Data Mining of the Caltrans

Pavement Management System (PMS) Database

Draft report prepared for the California Department of Transportation by

Jeremy Lea, Research Engineer
Infrastructure Engineering
Transportek, CSIR
Republic of South Africa

John T. Harvey, Associate Professor
University of California, Davis
Institute of Transportation Studies, Pavement Research Center

Pavement Research Center
University of California, Berkeley
1353 S. 46th St., Bldg. 452
Richmond, CA 94804

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Since 1977, Caltrans has been routinely collecting performance information for its pavement network and using a pavement management system (PMS) to manipulate this information in order to aid in the management of the network. This report details the "mining" of this database to extract environmental performance indicators for the various climate regions in California, and to extract section information for portland cement concrete (PCC) pavements that have been overlaid with asphalt concrete (with the specific goal of obtaining information regarding the reflection cracking performance).

The first objective of this study is to provide the best possible estimate of the performance of the standard Caltrans strategy for asphalt concrete overlays of PCC pavements, to provide an estimate to Caltrans, and to provide calibration data for the development of mechanistic-empirical models for reflection cracking. The second objective of this study is to provide recommendations for short-term and long-term changes to the Caltrans PMS and the operations that support and maintain it.

Before performance models could be developed, the PMS database required the following work:

- Conversion from the data records that were collected following the Caltrans "dynamic segmentation" procedure to fixed-length pavement segments. Dynamic segmentation means that for each year, the nodes that define pavement segments change depending upon the observed condition of the pavement surface. Dynamic segmentation is a very good approach for maintenance scheduling, but does not lend itself to predicting performance over time, which is necessary for any optimization of expenditure and the extraction of a statistical sample for performance modeling.

- Conversion of data to appropriate formats for analysis (primarily conversion of text strings to numeric values).
- Removal of empty and redundant fields.
- Establishment of a primary index to link records across time. This was necessary because the "sequence numbers" used to identify sections over time were found to be non-unique and not uniformly applied.
- Linking of the several databases of condition survey data with the traffic database and the awards database.

Problems encountered while converting the data to fixed segments and merging of the several PMS databases developed between 1978 and 2000 were as follows:

- The biggest problem with extracting pavement performance information from the database is that the only information contained in the database that relates to the pavement structure is whether the pavement surface is flexible (asphalt concrete) or rigid (portland cement concrete). This is a major problem which it was hoped could be solved by relying on the fact that Caltrans has used the same procedures for designing and rehabilitating their pavements for most of the time period spanned by the databases. In all analyses, it had to be assumed that the pavements are a homogenous population that can be expected to have the same performance except for external factors.
- All of the Caltrans databases are tied to one another and to the physical pavement network by the milepost information. However, the handling of this information is different in each database and the milepost information for the network is not fixed. This means that the milepost system is not linear or consistent, making it very

difficult to manipulate. This problem is compounded by different precisions (decimals included in the milepost field) in the databases which causes problems due to rounding, and by the dynamic segmentation which results in very short segments across time which the rounding errors confuse.

The accumulated problems with the dynamic segmentation and the milepost rounding resulted in the decision to use only the 1978 to 1992 data for performance modeling, and to not try to merge that database with the 1992 to 1997 database. Similarly, the Awards database was not merged with the pavement condition databases because: the awards information did not seem to match changes in pavement condition, and there was very little information on what actual maintenance or rehabilitation treatment was performed.

Problems were encountered with the milepost information in the Traffic database. In particular, the milepost information is different from the milepost information in the pavement condition databases.

The final outcome of the data processing was a single database containing pavement and condition information based on fixed sections. This database is being delivered to Caltrans with this draft report. This database is only based on the 1978 to 1992 data. The report contains a description of the database structure.

The two queries performed on the database establish the performance of asphalt overlays on existing cracked PCC pavements and the differences in performance of pavement in the various climate regions in the state.

With regard to the reflection cracking performance of AC overlays of PCC pavements, 61 sections were included in the sample. It was found that there were two populations: one that lasted about two years before cracking appeared, and one for which approximately 50 percent of the overlays showed cracking after 10 years. It has been suggested that the short-lived overlays may be predominantly “maintenance” overlays of 30 to 45 mm, and are not “rehabilitation” overlays of 106 mm, which are expected to provide a design life of about 10 years. However, there is no information in the database regarding the thickness of the overlays, or the crack and seat method used, the type of asphalt used, or the construction quality. The difficulty of using a PMS database with no structural information is illustrated by this case.

The performance of the AC overlays of PCC pavements showed that sections with medium traffic had the worst performance, followed by the high traffic sections and the low traffic sections. This result could be due to the small data set for the low traffic sections, or because the traffic counts in the PMS are not valid. A third possible reason is that the medium traffic set contains many of the thin “maintenance” overlays, which results in a shorter mean life for this group.

With regard to the performance of AC overlays of AC pavements, and AC overlays of PCC pavements, performance was evaluated with regard to the seven climate zones defined in a previous report (*1*): Bay Area, Central Valley, Desert, High Desert, Mountain, North Coast and South Coast.

For AC overlays of AC pavements, the assumption is that the Caltrans AC overlay design method (California Test Method 356) accounts for traffic volume and pavement condition to provide a 10-year design life, but does not account for difference in climate region. Again, the assumption is that the overlays are designed for 10-year life, but because of the lack of structural information in the PMS, it is likely that the sample included some thin maintenance overlays. The results indicated that in the Bay Area, Central Valley, and North Coast climate regions, the overlays have good performance, while in the other climate zones the performance is not as good. The South Coast and High Desert regions appear to be bimodal. The mean lives to Stage 3 cracking were between 9 and 12 years.

For AC overlays of PCC pavements, there was little difference observed between the climate regions.

