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16. Abstract

This report describes the most current tasks developed under Research Project 0-1778 of the Texas Department of Transportation. The report focuses on the description of the CRCP sections contained in the Rigid Pavement Database, which compiles 26 years of information about representative pavement sections spread across the state. A demographic analysis of the CRCP sections in the database, achieved and pursued tasks, and recommendations are among the topics treated herein.

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Updated Status of the Continuously Reinforced Concrete Pavement Database in Texas: Improvements and Trends

Cesar Ivan Medina Chavez
Terry Dossey
B. Frank McCullough

Research Report 1778-2

Research Project 0-1778
TxDOT Rigid Pavement Database

Conducted for the
Texas Department of Transportation
by the
Center for Transportation Research
Bureau of Engineering Research
The University of Texas at Austin

May 2000
Revised February 2003

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Research performed in cooperation with the Texas Department of Transportation.

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1. Introduction

1.1 Background

This report is an update on Research Project 01778 "The Rigid Pavement Database", conducted by the Center for Transportation Research (CTR) of the University of Texas at Austin and funded by the Texas Department of Transportation (TxDOT). As is well known, this Rigid Pavement Database (RPDB) project contains vast information of a selected group of test sections that represent the Portland Cement Concrete Pavement (PCCP) network in the state of Texas. Condition surveys have been regularly conducted for the last 26 years, and this invaluable information has facilitated the understanding of pavements' performance and the effect of different variables on them. Additionally, as a result of this research project, some special studies have emerged focusing on different variables like aggregate type and placement season of concrete pavement. This report briefly documents some of those studies that have been and are still conducted by the Center for Transportation Research. For previous information or data related to this project, CTR's series reports 1908, 1342, 1244, and 472 might be reviewed for details.

1.2 Objectives

The goal of this report is to document and provide information about activities connected with the RPDB. Ongoing activities that need to be tracked are cited and highlighted throughout the different chapters. Particular attention has been paid to special research studies that either have emerged from this RPDB project or have been incorporated into this project because of their relevance and have enriched the contents of the RPDB itself.

1.3 Methodology

To accomplish the goal of this report, the chapters contained herein report or describe different tasks as follows:

Chapter 2 describes the demographics of the data collected up to date. This demographics description is carried out through the display of charts that summarize the status of the database. This chapter also explains if changes were made in the population of sections conforming the database and the reasons for those changes.

Chapter 3 briefly describes the two main components of the RPDB, the Inventory Data and Performance Data. It explains the evolution of these data and reports any relevant information related to data collection. Additions to the RPDB, are briefly included and details are covered in the appendices.

Chapter 4 describes the tasks that have been pursued to complete full access to TxDOT's Pavement Management Information System (PMIS) database and generation of reports.

Chapter 5 contains conclusions and recommendations.

2. Demographics of the Database

2.1 Description of Data

This section displays the evolution of the data contained in the RPDB. This information is known as inventory data and it changes only when sections are surveyed and added to the database. It contains basic information of the pavement sections and is considered valuable information because it provides with a broad idea of the pavement sections population.

Among the inventory data included in the database are: district number, county name, highway name, reference markers, global positioning system coordinates (GPS), number of lanes per surveyed roadbed, surveyed lane, highway geometric characteristics (alignment and roadbed), coarse aggregate type, construction date, pavement thickness, and climatic information. All these data are contained in the database for all the CRCP sections surveyed so far and are included in Appendix A.

2.2 Evolution of the Database

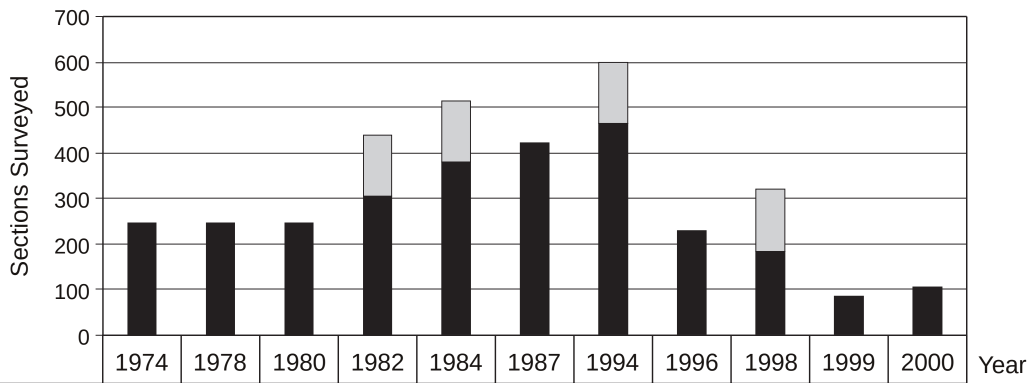
The history of the RPDB goes back to 1974. Since then, different condition surveys have been conducted every year. Table 2.1 summarizes the evolution of condition surveys of Continuously Reinforced Concrete Pavements (CRCP) conducted and it also displays what type of data was collected every year.

Table 2.1 Data collection history for CRCP sections

Distress	Type	Severity/ Extent	1974	1978	1980	1982	1984	1987	1994	1996	1998	1999	2000	2001	2002
Cracking	Transverse	Spacing						x	x	x	x	x	x	x	x
	Longitudinal	Length	x								x	x	x	x	x
	Spalling	Minor	x	x	x	x	x				x	x	x	x	x
		Severe	x	x	x	x	x				x	x	x	x	x
	Alligator	Minor								x	x	x	x	x	x
		Severe								x	x	x	x	x	x
	Block	Minor								x	x	x	x	x	x
		Severe								x	x	x	x	x	x
	Faulting	Minor									x	x	x	x	x
		Severe									x	x	x	x	x
Corner Break										x	x	x	x	x	x
D-Cracking											x	x	x	x	x
Rutting		Shallow								x	x	x	x	x	x
		Deep								x	x	x	x	x	x
Patching	AC	0-50 ft^2	x	x	x	x	x	x	x	x	x	x	x	x	x
		51-150 ft^2								x	x	x	x	x	x
		>150 ft^2								x	x	x	x	x	x
	PCC	0-50 ft^2	x	x	x	x	x	x	x	x	x	x	x	x	x
		51-150 ft^2								x	x	x	x	x	x
		>150 ft^2								x	x	x	x	x	x
Punchout		Minor	x	x	x	x	x	x	x	x	x	x	x	x	x
		Severe	x	x	x	x	x	x	x	x	x	x	x	x	x
GPS coordinates											x	x	x	x	x

As shown in Table 2.1, the type of information collected has varied with time. During the 1970s and 1980s the collected distresses included longitudinal and transverse cracking patterns, spalling, punchouts, and patches; it was not until the late ’80s and early ’90s that more detailed information was collected, including crack spacing, overlay status, and distresses for overlaid pavements. It was not until the late ’90s that GPS coordinates were incorporated into the database and the redundant method (locating a section on the pavement with paint, mileposts, and GPS data) was applied for different reasons including available technology, repeatability, and usefulness.

Figure 2.1 shows the number of sections that have been surveyed each year and displays information about both Jointed Concrete Pavement (JCP) and CRCP sections. The number of sections surveyed each year has varied depending on the level of funding and reliability of the collected data, among other factors.



	1974	1978	1980	1982	1984	1987	1994	1996	1998	1999	2000
JCP	0	0	0	135	135	0	135	0	137	0	0
CRCP	246	246	246	304	380	423	463	230	184	79	105

Figure 2.1 Condition surveys conducted from 1974 to 2000

2.3 Demographics of the Database

As is customary, and as per the request of the project director, every report is prepared for the RPDB project includes a section showing the progress made in terms of surveyed sections. Report 2952-2 included demographics of the sections' population collected back in 1995 and 1996 and stated at that a more comprehensive analysis was going to be conducted in the near future. Thus, this section of the report shows the characteristics of the CRCP test sections surveyed during late 1998, 1999, and 2000. The analysis though, does not include all the sections surveyed up to the present, but it includes the sections that have been consciously reviewed and compared to previous years' information.

2.3.1 Overlaid and Non-Overlaid Sections

This information is relevant because it provides accurate information about the number of sections that are or have been overlaid. Once a section is overlaid, its distress evolution (performance) should be carefully monitored and interpreted; major maintenance or rehabilitation activities not considered in the distress progress evaluation may yield absurd results when the section is analyzed for two or more different years. In this report a total of 236 sections are included in the analysis. The overlaid sections represent 61 percent of those sections, the non-overlaid sections are the remaining 39 percent. Figure 2.2 shows the distribution of the sections.

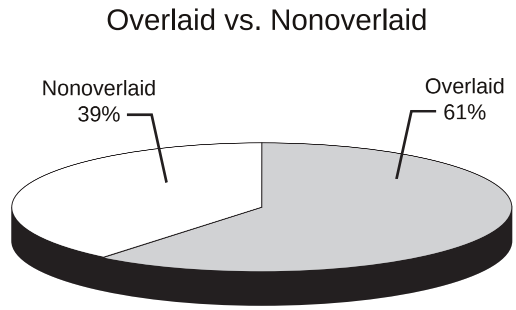


Figure 2.2 Overlaid and non-overlaid sections

2.3.2 Pavement Age

The pavement age parameter is a good indicator of the need for selection of new pavement sections. By continuously checking this type of data researchers can make prompt decisions in order to avoid biased or skewed results when analyzing the performance of particular old sections in the database. Of the sections included in the analysis, the youngest is 11.1 years old, the oldest section is 50.5 years old, and the median age for the group is 30.4 years. Figure 2.3 shows the age distribution of the sections and their cumulative percentages.

Figure 2.3 Age distribution of CRCP sections (overlaid and non-overlaid)

2.3.3 Slab Thickness

As was previously mentioned, the median age for the analyzed sections is 30.4 years. The slab thickness parameter here can be well correlated to the age distribution of the sections and can help understand why most of the sections in the database are 8 in. thick.

Most of the old CRCP sections were built using that thickness as per the specifications. Newer sections are thicker and this might be a good reason to add newer sections thicker than 8 in. to the database. Figure 2.4 shows the slab thickness distribution of the sections.

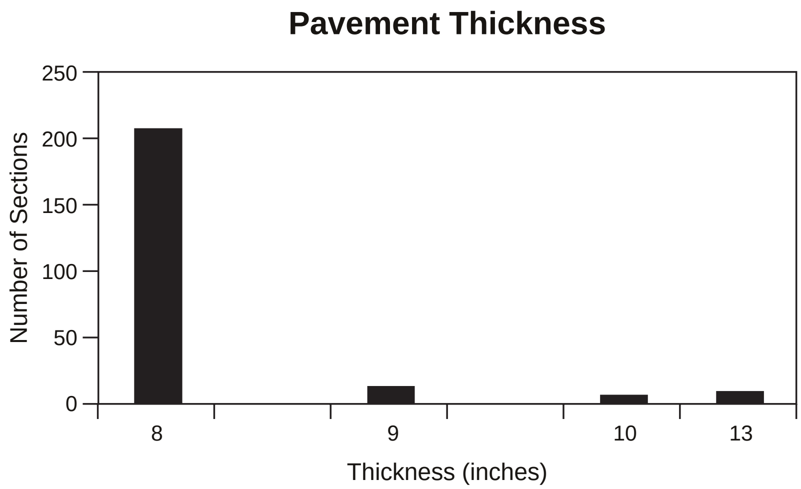


Figure 2.4 Slab thickness distribution (overlaid and non-overlaid)

2.3.4 Coarse Aggregate Type (CAT)

The two most commonly used concrete pavement aggregates in Texas are silica-based aggregates (e.g, siliceous river gravel), calcium based aggregates (e.g, limestone); and a combination of both. In a few cases a special aggregate or combination has been used for special studies. The coarse aggregate type (CAT) parameter is always a good variable that has been used for performance comparison between the two types of aggregate. Research Report 1778-1 showed that sections containing siliceous river gravel (SRG) performed almost as well as those sections built with limestone (LS), but those sections were JCP sections. In contrast, different analyses conducted for CRCP sections have demonstrated that LS performs better than SRG, especially under certain circumstances (e.g, particular construction seasons and construction techniques). Figure 2.5 displays the distribution of the sections containing the different aggregates.

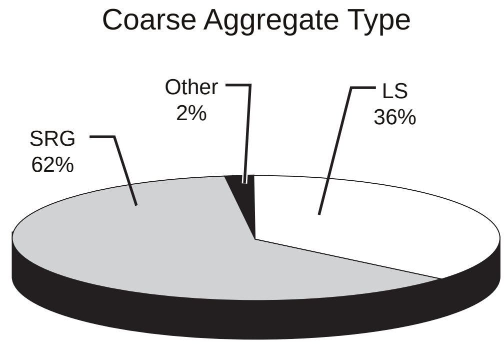


Figure 2.5 Coarse aggregate type (CAT) distribution (overlaid and non-overlaid)

2.3.5 Roadbed Type Distribution

Studies performed in the mid 1980s suggested that sections located in transition profiles (e.g, near overpasses) did not perform as well as sections located in fill, cut, or at grade profiles. It may be necessary to conduct more research on this matter because it has not fully been proved that roadbed is a variable of significance in a pavement's performance. Figure 2.6 shows that the majority of the sections in the CRCP database are located at grade and only a few are located in a transition profile.

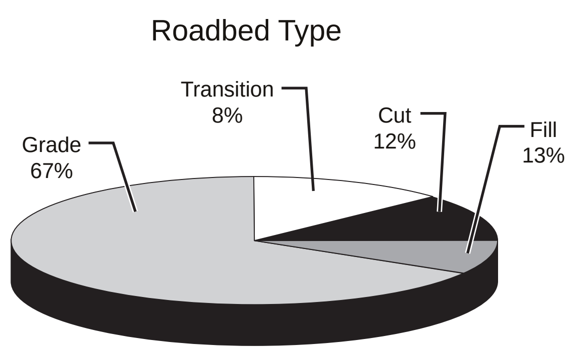


Figure 2.6 Roadbed classification distribution (overlaid and non-overlaid)

2.3.6 Highway Functional Classification

Another parameter analyzed herein is the location of CRCP sections within the highway network. It may be beneficial for research purposes to identify whether sections are located on either interstate highways (IH), US highways, or crowded loops in urban areas. By identifying this characteristic, researchers could better categorize the influence of other parameters such as traffic intensity on a pavement's performance. The parameter of location within the network is related to the topography of the state of Texas and to the use of CRCP pavements on heavy-traffic roads. Figure 2.7 shows the distribution of sections in the highway system.

