, and didn't leave that area until 1993. So I saw pretty much everything that was going on for about 14 years in the hot mix materials area of TxDOT business. And those were some interesting years. There were a lot of major changes made.

It was much more common back in those years to have problems with rutting, wheel path rutting. We usually didn't get called at the Materials and Tests Division to go out and look at a rutted pavement unless it was fairly severe. The ruts might be an inch deep. They might be two inches deep sometimes. Looking back, there were a variety of reasons for having more rutting then than we do now. The number of trucks and overweight vehicles out there were steadily increasing. At the same time, we were using a softer asphalt, and we were certainly using mix designs that had much less stone-on-stone contact. The Item 340 Type D mix was by far the most frequently used mix type in the late 1970's and well into the 1980's. The gradation requirements for Type D mix back then were about the same as they are today for Type D. It was a pretty fine mix. With the finer mix, and since we used a lot of AC-10 asphalt at the time, it's not a surprise I guess that we had more rutting.

A result of the more frequent rutting was that we had more opportunities than we would have preferred to develop forensic investigation skills on rutted pavements. We didn't refer to them as forensic investigations at the time, that's a relatively new term. We called them field service projects in the Materials and Tests Division. But the purpose was the same. We would try to figure out what was causing the premature pavement failure and offer some alternative suggestions to the district for rehabilitation.

The fine aggregate we were using in mixes then was also a factor. We didn't have a specification requirement to limit the amount of field sand until much later. There were even a few mixes made during that period that didn't include any crushed stone screenings at all. A typical mix did have some stone screenings, though, and the field sand percentage would be 15 percent or so. Since field sands are mostly sub-rounded or rounded particle shapes, we had just a whole lot of little ball bearings in many of our mixes. So the higher field sand contents didn't help out mix stability in the summertime.

Something else about those mixes is that the asphalt content tended to be lower. It wasn't always lower than what we see now, but it definitely tended to be lower. That was probably due to having more passing No. 200 material in those mixes. It was rare that the contractor used a washed stone screenings. So the typical blend of screenings and field sand had more passing No. 200 material than we see now, and it also had more field sand in it than we typically see now. The amount of passing No. 200 in the mix probably had a lot more effect on asphalt content than how much field sand the mix had in it. As I recall, asphalt content for Type D mixes would usually be in the area of 4.5 percent, give or take. Then in the Type C and the Type B mixes, which were the coarser mixtures, the asphalt content would typically be a half to one percent lower than that.

A typical overlay thickness back in the 1970s and 1980s was one inch. One and a half inches was a good, thick overlay. And a two-inch placement was rare. When they needed to place two inches of hot mix, they typically placed an inch lift first and called it a "level-up course" and followed that with another inch on top. The thought was that this gave a smoother ride, but we didn't really know how much it helped in those days, because we weren't checking ride quality or smoothness except occasionally with a 10-foot straight edge. As we moved to in-place density control, we started to see the overlay thicknesses and individual lift thicknesses for thicker pavements increase to one and a half and two inches. Including ride quality in the specifications also pushed us to call for thicker overlays.

Key Words, by Category:

Geographic Area – Statewide

Information Type – Legacy knowledge

Legacy Knowledge Source – Paul Krugler, July 2006 interview

Analyses Involved – Mix Design (Tex-204-F), ten-foot straight edge

Flexible Pavement Distresses Involved – Rutting

Other Descriptors – Asphalt concrete pavement, ACP, historical pavement performance, low asphalt content, AC-10, thin overlay thicknesses, lift, Type D, Type C, Type B, level-up course, field sand maximum, washed stone screenings, ride quality, in-place density control

Search Acronyms: Legacy Knowledge – Flexible Pavement – Forensics, lkfpf, Legacy Knowledge – Flexible Pavement – Mix Design, lkfpmd, Legacy Knowledge – Flexible Pavement – Specifications, lkfps, Legacy Knowledge – Flexible Pavement – Materials, lkfpmat, Legacy Knowledge – Flexible Pavement – Design, lkfpd