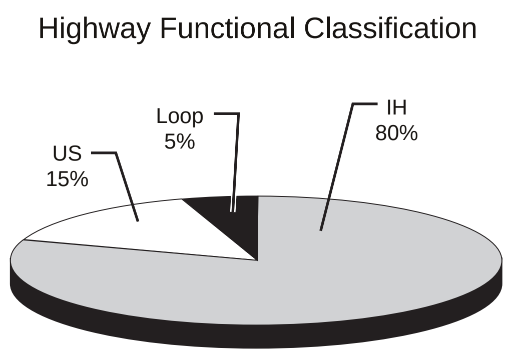


Figure 2.7   Highway functional classification and sections location (overlaid and non-overlaid)

3. Data Collection Process

3.1 Inventory Data

As it was mentioned in Chapter 2, the inventory data included in the RPDB are: district number, county name, highway name, reference markers, global positioning system (GPS) coordinates, number of lanes, surveyed lane, geometric characteristics (alignment and roadbed), coarse aggregate type (CAT), construction date, pavement thickness, and climatic information. All this information is stored in the database for all the sections surveyed each year. Appendix A contains a list of the CRCP sections surveyed. This data can be accessed via file transfer protocol (FTP) providing a username and a password.

3.2 Performance Related Data

Performance related data of the sections is collected in the field according to the project's field plan schedule and using condition survey forms. The parameters recorded might vary for two different years, and that depends on the amount or type of information that needs to be collected. The amount of collected information often depends on available budget, time to conduct surveys, and especial recommendations from researchers regarding specific distresses of the sections. Among the distress data collected every year are asphalt concrete or Portland cement concrete patches, punchouts, potholes, spalling, D-cracking and corner breaks (for JCP's), and also longitudinal cracking and transverse cracking. As in the case of the inventory data, this data can also be accessed via FTP.

3.3 GPS Data Collection

Since 1998, the implementation of a global positioning system (GPS) technology has been successfully used in this research project to locate the pavement sections in the field. Even though the equipment used in this project has limitations, the relocation of the sections has been much easier than it used to be, when GPS technology was not used. The continuation of use of the GPS equipment is advisable and acquisition of a better device is justifiable, given that the current equipment presents occasional problems while operating.

At the time of writing this document the Jointed Concrete Pavement (JCP) sections of the RPDB have been completely surveyed and more than 95 percent of the 137 sections have been assigned with GPS coordinates (latitude and longitude). Likewise, of the existing

488 Continuously Reinforced Concrete Pavement (CRCP) sections, nearly 90 percent have been surveyed and almost the totality have been assigned GPS coordinates.

GPS coordinates are not assigned only when for some unknown reason, the currently available device displays no reading. A reconfiguration of the device is necessary when this problem arises. Additionally, it is necessary to displace the device from one point to another in the van or vehicle so that it will better receive the satellites' signal. In summary, the main problem that the malfunction of the device is causing is a time delay while in the field, but the positive side is that the failure happens only occasionally.

3.4 Review of Reference Markers

All the surveyed sections since 1998 have updated information about reference markers. The procedure described in the PMIS Rater's Manual (Reference 3) has been used as a guideline and reference markers have been assigned with that recommendation. In the past, many sections used to be referenced to bridges, streets, and even traffic signs, which in reality did not give an accurate and compatible location of the sections to the PMIS grid system. As mentioned above, nearly 90 percent of the existing CRCP sections have been surveyed, and all the sections have been checked or reassigned reference markers according to the PMIS criteria. The redundant method of assigning a GPS location and a reference marker has been found to be a reliable procedure that provides an accurate location of the sections during condition surveys. Nowadays, every time a survey is performed the time savings and the confidence level that a section is really located at some point on the highway are remarkable.

Among the performed tasks related to reference marker location, the elimination of some sections from the database has been carefully managed. There are different reasons for which a section can or should be eliminated from the database, but probably the most important reason involves a safety issue. Districts or highway routes with outstanding traffic volumes have been candidates for this determination. The Dallas and Fort Worth districts where some of the removed sections were located are good examples. In almost all the cases, sections have been removed from the database because they are located close to either an exit ramp or merging ramp, where the traffic volumes are usually high. Another reason why sections have been removed from the database is the out-of-range discrepancy between already available data related to the section and the found field conditions. As an example, three sections were removed from the San Antonio district because, according to the existing data, the sections were located in a tangent span of the highway and a roadbed classified as at-grade, but in reality the sections were found in an area of overpasses on IH-37.

Another common reason for which some sections were removed from the database was the fact that the previously available information about some sections' reference markers was completely different from the reference markers found on the highway. A particular route that presented this problem is US-287, where the sections were never found in the northern counties of Texas, including Childress and Wichita Falls.

3.5 Miscellaneous Tasks

This section summarizes some of the tasks that reflect the progress achieved in the management of RPDB. Most of these tasks were fully described in References 1 and 2.

Among the tasks that have been pursued in this project, is the accurate evaluation of the sections and their location in the field. This task has been achieved by several means, including the preparation of a new condition survey form that can be used to survey any type of pavement, whether it is overlaid, JCP, CRCP, or any other type. The form has a layout that rates the pavement section and distresses in a very easy and readable way.

Another task that has been improved is the planning of the field trips. In the prior past, the field trips usually were conducted in a more disorganized way. Sections were surveyed without any previously elaborated plan. Nowadays, the field trips are planned ahead in such a way that the time spent on the highway is used in the best way possible. Surveyors compile district plans and sections information and then carry out a well scheduled field plan in order to avoid driving back while on the highway or forgetting to survey specific test sections. The accurate reference marker availability is a major factor that avoids problems in the field and helps optimize time.

As an additional effort that began with the interaction of information available from the database and other special studies, satellite factorials have been created and now are now part of the RPDB. A detailed description of the satellite factorials and their content are given in Appendix B of this report. The included satellite factorials are:

1. The sections from Project 1244 in Houston
2. The sections from Project 3925 in Houston
3. The sections of the quality control and quality assurance (QC/QA) projects spread throughout Texas
4. The sections of the 70 ksi reinforcement steel projects in Houston

Finally, Chapter 4 of this report focuses on other activities that are being conducted under this study. The activities include the creation and maintenance of a photodatabase that show visual conditions and description of distresses commonly found in pavements. Likewise, access to TxDOT Pavement Management Information System (PMIS) database via the Internet is described.

4. Further Tasks Related to the RPDB

4.1 Access to TxDOT PMIS Database

Among the tasks that have been strongly pursued in this project, gaining access to the TxDOT PMIS database is one that has taken more time than expected. At press time, Internet access has been gained, but for several reasons, it is still not possible to print reports.

According to the original plan, access to the PMIS database would help accomplish the following goals:

1. Compare the information contained in the PMIS database to that in RPDB to trace, complement, and prevent potential incompatibilities of the two sources of information.
2. Analyze the available information and decide which sections may need to be monitored more closely.
3. Generate reports that would provide vast information about construction projects or test sections. That information would be essential to potential special research studies.

4.1.1 Accessing and Browsing the PMIS Database

TxDOT PMIS management staff have provided access to the PMIS database via Internet through a secure mode. However, the printing capabilities in a remote printer (one not located at TxDOT facilities) are still presenting some problems at press time.

One may gain access to the PMIS database and generate reports by following the next procedure:

Using an Internet browser (Internet Explorer 3.0/Netscape 3.0 or newer versions), one should visit the site http://oc.dot.state.tx.us:2080/. Once in that location, the user should select the mode “3270-Mod 2” to start a new session. That is the default mode that should be used when one accesses the mainframe from a PC. Then the start button should be clicked. This will allow the user to begin with the session.

Figure 4.1 shows the layout of the window that appears when a user logs in to this site.

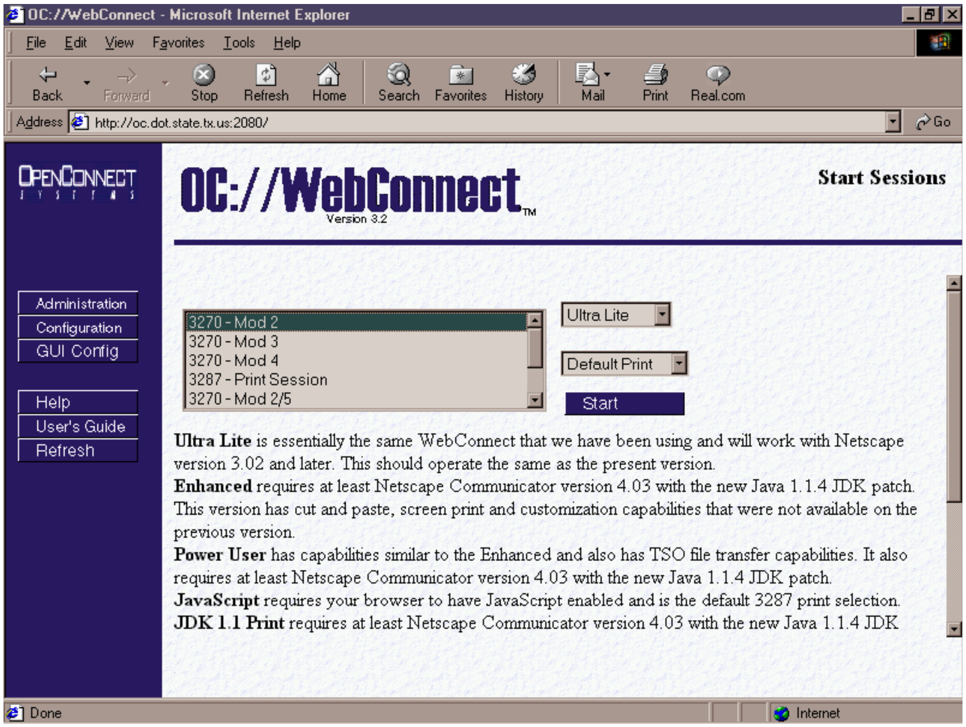


Figure 4.1 Layout of initial PMIS log-in window

Once the TxDOT computer system is accessed, it is necessary to get into the CICS[1] platform by typing CICS at the cursor prompt and pressing the enter key; then a user name and password should be provided. Right after this process is completed, the next command to be input is NAT2, followed by the enter key. Entering this command allows the user to input the security log-in information. Figures 4.2 through 4.4 display the windows that pop up when this process is followed.

[1] CICS is an application server that provides industrial-strength on-line transaction management for mission-critical applications.

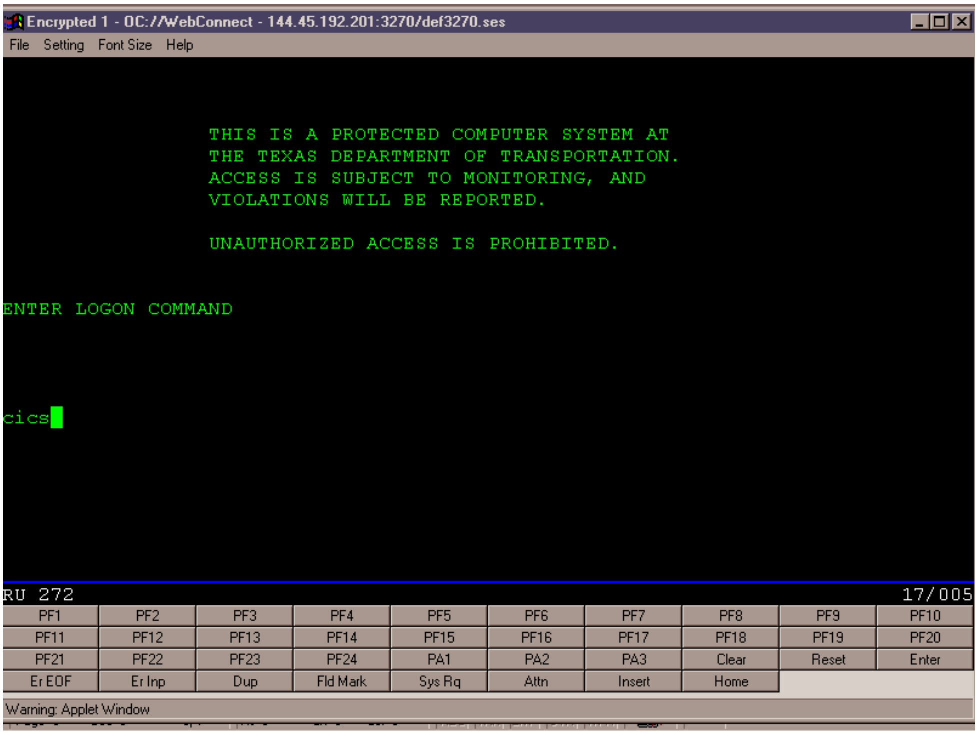


Figure 4.2 Window providing access to the CICS platform

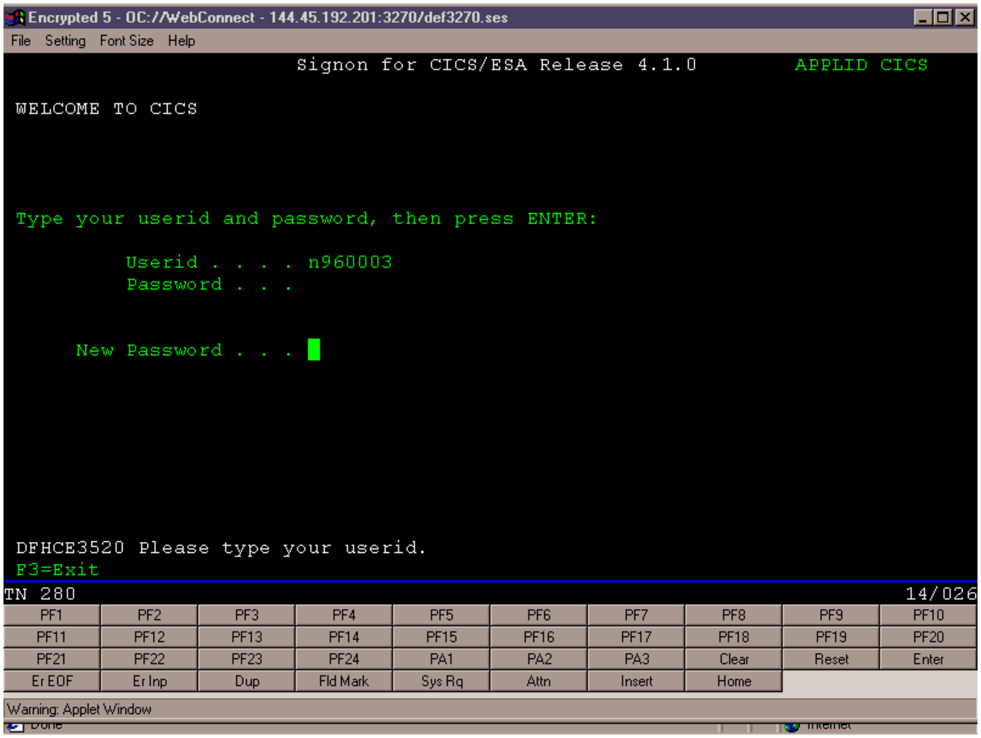


Figure 4.3 Access to the mainframe secured by providing a user name and a password

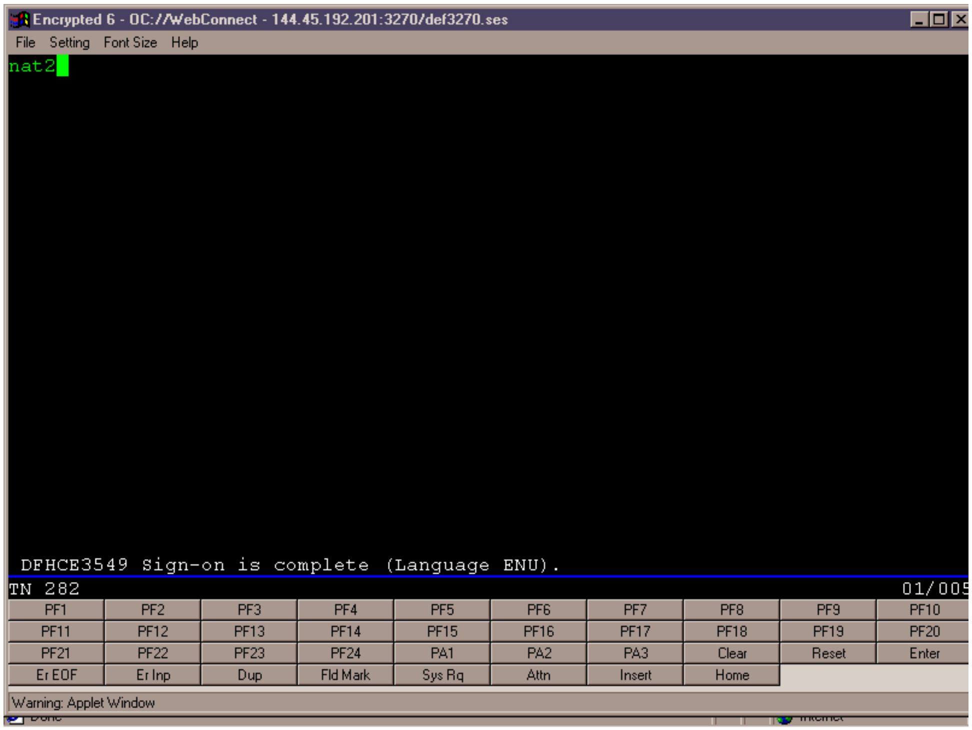


Figure 4.4 Final window to access the PMIS system

The next step in the process is to request access to the PMIS database, which is done by typing the command PMIS at the cursor prompt. Next the main PMIS database window appears. Now the user should follow the on-line guide to browse the information and then generate reports. Figures 4.5 and 4.6 show the windows that are displayed when all the previously described steps are achieved.

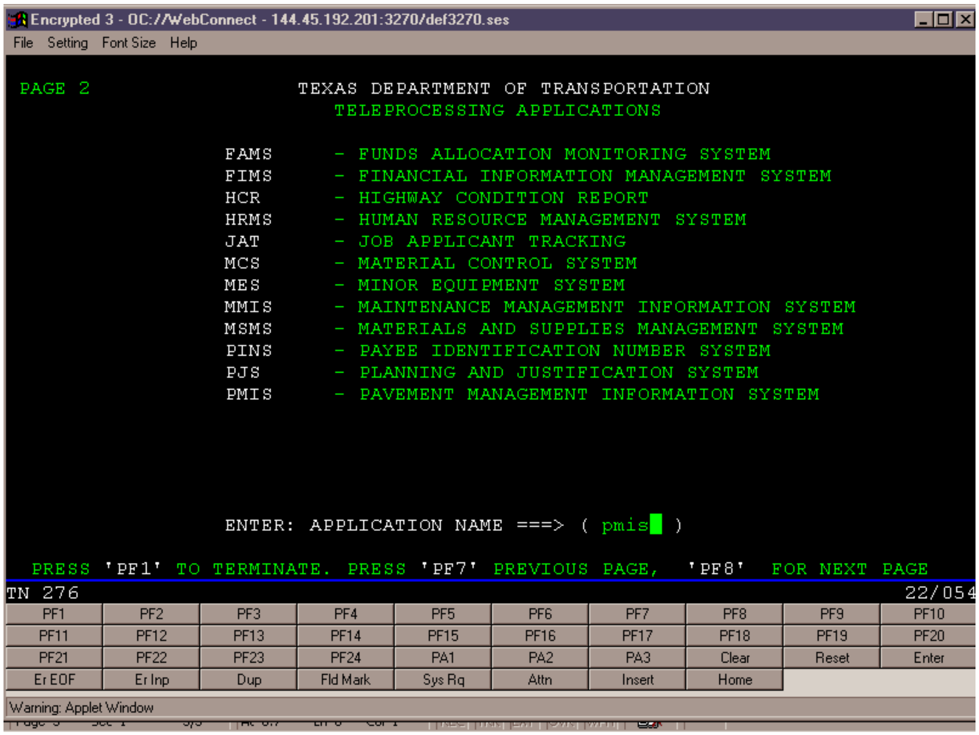


Figure 4.5 Window showing command to access the PMIS database

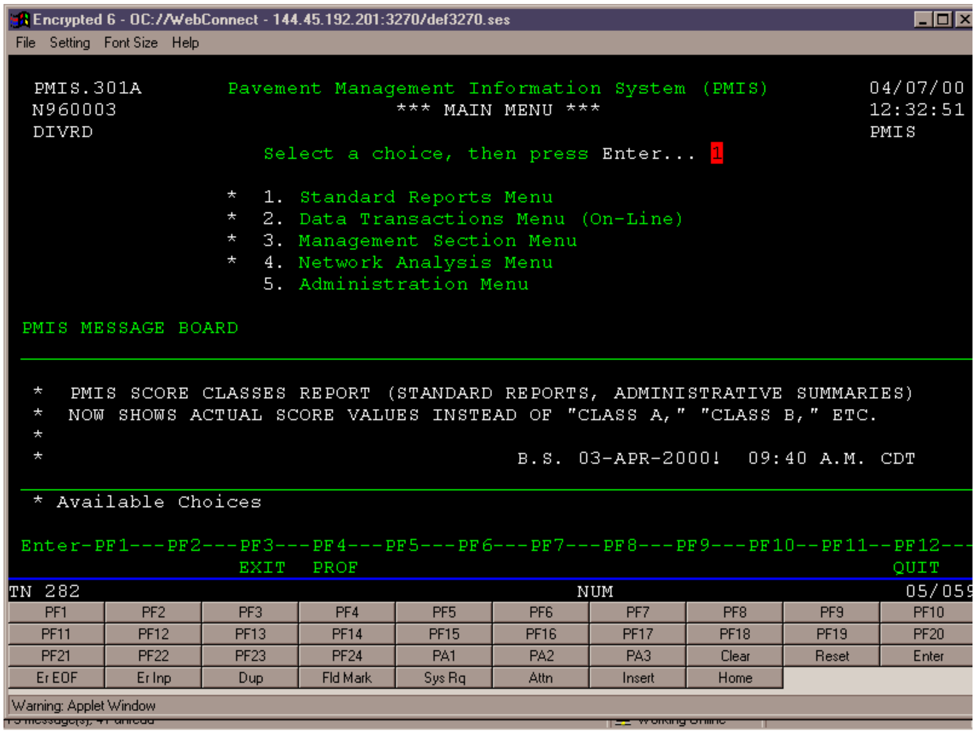


Figure 4.6 Main menu of the PMIS database

4.1.2 Printing on a Remote Printer

As part of the tasks planned for the PMIS database, the generation of reports showing data related to the test sections and printed reports is being evaluated. The first part of this assignment has been completed, and generation of reports is now possible, but the printing possibilities are not finalized. According to the guidelines received from TxDOT, a procedure to get a remote printer to generate reports can be summarized as follows:

1. Using an Internet browser, go to the site http://oc.dot.state.tx.us:2080/
2. Select the icon 3287 – Print Session; and click Start
3. A second window will pop up. Click Help on the menu bar, then click Help Desk
4. Locate the line that reads "Device Name: OC2W3231" or something similar. This is the remote printer name for the ROSCOE system, and it should be written down. It may be useful to leave these two windows open, but they may be minimized
5. Go back to the site http://oc.dot.state.tx.us:2080/ and click on "3270 – Mod 2" then click Start
6. This will grant access to TxDOT's mainframe
7. Create data/report using CICS
8. Once the job(s) has/have been submitted through CICS, it is necessary to sign off of CICS and begin a ROSCOE session
9. Sign onto ROSCOE and, once in, type at the top of the screen the command "pmis"
10. At the prompt, type the CICS User ID (This was listed when the job was submitted on CICS) and then press the enter key
11. At the job listing, type in "V" for view, for the job that wants to be seen, and press Enter
12. At the top of the screen showing the report, type "Print Des OC2W3231" (without quotes). Change the number to match the one described above in step

4. Press Enter. This will bring up a blank OC://WebConnect screen. Keep pressing the enter key until the whole job is on the screen

13. Once the complete job is on the screen, on the menu bar click File then Print
14. The job should be sent to the default printer in the PC, or another printer may be selected

Even though these steps have been followed so that previously generated reports could be printed, there are still some software or hardware related problems in getting a remote printer to print the reports.

4.2 Photo Database Development

An interesting and valuable endeavor that has been continuously updated is the compilation of photographs showing different characteristics of PCC pavements; this effort has resulted in the creation of a photo database that is linked to the RPDB. The photo database compiles a series of digital images that have been captured during condition surveys. The filed images contain different features of PCC pavements and can be categorized into two main groups: panoramic photographs, and photographs showing concrete pavement distresses.

Even though there are presently no guidelines for the field crew to follow when taking pictures in the field, this section of the report provides with some instructions for gathering useful photo images for the database. Photographs should be taken in the following cases:

1. Every time a field crew goes to the highway to collect information about a construction project or any sort of maintenance or rehabilitation activities.
2. Every time sections included in the RPDB are surveyed. It may not be necessary to take photos of every single section, but sections in which one or more characteristics are relevant (such as the number and types of distresses, and good or bad crack spacing) should definitely be included in the photo database.

3. In cases where distresses are beginning to develop (e.g, punchouts, and spalling) it is important to document and link the photograph to the condition survey information.
4. When a concrete pavement section is in very good or very bad condition, panoramic and localized photos should be taken. In these cases, it is very important to make some comments about the aggregate type that was used in the concrete mix (either LS or SRG, or another type of aggregate if it is the case). Any other information that may be known about the section must be documented.
5. The use of special equipment used to measure some properties of concrete or pavement should also be captured in images. Crack width data collection, coring of the pavement, deflection measurement with Falling Weight Deflectometer (FWD) or Rolling Dynamic Deflection (RDD) vehicle, and other laboratory tests are good examples.
6. Any other conditions in which useful images could be obtained are left to the experience of the field crew that is in charge of the data collection.

The photo database has been created using Microsoft Access, which is believed to be the most appropriate format and can be linked easily to the existing RPDB.

4.2.1 Layout of the Photo Database

Although this photo database has a very simple format, it contains browsable information about many sections. The existing fields include:

1. Identification number (ID) - this is a progressive list of numbers that is used by Microsoft Access as a primary key and is used to link the different tables that have been created for the RPDB.
2. JPEG number - this number corresponds to the image number (JPEG format) or photo number that is filed in the database. As more photos are incorporated into the database, this list of numbers increases. Additionally, this specific column has a hyperlink, and when a number is clicked with the computer's

mouse, the image that corresponds to that selected number opens in a new window, showing the stored photograph.

3. CFTR number - the number shown in this field corresponds to the RPDB identification number of the section. Usually, the first one or two digits of this number correspond to the Texas district number. When the photo does not correspond to a section included in the RPDB, then the words NO CFTR are typed.
4. Description - this column gives a brief report of what is shown in the image. Usually it mentions the highway, the city, or another feature of the photo.
5. Pav Type - this field classifies the pavement section in the photo as a JCP or CRCP.
6. Pav Condition - this field subjectively describes the condition of the pavement when the photo was taken. Typical conditions include Very Good, Good, Fair, Poor, Very Poor, and Not Shown when the photo is not showing the condition of the pavement.
7. Distress Highlighted - this field describes the distress shown in the photo.

Figure 4.7 displays a layout of the screen of the Microsoft Access photo database and its different fields.

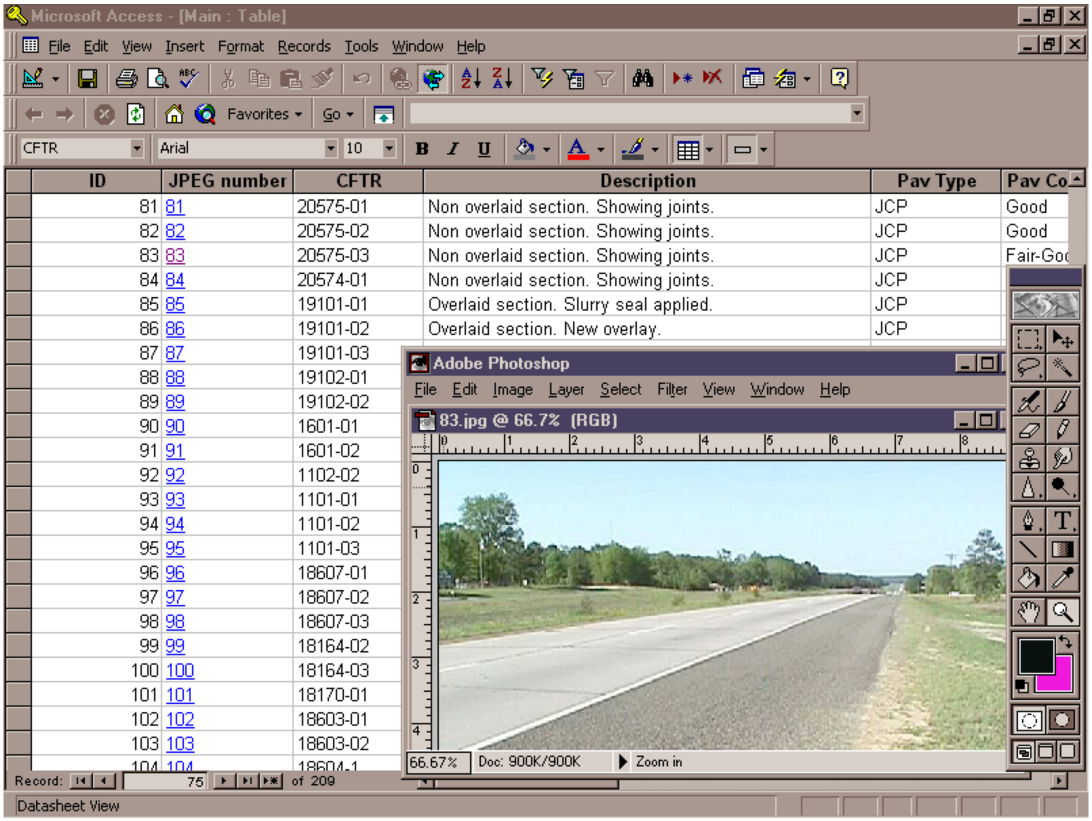


Figure 4.7 Layout of the photo database

5. Conclusions and Recommendations

5.1 General Conclusions

This report has discussed most of the activities that have been and are being conducted for the RPDB project. Many of the planned activities have been successfully completed, and some other tasks are still pending and require special attention. It is not an easy task to manage the RPDB, it requires a comprehensive knowledge of the information that the database contains, which has changed in format in the 26 years of its existence.

5.2 Achieved Activities

Among the tasks that have been a continuous workload for this project and that have been fully completed or implemented are the following:

A cleaning process of the inventory data for all sections has been established. This includes the JCP sections and the up-to-date surveyed CRCP sections (around 90 percent). All the data for these sections has been checked and typed into electronic files so that it is ready to be used for any purpose (e.g, demographic analysis, distress analysis, or special research studies). The information is readily available in different formats including Microsoft Excel, Access, and SAS.

Climatic data for all the sections has also been retrieved and processed by different means (References 1 and 2). This climatic information has been incorporated into the electronic database and is linked to the inventory and performance-related data. This task is relevant because the climatic variables have a major impact on the early and long-term performance of concrete pavement and may be used in special research studies.

A photo database has been created and linked to the existing RPDB. This photo database provides with invaluable graphic data that allows for easy identification of pavement distresses and their evolution with time, traffic, and other variables.

5.3 Pursued Activities

Even though a number of tasks have been completed in the last few years, there are still some activities that need to be pursued. Among the most relevant activities are the following:

The continuation of the organization of the information gathered for some special studies like the ones described in Chapter 4. The information collected for those special studies is quite vast and requires continuous reorganization in order to be user-friendly. This information should still be merged into the existing RPDB, and all the additional information available for the projects (e.g, concrete strengths) should be managed in such a way that it could be easily retrieved from the Access database.

At press time, nearly 90 percent of the overall CRCP sections have been completely surveyed. The sections that need to be surveyed to complete the whole CRCP database are located in the districts of Paris, Atlanta, and Beaumont. Because some changes in the field crew for this project have taken place, the field tasks are going to take more time than was previously planned.

Another pair of tasks that are being tracked for this project are the processes of gaining access to TxDOT's mainframe system PMIS and Design and Construction Information System (DCIS) databases. In the case of the PMIS, access and generation of reports have been successfully gained, but the report-printing capabilities are still having problems due to unknown causes. The whole process of requesting access to TxDOT is still required for the DCIS, but it has not been done yet because it would be better and easier to secure full capabilities on the PMIS first.

5.4 Recommendations

According to the contents of this report and the previous conclusions, a considerable amount of information has been processed through different activities in the project. Report 1778-1 (Reference 1) of this same project is the only one in which a distress analysis has been performed for all non-overlaid sections surveyed in the Dallas district (JCP sections). Thus a first general recommendation here would be to begin thinking about the possibility of conducting a broad analysis of the distresses on the sections for different years and obtaining performance-related characteristics of the sections for selected projects. It would be necessary to formulate a plan of attack for this extensive analysis.

Some other specific recommendations that will stress the usefulness of the RPDB include the following:

1. Identification and incorporation of new projects into the database should be pursued. It would be useful to pick projects that have characteristics different from the majority of the sections in the actual CRCP database (e.g, pavements with thickness greater than 8 in., CRCP sections where double steel mat is used, and sections in highways other than interstates). This inclusion of new sections in the database would give it a wider application.
2. As mentioned in the conclusions above, a good plan to conclude the CRCP's condition surveys should be formulated. Then a plan for the initiation of the JCP's surveys could be established.
3. Printing capabilities and access to TxDOT's PMIS and DCIS, respectively should be strongly pursued.
4. An effort to update the existing photo database, which currently has more than 200 photos capturing different types of images, should continue.
5. A plan to collect crack width data should be developed. It would be ambitious to try to collect crack width information for the entire database, but as is explained and proposed in Appendix C, at least some of the sections should be considered to execute this plan. It is well understood that crack width data and analysis are intrinsically complex, but the information provided may have still-unknown links to other characteristics of concrete pavements.
6. One last activity that should be revisited is the collection of traffic data. This is probably the task that has presented problems in the RPDB the most because the only traffic information currently available is from 1985.

This report compiles all the activities that have been conducted for the update of the RPDB and focuses on CRCP sections, in the same way Report 1778-1 focused on JCP sections. Most of the recommendations given here should be accomplished or pursued within the next few months, although some activities such as the continuous update of the database, which should be an endless endeavor, will require much more time.

Appendix A

Continuously Reinforced Concrete Pavement (CRCP) Sections in the Rigid Pavement Database

CFTR	COUNTY	HWY	RM1	RM2	GPSLON	GPSLAT	CRACK	DIR	LEN	LANES	LANE	RBD	CURVE	OVER
200201	PARKER	IH20	414+1.1	414+1.3	32.749	97.678	182	E	1000	3	R1	G	T	N
200202	PARKER	IH20	416+0.2	416+0.4	32.743	97.663	176	E	1000	3	R1	G	T	N
200203	PARKER	IH20	416+0.35	416+0.55	32.742	97.658	189	E	1000	3	R1	G	T	N
200204	PARKER	IH20	417+0.4	417+0.6	32.737	97.644	192	E	1000	3	R1	C	T	N
200205	PARKER	IH20	417+0.75	417+0.95	32.736	97.638	208	E	1000	3	R1	F	T	N
202801	JOHNSON	IH35W	37-0.4	37-0.6	32.540	97.313	3	S	1000	2	L1	G	R	Y
202801	JOHNSON	IH35W	32+0.4	32+0.6	32.487	97.280	0	N	1000	2	R1	C	T	Y
202802	JOHNSON	IH35W	33+0.1	33+0.3	32.497	97.288	0	N	1000	2	R1	G	T	Y
202802	JOHNSON	IH35W	33+0.2	36+0.0	32.535	97.312	0	S	1000	2	L1	G	T	Y
202803	JOHNSON	IH35W	36-0.2	36-0.4	32.529	97.310	0	S	1000	2	L1	G	T	Y
203101	TARRANT	IH820	17-0.1	17+0.1	32.839	97.307	0	E	1000	2	R1	G	R	Y
203101	TARRANT	IH820	20+0.22	20+0.02	32.840	97.250	0	W	1000	2	L1	C	L	Y
203102	TARRANT	IH820	20+0.02	20+0.22	32.840	97.253	0	E	1000	2	R1	C	T	Y
203102	TARRANT	IH820	20-0.2	20-0.4	32.840	97.258	0	W	1000	2	L1	F	T	Y
203103	TARRANT	IH820	18-0.45	18-0.65	32.840	97.294	0	W	1000	2	L1	F	T	Y
203104	TARRANT	IH820	18-0.65	18-0.85	32.840	97.297	0	W	1000	2	L1	G	T	Y
203201	TARRANT	IH30	4+0.0	4+0.2	32.731	97.501	0	W	1000	2	L1	G	T	Y
203201	TARRANT	IH30	0+1.6	0+1.8	32.721	97.539	192	E	1000	3	R1	G	T	N
203202	TARRANT	IH30	19+0.65	19+0.45	32.760	97.244	4	W	1000	3	L1	C	T	Y
203202	TARRANT	IH30	4+0.5	4+0.7	32.734	97.493	0	E	1000	2	R1	G	T	Y
203203	TARRANT	IH30	6+0.65	6+0.85	32.738	97.458	0	E	1000	3	R1	F	T	Y
204901	TARRANT	US287	264+0.8	264+1.0	34.281	99.691	0	S	1000	2	R2	G	T	Y
204902	TARRANT	US287	266+0.3	266+0.5	34.274	99.667	0	S	1000	2	R1	G	T	Y
204903	TARRANT	US287	266+1.6	266+1.8	34.268	99.644	0	S	1000	2	R2	G	T	Y
204904	TARRANT	US287	268-0.13	268+0.06	34.269	99.639	0	S	1000	2	R1	G	T	Y
204901	TARRANT	US287	266-1.0	266-1.2	34.281	99.687	62	N	1000	2	L1	G	T	Y
205001	TARRANT	US287	272+0.04	272+0.23	34.255	99.566	0	S	1000	2	R1	G	T	Y
205002	TARRANT	US287	272+1.2	272+1.4	34.252	99.547	0	S	1000	2	R1	G	T	Y
205001	TARRANT	US287	272+0.23	272+0.03	34.255	99.566	23	N	1000	2	L1	G	T	Y
205101	PARKER	IH20	388+0.6	388+0.8	32.622	98.086	0	E	1000	2	R1	G	T	Y
205101	PARKER	IH20	390-0.6	390-0.8	32.630	98.074	0	W	1000	2	L1	F	R	Y
205102	PARKER	IH20	388+0.95	388+1.15	32.625	98.081	0	E	1000	2	R1	G	T	Y
205901	ERATH	IH20	364+0.5	364+0.7	32.504	98.463	0	E	1000	2	R1	G	T	Y
205901	ERATH	IH20	368-0.03	368-0.23	32.505	98.409	0	W	1000	2	L1	G	T	Y
205902	ERATH	IH20	365-0.1	365-0.3	32.506	98.457	0	W	1000	2	L1	C	T	Y

205902	ERATH	IH20	366+0.85	367+0.05	32.507	98.424	0	E	1000	2	R1	C	T	Y
206001	TARRANT	IH20	445+0.7	445+0.9	32.675	97.193	262	E	1000	4	R1	F	R	N
206001	TARRANT	IH20	445-0.04	445+0.0	32.672	97.205	139	W	1000	4	L1	F	T	N
206002	TARRANT	IH20	445-0.4	445-0.6	32.671	97.210	148	W	1000	4	L1	G	T	N
207501	TARRANT	IH35W	42+0.4	42+0.6	32.623	97.321	136	N	1000	3	R1	F	T	Y
207501	TARRANT	IH35W	45+0.02	45-0.22	32.648	97.322	148	S	1000	3	L1	G	T	N
207502	TARRANT	IH35W	43-0.1	43-0.3	32.631	97.322	141	S	1000	3	L1	G	T	N
207503	TARRANT	IH35W	41-0.13	41-0.33	32.602	97.320	142	S	1000	3	L1	C	R	N
207504	TARRANT	IH35W	41-0.45	41-0.65	32.597	97.320	132	S	1000	3	L1	C	T	N
209801	TARRANT	IH820	11+0.15	11+0.35	32.821	97.397	178	N	1000	3	R1	G	T	N
209801	TARRANT	IH820	13-0.5	13-0.7	32.829	97.381	216	S	1000	3	L1	G	L	N
209802	TARRANT	IH820	12+0.1	12+0.3	32.827	97.385	175	E	1000	3	R1	G	T	N
209802	TARRANT	IH820	11+0.0	11-0.2	32.819	97.402	156	S	1000	3	L1	F	T	N
300101	WICHITA	IH44	4+0.45	4+0.25	33.964	98.531	0	W	1000	2	L1	G	L	Y
300101	WICHITA	IH44	4+0.2	4+0.4	33.960	98.530	215	E	1000	2	R1	G	R	N
300103	WICHITA	IH44	14-0.25	14-0.45	34.095	98.555	211	W	1000	2	L1	F	L	N
300102	WICHITA	IH44	5+0.0	5+0.2	33.975	98.534	0	W	600	2	L1	G	R	Y
300102	WICHITA	IH44	5+0.0	5+0.2	33.973	98.533	195	E	1000	2	R1	G	L	N
300401	WICHITA	IH44	12-0.35	12-0.15	34.066	98.557	220	E	1000	2	R1	G	T	Y
300403	WICHITA	IH44	12+0.15	12-0.05	34.072	98.558	220	W	1000	2	L1	G	T	N
300404	WICHITA	IH44	11+0.5	11+0.35	34.063	98.558	8	W	800	2	L1	G	T	Y
300405	WICHITA	IH44	11+0.25	11+0.45	34.060	98.557	0	E	1000	2	R1	G	T	Y
301001	WICHITA	US287	314+1.0	314+1.2	34.044	98.936	180	S	1000	2	R1	G	T	N
301002	WICHITA	US287	316-0.2	316+0.0	34.044	98.917	182	S	1000	2	R1	F	T	N
301003	WICHITA	US287	316+0.9	316+1.1	34.041	98.902	160	S	1000	2	R1	G	T	N
301004	WICHITA	US287	322+0.3	322+0.5	33.993	98.830	187	S	1000	2	R1	G	L	N
301005	WICHITA	US287	316+0.2	316+0.05	34.045	98.918	150	N	760	2	L1	F	T	N
301006	WICHITA	US287	317+0.2	317+0.0	34.039	98.883	169	N	1000	2	L1	C	T	N
301101	WILBARGER	US287	312-0.1	312-0.3	34.049	98.959	160	N	1000	2	L1	G	T	N
301102	WILBARGER	US287	312-0.5	312-0.7	34.051	98.965	120	N	1000	2	L1	T	R	N
301103	WILBARGER	US287	312-0.7	312-0.9	34.056	98.969	9	N	1000	2	L1	T	T	Y
301104	WILBARGER	US287	312-0.1	312+0.1	34.048	98.958	73	S	1000	2	R1	G	T	Y
301801	MONTAGUE	US287	390+0.4	390+0.6	33.568	97.887	0	S	1000	2	R1	F	T	Y
301802	MONTAGUE	US287	392+0.1	392+0.3	33.554	97.865	0	S	1000	2	R1	C	T	Y
301803	MONTAGUE	US287	394+1.4	394+1.6	33.523	97.823	165	S	1000	2	R1	T	T	N
301804	MONTAGUE	US287	394+1.6	394+1.8	33.520	97.821	177	S	1000	2	R1	G	T	N
301805	MONTAGUE	US287	222+0.4	222+0.2	34.496	100.356	127	N	1000	2	L1	G	T	Y

301806	MONTAGUE	US287	220-0.4	220-0.6	34.513	100.396	30	N	1000	2	L1	G	R	Y
302201	WILBARGER	US287	302+0.0	302-0.8	34.117	99.111	164	N	1000	2	L2	G	T	N
302202	WILBARGER	US287	304-0.4	304-0.6	34.106	99.086	180	N	1000	2	L1	G	T	N
302203	WILBARGER	US287	304-0.15	304-0.35	34.104	99.084	175	N	1000	2	L1	G	T	N
302204	WILBARGER	US287	302+0.6	302+0.4	34.113	99.102	205	N	1000	2	L1	G	T	N
302205	WILBARGER	US287	308-0.5	308-0.7	34.079	99.026	171	N	1000	2	L1	F	T	N
400201	POTTER	IH40	72-0.3	72-0.5	35.193	101.814	28	W	982	3	L1	T	T	Y
400202	POTTER	IH40	71+0.5	71+0.3	35.193	101.819	35	W	1000	3	L1	G	R	Y
400501	CARSON	IH40	92-0.2	92+0.0	35.222	101.464	0	W	1000	2	L1	G	T	Y
400501	CARSON	IH40	88+0.5	88+0.7	35.221	101.530	0	E	1000	2	R1	G	T	Y
400502	CARSON	IH40	91+0.0	91+0.2	35.221	101.486	2	E	1000	2	R1	G	T	Y
400502	CARSON	IH40	89+0.2	89+0.0	35.221	101.518	8	W	1000	2	L1	G	T	Y
400503	CARSON	IH40	86+0.2	86+0.0	NO GPS POSSIBLE		12	W	1000	2	L1	G	T	Y
400901	POTTER	IH40	67-0.15	67-0.35	35.191	101.900	14	W	1000	3	L1	G	T	Y
400902	POTTER	IH40	67-0.45	67-0.65	35.191	101.905	5	W	1000	3	L1	G	L	Y
400903	POTTER	IH40	66-0.15	66-0.35	35.187	101.916	17	W	1000	3	L1	T	R	Y
400904	POTTER	IH40	65+0.2	65+0.0	35.186	101.928	9	W	1000	3	L1	G	T	Y
400905	POTTER	IH40	63-0.25	63-0.45	35.188	101.971	11	W	1000	2	L1	G	R	Y
401001	POTTER	IH40	82+0.2	82+0.0	35.207	101.636	75	W	1000	2	L1	G	T	Y
401002	POTTER	IH40	79+0.2	79+0.0	35.199	101.686	1	W	1000	2	L1	G	T	Y
401003	POTTER	IH40	79-0.1	79-0.3	35.196	101.706	16	W	1000	2	L1	F	R	Y
401101	POTTER	IH40	61+0.2	61+0.0	35.190	101.998	13	W	1000	2	L1	G	T	Y
401102	POTTER	IH40	61-0.3	61-0.5	35.190	102.006	56	W	1000	2	L1	T	T	Y
401103	POTTER	IH40	56+0.2	56+0.0	35.192	102.086	36	W	1000	2	L1	G	T	Y
401101	POTTER	IH40	60+0.0	60+0.2	35.190	102.019	39	E	1000	2	R1	G	T	Y
401102	POTTER	IH40	60+0.5	60+0.7	35.190	102.010	14	E	1000	2	R1	T	T	Y
402201	GRAY	IH40	115+0.0	115+0.2	35.194	101.073	389	E	1000	2	R1	G	T	N
402201	GRAY	IH40	115+0.2	115+0.0	35.194	101.070	379	W	1000	2	L1	G	T	N
402202	GRAY	IH40	114+0.7	114+0.5	35.196	101.079	376	W	1000	2	L1	G	R	N
402301	DONLEY	IH40	125-0.4	125-0.6	35.183	100.905	1	W	1000	2	L1	C	L	Y
402302	GRAY	IH40	124+	124+	35.183	100.909	10	W	1000	2	L1	C	L	Y
402303	GRAY	IH40	123+0.15	123-0.05	35.183	100.931	2	W	1000	2	L1	G	T	Y
402501	DONLEY	IH40	130-0.2	130-0.4	35.185	100.818	0	W	1000	2	L1	C	T	Y
402502	DONLEY	IH40	130-0.5	130-0.7	35.182	100.824	0	W	1000	2	L1	C	R	Y
402503	DONLEY	IH40	128+0.1	128-0.1	35.181	100.846	0	W	1000	2	L1	F	T	Y
402504	GRAY	IH40	128-0.4	128-0.6	35.183	100.859	0	W	1000	2	L1	T	T	Y
410001	OLDHAM	IH40	33-0.04	33-0.24	35.255	102.484	148	W	1000	2	L1	G	T	N

410002	OLDHAM	IH40	33-0.35	33-0.55	35.256	102.489	33	W	1000	2	L1	G	T	N
500501	HALE	IH27	43+0.0	43-0.2	34.233	101.710	365	S	1000	2	L1	G	T	N
500501	HALE	IH27	39+0.0	39+0.2	34.076	101.834	195	N	900	2	R1	G	R	N
500502	HALE	IH27	42+0.47	42+0.27	34.106	101.781	347	S	1000	2	L1	G	T	N
500502	HALE	IH27	43-0.2	43+0.0	34.107	101.779	352	N	1000	2	R1	G	T	N
500701	HALE	IH27	39-0.5	39-0.7	34.073	101.840	155	S	1000	2	L1	T	L	N
500702	HALE	IH27	38+0.07	38-0.13	34.066	101.844	146	S	1000	2	L1	C	T	N
500703	HALE	IH27	39+0.0	39-0.2	34.077	101.835	184	S	1000	2	L1	G	L	N
500801	HALE	IH27	57+0.0	57-0.2	34.287	101.721	317	S	1000	2	L1	G	T	N
500801	HALE	IH27	55+0.0	55-0.2	34.257	101.709	408	N	1000	2	R1	G	L	N
500802	HALE	IH27	57+0.0	57-0.2	34.285	101.720	395	N	1000	2	R1	G	T	N
500802	HALE	IH27	55+0.0	55-0.2	34.260	101.710	257	S	1000	2	L1	G	R	N
500901	HALE	IH27	60+0.1	60+0.3	34.331	101.740	343	S	1000	2	L1	G	T	N
500901	SWISHER	IH27	60+0.0	60+0.2	34.328	101.738	334	N	1000	2	R1	G	T	N
500902	HALE	IH27	59+0.1	59+0.3	34.317	101.734	298	S	1000	2	L1	G	T	N
900101	McLENNAN	IH35	313+0.6	313+0.8	31.267	97.268	0	N	1000	2	R1	G	T	Y
900102	FALLS	IH35	313+1.1	313+1.3	31.270	97.267	5	N	1000	2	R1	G	R	Y
900103	FALLS	IH35	314+0.65	314+0.85	31.281	97.226	5	N	1000	2	R1	G	T	Y
900104	FALLS	IH35	315+0.1	315+0.3	31.286	97.256	8	N	1000	2	R1	G	L	Y
900105	FALLS	IH35	315-0.1	315-0.3	31.284	97.258	2	S	1000	2	L1	G	R	Y
900201	McLENNAN	IH35	316+0.3	316+0.5	31.301	97.248	4	N	1000	2	R1	G	T	Y
900202	McLENNAN	IH35	316+.09	316+1.1	31.310	97.243	0	N	1000	2	R1	G	T	Y
900203	McLENNAN	IH35	318+0.1	318+0.3	31.324	97.231	7	N	1000	2	R1	G	L	Y
900204	McLENNAN	IH35	319-0.3	319-0.5	NA	NA	17	S	1000	3	L1	G	T	Y
900205	McLENNAN	IH35	318-0.3	318-0.5	NA	NA	3	S	1000	2	L1	F	L	Y
900206	McLENNAN	IH35	318-0.8	318-1.0	31.313	97.242	15	S	1000	2	L1	G	T	Y
900401	McLENNAN	IH35	335-1.7	335-1.9	31.526	97.134	167	S	1000	3	L1	G	T	N
900402	McLENNAN	IH35	335-1.9	335-2.1	31.523	97.135	123	S	1000	3	L1	C	T	N
900403	McLENNAN	IH35	331+0.7	331+0.9	31.504	97.144	150	N	1000	3	R1	G	T	N
900404	McLENNAN	IH35	332+0.5	332+0.6	31.516	97.138	87	N	500	3	R1	G	T	N
1212301	HARRIS	IH10	775+0.6	775+0.4	29.778	95.414	128	W	1000	5	L1	C	T	N
1212302	HARRIS	IH10	766+0.05	765+0.85	29.778	95.404	125	W	1000	5	L1	C	L	N
1212303	HARRIS	IH10	764+0.7	764+0.5	29.778	95.428	181	W	1000	5	L1	C	T	N
1244301	HARRIS	SH6	666-1.1	666-1.3	29.909	95.629	261	N	1000	3	K1	G	R	N
1244401	HARRIS	SH6	666-1.4	666-1.6	29.911	95.629	160	N	1000	3	K1	G	R	N
1243901	HARRIS	BW8	ANTOINE	ANTOINE	29.938	95.480	92	E	1000	3	A3	G	T	N
1244001	HARRIS	BW8	ANTOINE	ANTOINE	29.937	95.481	119	E	1000	3	A3	G	T	N

1244101	HARRIS	IH45	73+0.1	73+0.3	30.115	95.438	144	N	1000	4	R4	F	T	N
1244102	HARRIS	IH45	73+0.3	73+0.5	30.118	95.441	121	N	1000	4	K4	G	R	N
1244702	HARRIS	SH6	672+0.6	672+0.8	29.805	95.645	111	S	1000	3	K1	F	T	N
1244701	HARRIS	SH6	672+0.3	672+0.5	MISSED	MISSED	133	S	1000	3	K1	F	T	N
1290601	HARRIS	BW8	702+0.0	702+0.2	29.801	95.563	168	N	1000	3	A1	G	T	N
1290701	HARRIS	BW8	702+0.0	702-0.2	29.801	95.564	138	S	1000	3	X1	G	T	N
1290801	HARRIS	BW8	706+0.0	706-0.2	29.858	95.564	125	S	1000	3	X1	G	L	N
1290901	HARRIS	BW8	706-0.2	706+0.0	29.858	95.563	128	N	1000	3	A1	G	T	N
1290101	HARRIS	BW8	722+0.25	722+0.45	29.939	95.376	35	E	1000	3	R1	G	T	Y
1290102	HARRIS	BW8	722+0.45	722+0.65	29.939	95.373	38	E	1000	3	R1	G	T	Y
1290103	HARRIS	BW8	724-0.87	724-1.07	29.939	95.362	101	W	1000	3	R1	G	T	Y
1290104	HARRIS	BW8	724-1.07	724-1.27	29.939	95.365	104	W	1000	3	R1	G	T	Y
1290201	HARRIS	BW8	720+1.4	720+1.6	29.939	95.559	85	E	1000	3	R1	G	T	Y
1290202	HARRIS	BW8	722-0.3	722-0.5	29.939	95.388	27	W	600	3	R1	G	T	Y
1290408	HARRIS	BW8	735+0.7	735+0.9	29.925	95.553	114	N	1000	3	A1	G	R	N
1290508	HARRIS	BW8	736-0.25	736-0.45	29.923	95.556	78	S	1000	3	X1	G	L	N
1292001	HARRIS	IH610 FRTG	34+0.0	34+0.31	29.695	95.320	258	W	1000	3	X1	G	T	N
1292002	HARRIS	IH610 FRTG	34-0.01	34-0.21	29.695	95.318	94	E	1000	2	A1	G	T	N
1292501	HARRIS	IH10	766+0.7	766+0.9	29.777	95.394	52	E	1000	5	R1			N
1299601	HARRIS	SH249	460+0.0	460+0.2	29.983	95.569	145	S	1000	2	R1	G	T	N
1299602	HARRIS	SH249	460+0.2	460+0.0	29.984	95.577	157	N	1000	2	L1	G	T	N
1299701	HARRIS	IH45	65+0.0	65+0.2	29.999	95.425	61	N	1000	4	R3	F	T	N
1299702	HARRIS	IH45	65+0.4	65+0.2	29.986	95.438	62	S	1000	4	L1	F	T	N
1299801	GALVESTON	IH45	19+0.0	19+0.2	29.447	95.075	189	N	600	3	R1	G	T	N
1299802	GALVESTON	IH45	20+0.0	20+0.2	29.459	95.085	247	N	1000	3	R1	G	T	N
1299901	HARRIS	SH146	494+0.0	494+0.2	29.658	95.029	48	N	1000	2	R1	G	T	N
1299902	HARRIS	SH146	494+0.0	494-0.2	29.658	95.036	40	S	1000	2	L1	G	T	N
1300901	VICTORIA	US77	546-1.2	546-1.4	28.713	97.043	16	N	1000	2	R1	G	L	Y
1300902	VICTORIA	US77	546+1.5	546+1.7	28.709	97.045	0	S	1000	2	L1	G	L	Y
1503202	BEXAR	US281	143+0.8	144+0.0	29.451	98.484	22	N	1000	3	R1	G	R	Y
1503601	BEXAR	US281	144+1.1	144+1.3	29.464	98.474	75	N	1000	3	R1	C	L	Y
1503602	BEXAR	US281	147+0.8	148+0.0	29.500	98.482	4	N	1000	3	R1	F	T	Y
1503603	BEXAR	US281	147+0.4	147+0.6	29.494	98.484	5	N	1000	3	R1	F	R	Y
1590101	BEXAR	IH35	167+0.89	168+0.04	29.536	98.386	89	N	800	4	R1	G	T	N
1590201	BEXAR	IH35	166+0.0	166+0.16	29.511	98.398	27	N	800	3	R1	T	T	Y
1590202	BEXAR	IH35	165+0.65	165+0.85	29.505	98.399	0	N	1000	3	R1	G	T	Y

1700701	LEON	IH45	173+0.0	173-0.2	31.367	96.018	309	S	1000	2	L1	G	T	N
1700702	LEON	IH45	172+0.2	172+0.0	31.367	96.018	307	S	1000	2	L1	G	T	N
1700703	LEON	IH45	171+0.9	171+0.7	31.367	96.018	328	S	1000	2	L1	G	T	N
1700704	LEON	IH45	171+0.6	171+0.4	31.363	96.016	317	S	1000	2	L1	G	T	N
1700705	LEON	IH45	171-0.2	171-0.4	31.351	96.014	408	S	1000	2	L1	G	T	N
1700706	LEON	IH45	170+0.2	170+0.0	31.343	96.012	396	S	1000	2	L1	G	T	N
1700201	WALKER	IH45	124+0.0	124+0.2	31.037	95.939	0	N	1000	2	R1	G	T	Y
1700202	WALKER	IH45	132-0.1	132-0.3	30.866	95.756	0	S	1000	2	L1	G	T	Y
1700203	WALKER	IH45	131-0.6	131-0.8	30.849	95.736	0	S	1000	2	L1	G	T	Y
1700204	WALKER	IH45	130+0.0	130-0.2	30.847	95.733	0	S	1000	2	L1	G	T	Y
1700205	WALKER	IH45	130-0.5	130-0.7	30.841	95.725	0	S	1000	2	L1	G	T	Y
1700206	WALKER	IH45	129-0.5	129-0.7	30.832	95.714	0	S	1000	2	L1	G	T	Y
1700207	WALKER	IH45	128-0.7	128-0.9	30.832	95.713	0	S	1000	2	L1	G	T	Y
1700301	LEON	IH45	152+0.8	153+0.0	30.832	95.713	0	N	1000	2	R1	G	T	Y
1700302	LEON	IH45	153+0.5	153+0.7	31.099	95.963	4	N	1000	2	R1	G	T	Y
1700303	LEON	IH45	153+0.9	154+0.1	31.099	95.963	0	N	1000	2	R1	G	T	Y
1700304	LEON	IH45	157+0.2	157+0.4	31.160	95.985	0	N	1000	2	R1	G	T	Y
1700305	LEON	IH45	157+0.5	157+0.7	31.166	95.986	0	N	1000	2	R1	G	T	Y
1700306	LEON	IH45	158+0.0	158+0.2	31.171	95.989	0	N	1000	2	R1	G	T	Y
1700401	MADISON	IH45	152-0.2	152-0.4	31.284	96.232	2	S	1000	2	L1	G	T	Y
1700402	MADISON	IH45	150+0.0	150-0.2	31.060	95.950	0	S	1000	2	L1	G	T	Y
1700403	MADISON	IH45	150-0.3	150-0.5	31.056	95.949	0	S	1000	2	L1	G	T	Y
1700404	MADISON	IH45	149+0.2	149+0.0	31.048	95.947	0	S	1000	2	L1	G	T	Y
1700405	MADISON	IH45	149-0.1	149-0.3	31.045	95.945	1	S	1000	2	L1	G	T	Y
1700406	MADISON	IH45	148-0.5	148-0.7	31.028	95.933	0	S	1000	2	L1	G	T	Y
1805401	DALLAS	IH30	50-0.1	50+0.1	32.791	96.739	0	E	1000	4	R1	C	T	Y
1805401	DALLAS	IH30	50+0.1	50-0.1	32.792	96.735	0	W	1000	4	R1	C	T	Y
1805402	DALLAS	IH30	49+0.2	49+0.0	32.791	96.752	0	W	1000	3	R1	T	T	Y
1806201	DALLAS	IH30	46-0.15	46+0.05	32.772	96.800	149	E	1000	3	R1	C	R	N
1806601	DALLAS	IH35E	422+0.2	422+0.4	32.693	96.823	183	N	1000	3	R1	F	T	N
1806602	DALLAS	IH35E	423+0.3	423+0.5	32.701	96.880	175	S	1000	3	L1	C	R	N
1807203	DALLAS	IH635	25+0.4	25+0.2	32.915	96.864	228	E	1000	5	L1	G	T	N
1807203	DALLAS	IH635	25-0.06	25-0.26	32.917	96.857	193	W	1000	5	L1	C	T	N
1807204	DALLAS	IH635	24+0.4	24+0.2	32.922	96.847	170	E	1000	5	L1	T	T	N
1807301	DALLAS	IH635	23+0.7	23+0.5	32.926	96.838	152	E	1000	5	L1	F	R	N
1807901	DALLAS	IH635	19-0.76	19-0.96	32.918	96.746	221	E	1000	5	L1	C	R	N
1807903	DALLAS	IH635	31+0.7	31+0.9	32.918	96.970	92	W	1000	3	R1	G	T	N

1810601	DALLAS	IH20	467-0.04	467-0.24	32.643	96.836	150	W	1000	4	L1	G	R	N
1810601	DALLAS	IH20	464+0.2	464+0.4	32.655	96.881	192	E	1000	4	R1	C	T	N
1810602	DALLAS	IH20	465+0.7	465+0.9	32.646	96.857	162	E	1000	4	R1	F	T	N
1810602	DALLAS	IH20	466+0.2	466+0.0	32.645	96.847	155	W	1000	4	L1	G	T	N
1810603	DALLAS	IH20	466-0.75	466-0.95	32.648	96.863	133	W	1000	4	L1	F	T	N
1810701	DALLAS	IH20	457+0.61	457+0.81	32.673	96.989	130	E	1000	4	R1	G	T	Y
1810702	DALLAS	IH20	458-0.8	457+0.0	32.674	96.996	0	W	1000	4	L1	G	T	Y
1810702	DALLAS	IH20	457+0.4	457+0.6	32.673	96.993	3	E	1000	4	R1	G	T	Y
1810703	DALLAS	IH20	460-0.6	460-0.4	32.676	97.024	126	W	1000	4	L1	G	T	N
2410001	EL PASO	IH10	36+0.0	36+0.2	31.679	106.260	156	E	1000	2	R2	G	T	N
2410002	EL PASO	IH10	37+0.0	37+0.2	31.669	106.248	168	E	1000	2	R2	G	R	N
2410003	EL PASO	IH10	31+0.8	31+0.6	31.724	106.308	148	W	1000	3	L3	T	T	N
2420001	EL PASO	IH10	39+0.83	40+0.03	31.635	106.221	118	E	1000	2	R2	G	T	N
24QCQA02	EL PASO	IH10	38+0.25	38+0.45	31.667	106.247	113	E	800	2	R2	G	T	N
2420003	EL PASO	IH10	41+0.5	41+0.3	31.610	106.201	99	W	1000	2	L2	G	T	N
2430001	EL PASO	IH10	45+0.0	45+0.2	31.574	106.173	103	E	1000	2	R2	G	T	N
2430002	EL PASO	IH10	46+0.0	46+0.2	31.562	106.164	100	E	1000	2	R2	G	T	N
2430003	EL PASO	IH10	46+0.0	46-0.2	31.562	106.164	142	W	1000	2	L2	G	T	N
2400301	EL PASO	IH10	20+0.2	20+0.4	31.768	106.480	197	E	1000	5	R5	G	T	N
2400401	EL PASO	IH10	21+0.0	21+0.2	31.775	106.468	193	E	1000	5	R5	G	T	N
2400601	EL PASO	IH10	18+0.6	18+0.4	31.760	106.504	152	W	1000	4	L4	G	R	N
2400602	EL PASO	IH10	19+0.1	18+0.9	31.759	106.498	121	W	1000	4	L4	G	R	N
2400701	EL PASO	IH10	17+0.7	17+0.5	31.770	106.511	254	W	1000	4	L4	T	L	N
2400702	EL PASO	IH10	16+0.6	16+0.4	31.785	106.518	225	W	1000	4	L4	C	T	N
2400703	EL PASO	IH10	18+0.85	15+0.65	31.799	106.520	222	W	1000	4	L4	F	R	N
2400704	EL PASO	IH10	14+0.8	14+0.6	31.809	106.527	178	W	1000	3	L3	T	L	N
2400901	CULBERSON	IH10	177+0.25	177+0.45	31.065	104.211	0	E	1000	2	R2	G	T	Y
2400902	CULBERSON	IH10	178+0.5	178+0.7	31.063	104.186	0	E	1000	2	R2	C	T	Y
2400903	CULBERSON	IH10	178-0.01	178-0.21	31.065	104.197	0	W	1000	2	L2	T	T	Y
2401001	CULBERSON	IH10	185+0.0	185-0.2	31.083	104.086	0	W	1000	2	L2	C	T	Y
2401002	CULBERSON	IH10	183+0.7	183+0.5	31.082	104.108	0	W	1000	2	L2	T	T	Y
2401003	CULBERSON	IH10	182+0.6	182+0.4	31.074	104.123	0	W	1000	2	L2	G	R	Y
2401004	CULBERSON	IH10	181+0.0	180+0.8	31.064	104.148	0	W	1000	2	L2	T	T	Y
2401005	CULBERSON	IH10	186+0.2	186+0.4	31.084	104.065	0	E	1000	2	R2	F	T	Y
2401006	CULBERSON	IH10	180+0.8	180+0.6	31.063	104.151	0	W	1000	2	L2	F	R	Y
2401101	CULBERSON	IH10	175+0.0	175+0.2	31.066	104.247	0	E	1000	2	R2	G	T	Y
2401202	CULBERSON	IH10	166+0.2	166+0.4	31.072	104.395	0	E	1000	2	R2	G	T	Y

2401401	CULBERSON	IH10	154+0.05	154+0.25	31.054	104.598	0	E	1000	2	R2	G	T	Y
2401402	CULBERSON	IH10	155+0.8	156+0.0	31.056	104.568	0	E	1000	2	R2	G	T	Y
2401403	CULBERSON	IH10	164-0.04	164+0.24	31.060	104.524	0	E	980	2	R2	G	T	Y
2401404	CULBERSON	IH10	165+0.0	165+0.2	31.074	104.414	0	E	1000	2	R2	T	R	Y
2401501	CULBERSON	IH10	153+0.1	153+0.3	31.053	104.614	0	E	1000	2	R2	G	T	Y
2402001	CULBERSON	IH10	142+0.0	142+0.2	31.043	104.800	0	E	1000	2	R2	G	T	Y
2402201	CULBERSON	IH10	138+0.25	138+0.45	31.036	104.862	0	E	1000	2	R2	C	L	Y
2402202	CULBERSON	IH10	139+0.7	139+0.5	31.036	104.837	0	W	1000	2	L2	G	T	Y
2402203	CULBERSON	IH10	138+0.0	137+0.8	31.037	104.866	0	W	1000	2	L2	G	L	Y
2402301	CULBERSON	IH10	140+0.2	140+0.4	31.038	104.830	0	E	1000	2	R2	F	T	Y
2402801	EL PASO	IH10	4+0.0	4+0.2	31.940	106.583	5	E	1000	2	R1	F	T	Y
2402802	EL PASO	IH10	5+0.5	5+0.7	31.921	106.583	5	E	1000	2	R1	F	T	Y
2402803	EL PASO	IH10	6+0.0	6+0.15	31.913	106.583	6	E	800	2	R1	F	T	Y
2409101	EL PASO	IH10	97+0.7	97+0.5	31.210	105.502	180	W	1000	2	L2	F	T	N
2409102	EL PASO	IH10	93-0.04	93-0.24	31.209	105.502	169	W	1000	2	L2	G	T	N

Appendix B

Satellite Factorial Concept

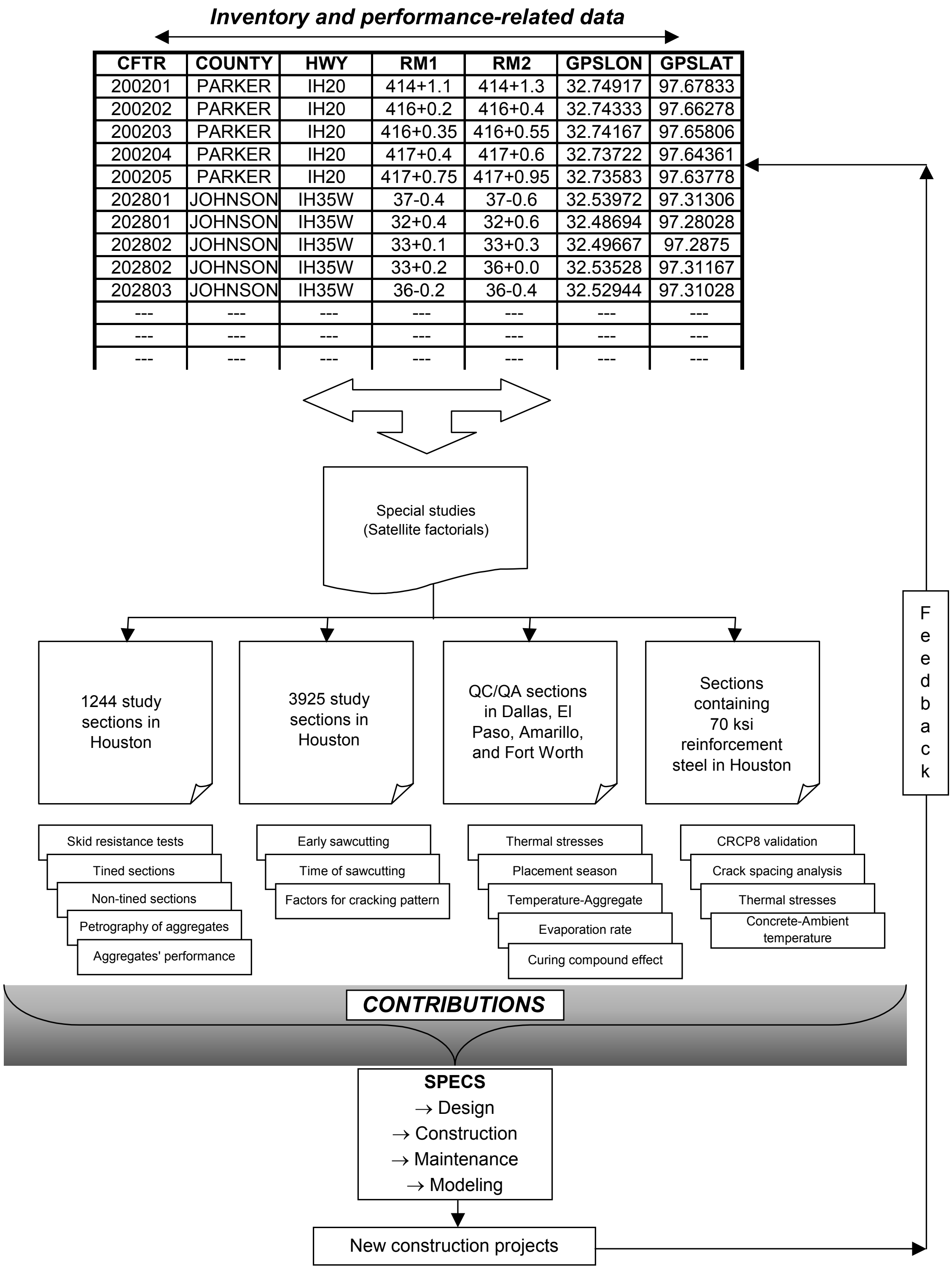
Satellite Factorial Concept

The RPDB provides detailed information about hundreds of pavement sections that fairly represent the PCCP network and its conditions in terms of pavement types (JCP or CRCP), climate, and CAT used in concrete pavement. All that information has been compiled for a period of 26 years and has served as a basic tool to provide key information for updating design and construction specifications and about the feasibility of the use of aggregates according to placement season. Analysis of the database has provided invaluable information about the performance of concrete pavements.

Because of the nature of the RPDB and its extensive information, the need for further analysis of particular construction projects has resulted in the development of special research studies. These specific research studies are of special interest because of the potential information they could provide that would determine the path to be followed in the design and construction of future projects. Detailed information collection of specific construction projects has included:

1. extraction of information from the database by collecting data about projects selected from the rigid pavement database (RPDB).
2. incorporation of information into the database by collecting data from projects that, because of their relevance, have been incorporated into the database.

For identification purposes of the RPDB, the special research studies are part of satellite factorials and contain more detailed information than the rest of the sections in the RPDB. Figure A.1 shows how the satellite factorials are included in the RPDB.



CFTR	COUNTY	HWY	RM1	RM2	GPSLON	GPSLAT
200201	PARKER	IH20	414+1.1	414+1.3	32.74917	97.67833
200202	PARKER	IH20	416+0.2	416+0.4	32.74333	97.66278
200203	PARKER	IH20	416+0.35	416+0.55	32.74167	97.65806
200204	PARKER	IH20	417+0.4	417+0.6	32.73722	97.64361
200205	PARKER	IH20	417+0.75	417+0.95	32.73583	97.63778
202801	JOHNSON	IH35W	37-0.4	37-0.6	32.53972	97.31306
202801	JOHNSON	IH35W	32+0.4	32+0.6	32.48694	97.28028
202802	JOHNSON	IH35W	33+0.1	33+0.3	32.49667	97.2875
202802	JOHNSON	IH35W	33+0.2	36+0.0	32.53528	97.31167
202803	JOHNSON	IH35W	36-0.2	36-0.4	32.52944	97.31028
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Figure A.1 Major satellite factorials included in the RPDB

Current Satellite Factorials in the Database

The satellite factorials described in this section are not the only ones in the RPDB, but they represent those that have been of most interest in the last few years because of the valuable information they have provided. This section contains a description of the results obtained from partial analysis of sections in the satellite factorials.

Pavement Sections from Research Project 1244

Back in 1986, prior to Project 1244, Project 422 evaluated a set of new pavement sections cured by different techniques and investigated crack control methods to prevent very close crack spacing. Thus, four more locations were selected in the Houston area. The test sections were placed during summer and winter conditions. The locations and seasons in which they were placed are shown in Figure A.2.

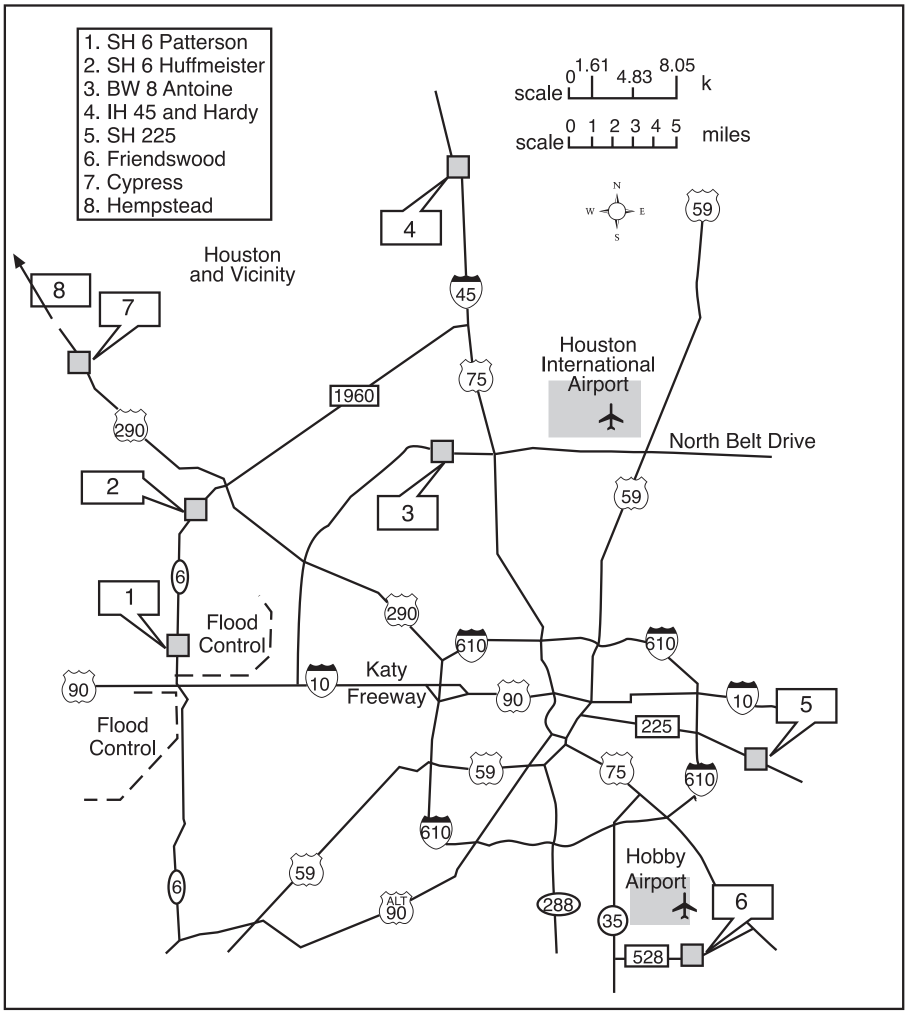


Figure A.2 Location of test sections of the 1244 research study

Different properties of the concrete were measured at the time the project was developed. Concrete strength, crack spacing and width, and weather conditions were evaluated. Later, as an effort on this RPDB project, the sections belonging to this study were revisited and tests were conducted in different ways. The testing program included splitting tensile and compressive strengths of cores, abrasion resistance, modulus of elasticity, density, skid resistance, and petrographic analysis. Additionally, condition surveys were conducted.

The sections in this factorial basically investigated the effect of different coarse aggregates on the performance of PCCPs.

Summary of Results of the 1244 Research Study

The following points provide with a summary of the results of the study:

1. There were significant differences in both crack spacing and crack width between SRG and LS sections. LS sections presented larger crack spacing and smaller crack widths than the SRG sections.
2. All the test sections presented a skid resistance number that complied with TxDOT's minimum specifications.
3. The lowest skid resistance numbers were found in the recycled pavement, which was the most recently built section in the project.
4. The highest skid resistance numbers were found on the tined sections placed during the winter.
5. The relationship between skid resistance and placement season is not well understood yet because of a variety of factors that should be analyzed. Further research is necessary.
6. Tined sections consistently presented higher skid resistance numbers than non-tined sections.
7. SRG sections presented a higher strength and density than LS sections.
8. The overall condition of the sections containing SRG was poorer than that of the rest of the sections.

Pavement sections from research study 3925

According to the literature available from this project (Reference 4), the results obtained from Projects 6 and 7 in Friendswood (FM 528) and Cypress (US 290), respectively, were not reported as part of Study 1244. The results were instead shown on Study 3925 along with the results from the sections located in Hempstead, which were the core of the study. Figure A.2 shows the general location of these test sections (Projects 6 and 7) in relation to the rest of the sections. Figure A.3, shows the location of the sections in Hempstead.

From the results obtained from the analysis of these sections, the following conclusions were made:

1. Early-age sawcutting suggests that surface crack initiation is more efficient than interior crack initiation.
2. Sawcutting should be performed between the initial and final settings of the concrete (in the first 48 to 72 hours after placement).
3. The crack pattern in CRCP pavements is affected by different factors including CAT, prompt sawcutting, good concrete mix design, reinforcement steel design, and construction practices.

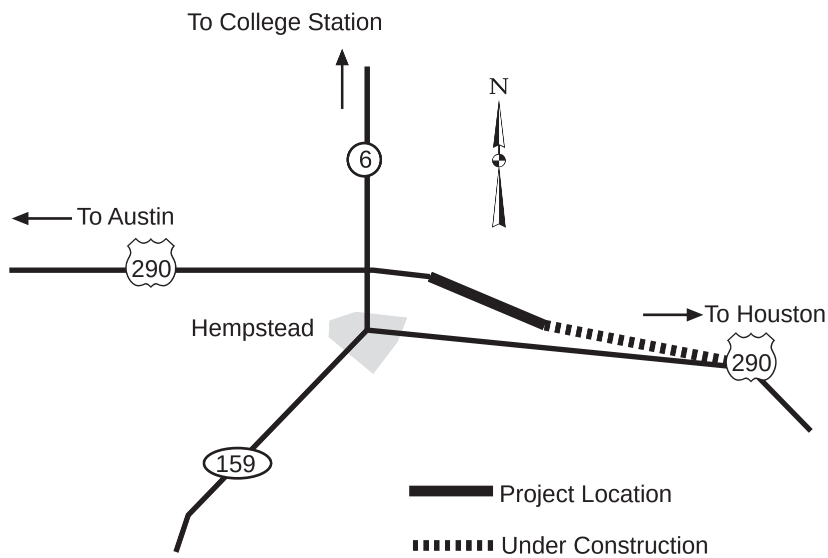


Figure A.3 Location of test sections on US 290 in Hempstead, Texas

Pavement sections contained in the QC/QA projects

From all the satellite factorials, the quality control and quality assurance (QC/QA) projects are the ones for which the most information has been gathered and the most analysis has been performed. One of the reasons for highlighting these sections as being part of the database is that TxDOT has initiated a program that will provide QC/QA performance-related specifications for PCCPs. These specifications are currently in the final stages before implementation.

The QC/QA projects include pavement sections that have been selected from different sites. Those construction projects have various component variables: they were built using different types of aggregate, different pavement types (CRCP and JCP), and different thicknesses, and were they were placed in different seasons (winter and summer). All of this information has served to evaluate the response of pavements under the influence of a combination of some of those factors, and to differentiate between desirable and undesirable conditions regarding construction practices and use of materials.

The construction projects included in this study are spread throughout Texas. There are three construction projects in El Paso (El Paso 1, El Paso 2, and El Paso 3); one in Garland (north of Dallas), one in Amarillo, and one in Fort Worth. Dallas, El Paso 1, and El Paso 2 provided vast information about climatic conditions and concrete strength. The other projects only provided partial information about concrete strength.

The following results from the analysis of the QC/QA projects are considered important:

1. CAT is a major factor that should be carefully supervised during pavement construction. The greater the coefficient of thermal expansion (COTE) of the aggregate, the more volumetric changes the concrete mass will experience. Consequently, the higher the detrimental tensile stresses will be.
2. The season in which pavements are placed plays an important role in the early and long-term performance of the structure.
3. Combinations of high ambient temperatures (summer conditions) and the utilization of aggregates containing silicates should be avoided as possible.
4. A good correlation was found between splitting tensile strength and flexural strength of concrete samples.
5. Evaporation rates above 0.2 $lb/ft^2/hr$ are considered undesirable and thus should be avoided.
6. Prompt curing of the concrete pavement should always be pursued to avoid a negative impact on concrete durability.

Projects in Houston containing 70 ksi reinforcement steel

Other construction projects that have been considered for further study and that are part of a satellite factorial are the ones built in Houston in 1996 and 1997 that contain 70 ksi reinforcement steel. These construction projects were selected for inclusion in a new special study because there was an interest from TxDOT in analyzing the results of the introduction of the use of Grade 70 steel in the Houston district.

In all the projects being studied, the use of Grade 70 steel was recommended by contractors, and TxDOT officials analyzed and accepted the requested change based on their previous experiences. Thus, using construction plans, the contractors prepared proposals suggesting the use of Grade 70 steel instead of Grade 60 steel. The change, according to the proposals, would yield lower construction costs per square yard of constructed pavement without compromising the performance of the structure.

The projects included in the study and incorporated into the RPDB are located on IH-45, SH-249, and SH-146. There are two test sections in every construction project, yielding a total of eight sections included in a factorial. Considerable analysis has been conducted in the past to evaluate the behavior of the different sections, and it is believed that new information should be collected to clarify a few concerns that resulted from the previous analysis.

A summary of the results of the analysis produced from these sections includes the following points:

1. All the sections were investigated with the objective of evaluating their performance under certain conditions.
2. The construction conditions of the sections were collected from plans and construction specifications, then with that information, environmental conditions at the time of construction were obtained from the National Oceanic and Atmospheric Administration (NOAA) website.
3. The CRCP8 software was successfully run for every single section to predict the crack spacing occurrence.
4. The sections located on IH-45 already presented 25 percent to 45 percent of the transverse cracks spaced under 3 ft, as was predicted by the CRCP8 software.
5. The use of coarse aggregates with a high COTE should be considered carefully because of potential development of undesired thermal stresses in the pavement.

6. The concrete setting temperature should be observed, and values above 90 ºF should be avoided. The ambient temperature at which the concrete is placed should never be greater than that value.

The concrete set temperature should be observed and values above 90 degrees Fahrenheit should be avoided. It means that the ambient temperature at which the concrete is placed should be never above that value.

Appendix C

Proposed Distress Analysis of the Sections

Proposed Distress Analysis of the Sections

Proposed Distress Analysis for the Sections

In the summer of 1999, as part of research study 01778, a qualitative and quantitative analysis of some sections contained in the RPDB was conducted. A total of 28 JCP sections located in the Dallas district were analyzed. The sections analyzed presented different distresses such as ACPs, portland cement concrete patches (PCP), punchouts, D-cracking, and corner breaks. The study also computed and analyzed crack and joint spacing distributions.

This time, as a complement to the previous analysis made for the JCP sections, a similar study will be conducted exclusively for CRCP sections. This analysis will show the existence of different distress types and crack spacing distributions for sections containing different aggregates. The study will compare sections showing poor crack spacing distributions with those showing good cracking distributions.

The analysis of the CRCPs will differ a bit from the one performed for the JCPs because in this case, no joint spacings are present. Likewise, some distresses that are specific to JCP pavements will not be considered (e.g, corner breaks and D-cracking).

Structure of the Analysis Plan

Figure C.1 shows the proposed analysis plan to be conducted. The first step consists of revising the entire CRCP database district by district; the analysis will be conducted for some of the districts that contain enough non-overlaid test sections. Having selected the districts to be analyzed, the next step will be to separate those test sections containing LS from those containing SRG.

The distresses to be included in the analysis are spalled cracks, punchouts, ACPs, and PCPs. Transverse crack spacing will be analyzed in a separate form and this information could be validated by running the CRCP8 software.

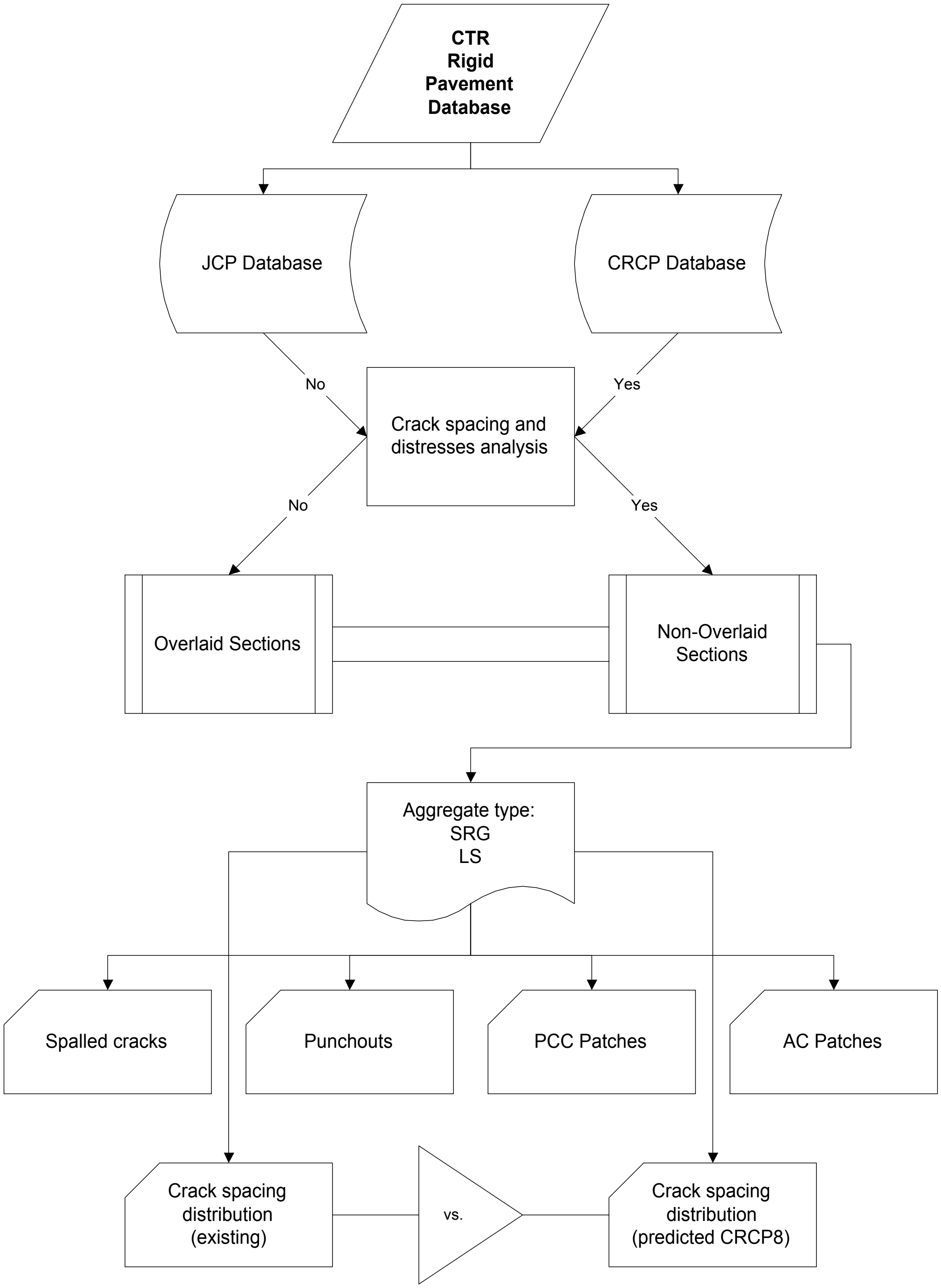


Figure C.1 Analysis plan for crcp sections

Coarse aggregate type consideration

As previously mentioned, the effect of coarse aggregate type and the distresses observed in different test sections will be analyzed for some districts. The evaluation of distresses could be approached by computing the following:

1. Overall distresses - this represents the number of failures (occurrences) for each aggregate type separately (LS and SRG) in the whole length of the section.
2. Computed mean distress - a series of charts showing the mean number of failures for the overall sections containing every aggregate type (LS and SRG).
3. Standardized mean distress - this shows the number of failures assuming a standard mile of pavement having the standardized mean distress per mile (DPM).

Crack spacing distribution

This section of the analysis will focus on the evaluation of transverse crack spacing distribution of the concrete pavement sections. As in the distress analysis section, the crack spacing will be evaluated based on aggregate type, either LS or SRG. In general, the crack spacing analysis could be approached by computing the following:

1. The crack spacing for the first 200 ft of the section - reliable cracking distribution can be computed for every single section (LS and SRG) because the location of every crack is available with an accuracy of one tenth of a foot.
2. The overall mean crack spacing - this is computed by considering the total length of the section and dividing that distance by the total number of cracks found.
3. A calibration-validation of the CRCP8 program - specific sections could be used to validate the CRCP8 software and predict punchouts' appearance.

Sub-Factorial for Crack Width Analysis

In accordance with discussions about the current status of the database and analysis of the available data for the pavement sections, CTR staff and the project director decided to prepare a sub-factorial of sections for which collection of crack width data could be conducted in following years. The objective of this section of the report is to provide a guideline for how to select that group of sections and how to conduct the crack width data collection. Previous experiences from TxDOT research studies 472 and 1342 provide some steps to be followed.

Selection of Test Sections for the Sub-Factorial

To complete the surveys of all CRCP test sections, one hundred sections are left approximately. This estimate includes sections that might be incorporated into the database for the first time as new sections. Thus, a sub-factorial was prepared and it represents those remaining sections for which crack width data will be collected.

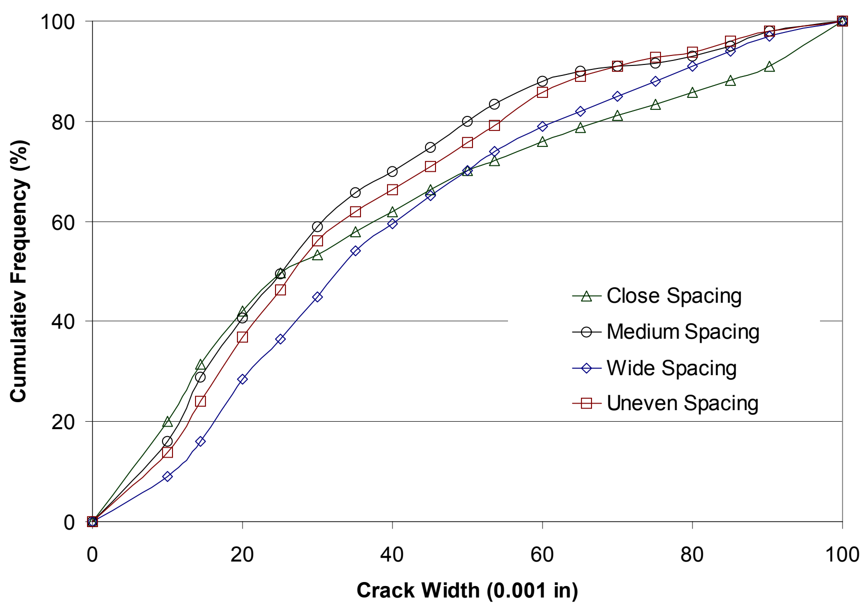
An effective sampling factorial was developed back in 1994 for research project 1342; and Reference 5 contains the detailed information. Using that procedure as a base a sub-factorial was developed for crack width data collection. The sub-factorial includes a number of sections that best represent the entire database, so it includes key factors that affect pavements' performance. According to previous experience significant factors that should be somehow included in the sub-factorial are the following: CAT, pavement thickness, crack spacing distribution, and pavement temperature. A climatic variable that may be included in the sub-factorial is the evaporation rate. Last year, as part of this research project, evaporation rates as well as other climatic variables were deducted from available weather and construction data for both the JCP and CRCP databases. Reference 1 contains detailed information about the estimation of those parameters.

Description of Factors to be Included in the Sub-Factorial

Coarse aggregate type: Different research studies performed at the CTR have found that the aggregate type in concrete is a key factor in pavements' performance. The two most commonly used aggregates in Texas, SRG and LS, have been investigated in those studies. For the sub-factorial, a variable including both aggregate types would be considered.

Pavement thickness: Because thicknesses of the CRCP pavement sections contained in the database range from 8 to 13 in. a middle value in this range would be considered the limiting one. Consequently, all the pavements of thicknesses ranging from 8 to 10 in. would be cataloged as "thin," and all the pavements with a thickness of more than 10 in. would be classified as "thick." This variable is related to the reinforcement steel in the pavement; the thicker the pavement, the greater the percentage of reinforcement steel.

Crack spacing distribution: According to theory and some previous studies, the greater the crack spacing, the wider the crack width (Reference 6). However, some deeper analyses showed that crack spacing is imprecise for some sections, and that, usually, wide crack spacing and uneven crack spacing yield a noticeable influence in crack width distributions. Figure C.2 explains these findings.



Source: Reference 6

Figure C.2 Cumulative distribution of crack width by crack spacing

Then, for this sub-factorial it would be interesting to consider sections previously surveyed showing wide crack spacing and uneven crack spacing distributions.

Concrete pavement temperature: This variable is related to the coefficient of thermal expansion (COTE) of the coarse aggregate in the concrete. When the temperature of the concrete is high, the concrete expands, and the cracks are narrow; on the other hand, when the temperature decreases, the concrete shrinks and the crack widths get wider. For the sub-factorial, temperatures would be categorized as "low" and "high," and readings should be obtained for both scenarios.

Evaporation rate: As one of the most important factors in both the early-age and long-term performance of pavements, evaporation rate is a must in this sub-factorial. According to previous experiences, a value of 0.20 lb/ft^2/hr would define a limiting value for this parameter. Concrete pavements with evaporation rates below that limiting value would be classified as having "acceptable" evaporation rates. Everything above that limit would be classified as having a "high" evaporation rate.

Figure C.3 presents the layout of the sub-factorial, including all the variables previously described.

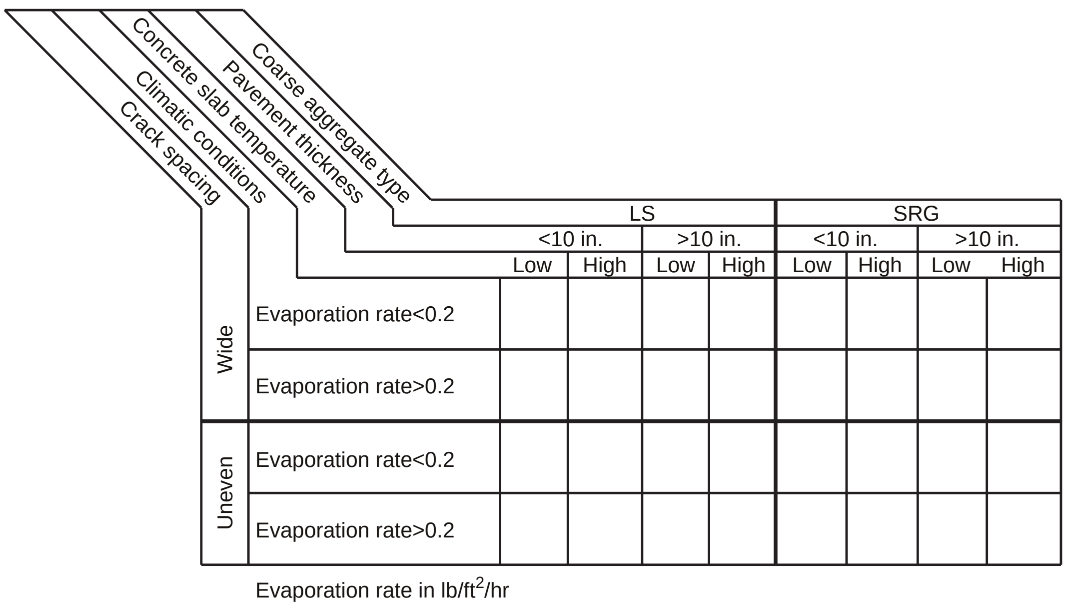


Figure C.3 Layout of the sub-factorial for crack width data collection

Recommendation for Field Crack Width Data Collection Procedure

CRCPs are designed to be able to crack, and the cracks are held tightly closed by the steel reinforcement. Hence it is vital to retain aggregate interlock to assure load transfer across the crack and to prevent the intrusion of undesirable materials or water that cause pavement distress. If the cracks are too wide, the load transfer is almost null, and high stresses will develop.

When measuring crack width, and for the purposes of this project, it may be necessary to measure crack movements at different temperature rates. It has been debated whether changes in slab temperature affect crack opening in a detectable way, but studies conducted in the last few months have demonstrated that there is definitely some correlation between slab temperature and crack width. Based on these findings, it is suggested that a minimum reliable number of crack width measurements should be taken to achieve a reasonable standard error.

A final decision should be made about the field procedure to measure the crack width. During research projects 472 and 1244, a microscope was used to obtain accurate readings, and an experimental design was conducted to determine the dependability of the measurements when taken by different operators, ranging from an unskilled operator to an expert engineer with high skills in field data collection. From the investigations, it was concluded that no significant difference existed between the measurements taken by different people, except that the measurements taken by an unskilled operator had a higher variance than those taken by the other operators.

Field Data Collection Procedure

Based on the preliminary considerations above, it may be worthwhile to collect crack width data at different points in the pavement section. Because of budgetary and time constraints for this project, a microscope would not be used. Instead, a crack comparator that could give an acceptable and comparable crack width value could be used. Additionally, the measurement of the cracks should be conducted at different times during a given day when a section is surveyed. Figure C.4 shows a crack comparator that is used for concrete and masonry crack width measurements.

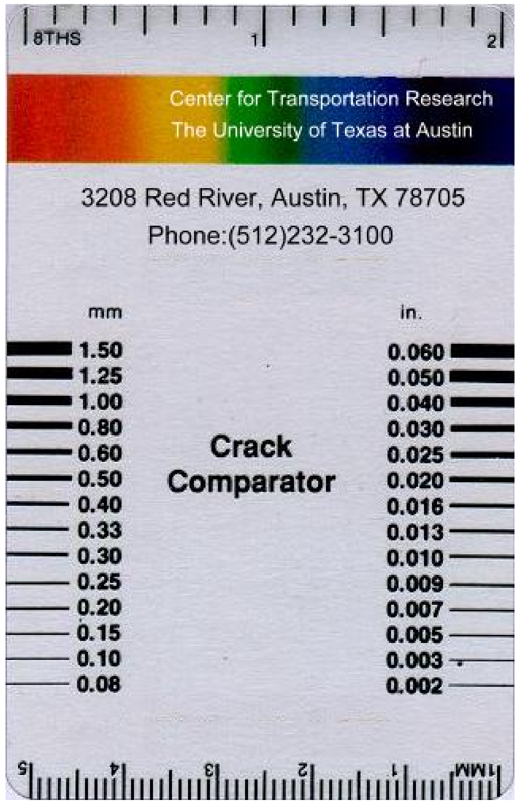


Figure C.4   Crack comparator used for crack width measurements

In order to obtain reliable information, it may be necessary to take at least five different crack width readings per surveyed section (one every 200 ft, or a different pattern, at surveyor's discretion). The final decision on this matter would depend on the prevailing conditions of traffic, weather, and availability of time. The crack width recordings should be written down in the Comments section of the condition survey form. All the necessary computations and analyses regarding crack width should be executed at the office.

Final Considerations

Spalled cracks should be avoided in the measuring of crack width because they cannot be reproduced or repeated well and because they may contribute to bias in analysis of the overall readings.

It is important to obtain the pavement temperature when measuring the crack widths, this procedure takes very little time but can provide useful information.

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