Recommendations for changes in the operation of the Caltrans pavement management system database are:

- Develop a new milepost system,
- Include structural information in the PMS database,
- Use fixed evaluation segments for the condition survey, and develop the dynamic segmentation for maintenance management through post-processing,
- Rationalize the database structure used to store pavement related data, including the use of more appropriate primary keys than the currently used concrete or asphalt surface type, and
- Perform quality checking of the traffic database using Caltrans Weigh-In-Motion (WIM) data.

Future research and performance model development using the Caltrans PMS database requires implementation of the previous recommendations. Once these recommendations have been implemented, it is recommended that the database be used to develop more sophisticated models than those that could be developed with the current database. These models can look at additional distress mechanisms and ride quality as measured using the International Roughness Index (IRI). More sophisticated models should include:

- More distress mechanisms, and
- More explanatory variables, including materials types, rehabilitation strategies, maintenance strategies, and if connected to the database, construction quality.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

Since 1977, Caltrans has been routinely collecting performance information for its pavement network, and using a pavement management system (PMS) to manipulate this information in order to aid in the management of the network. This report details the "mining" of this database to extract environmental performance indicators for the various climatic regions in California, and to extract section information for portland cement concrete (PCC) pavements that have been overlaid with asphalt concrete (with the specific goal of obtaining information regarding reflection cracking performance). The first objective of this report is to provide the best estimate possible of the performance of the standard Caltrans strategy for asphalt concrete rehabilitation of PCC pavements.

The Caltrans PMS Database, as referred to in this report, consists of five separate databases obtained by the University of California Pavement Research Center from the Caltrans Maintenance Program. These databases are as follows:

- A database of pavement sections covering the period 1978 to 1992,
- a corresponding database of lane conditions covering the period 1978 to 1992,
- a combined section and condition database covering the period 1992 to 1997,
- a spreadsheet which contains awards information from 1978 to 1997, and
- a database of traffic counts for the network, covering the period 1980 to 1997.

These databases have been imported into Microsoft Access and (to the extent possible) the tables have been cleaned and manipulated to try and provide a consistent set of data.

The Caltrans PMS database is used for maintenance scheduling, and therefore most of the information contained within the systems is focused on institutional data rather than pavement related data. This, along with the evolution of the system over time, has made the extraction of meaningful statistical data from the system very difficult. Because of these difficulties, this report also makes some recommendations for changes or improvements to be applied to any future PMS system, especially any system directed towards research or strategic management rather than the day to day management of the network.

The second objective of this report is to provide short-term and long-term recommendations for change to the Caltrans PMS and the operations that support and maintain it.

2.0 BACKGROUND

The University of California Pavement Research Center (PRC) along with its research partners is currently developing a new pavement design methodology for Caltrans, compatible with the AASHTO 2002 method, that will make use of a mechanistic-empirical design process. As implied by the term “empirical,” the equations used by the methodology require calibration from field data. Along with heavy vehicle simulator (HVS) test sections and experimental sections, one of the main sources of data for calibration of empirical pavement performance models is from historical pavement performance information collected and used by road agencies in the context of day-to-day management of a highway network. This data is normally stored within a pavement management system (PMS).

One of the goals in the Strategic Plan (*2*) for the PRC is the calibration of mechanistic-empirical performance models. A task of this goal, also necessary for the development of the Caltrans Mechanistic-Empirical Design Procedure, was to investigate the use of the Caltrans PMS database as a source for information to build statistical models for pavement performance, a task normally referred to as *data mining*. In particular, two sets of performance models are difficult to develop using only HVS testing and field experimental test sections: differences in pavement performance within various environmental regions in the state; and reflection cracking of thin overlays on cracked pavements (either rigid or flexible), because of the effects of climate on reflection cracking.

Caltrans first implemented a pavement management system in 1977, when the concept of pavement management was relatively new, and computers were not as powerful as they are today. Over the subsequent 25 years, there have been large improvements in computers and significant changes in the theory and practice of pavement management, both within the way pavements are maintained in the State of California, and within Caltrans itself. These changes have led to the slow evolution of the Caltrans PMS database. In particular, the database management software has been changed three times, with concurrent changes in the structure of the database. There have also been changes in the structure and usage of various fields within the database structure. These changes have primarily been made to improve the capability of the PMS for day-to-day management of the network, but have sometimes made performance modeling more difficult because of lack of compatibility of the data fields across the changes.

Within the set of databases referred to in this report, two distinct databases of pavement condition information exist: 1978-1992 and 1992 onwards. The earlier data was stored in two tables, which were not related; the more recent data was stored in one table. These tables were in Microsoft FoxPro format. In addition, a table of traffic data (also in FoxPro format) and a Microsoft Excel spreadsheet containing contact awards information were also obtained from Caltrans.

Because of the evolution of the Caltrans PMS over the years, the historical information contained in the database was difficult to extract. The evolution of the PMS has mostly been guided by the way that the system has been used within Caltrans, and in today's PMS literature, the system would be referred to as a *maintenance management system* because it is geared toward providing information for short-term maintenance activities rather than long-term optimization of expenditure on the pavement network.

In particular, Caltrans has adopted a “dynamic segmentation’ procedure in which the pavements are not evaluated over fixed lengths, rather, the pavement is divided into sections of similar distress during each assessment. While this is a very good approach from the perspective of maintenance scheduling, it does not lend itself to predicting performance over time, which is necessary for any optimization of expenditure, nor to the extraction of a statistical sample for performance modeling.

2.1 Conversion to Fixed Length Pavement Segments

Before any analysis of the data as a time series could be performed, the data had had to be converted into a format amenable to performance modeling—performance information over fixed sections from assessment to assessment. The process of converting to this format is theoretically very easy, provided the data is clean. It involves extracting all of the dynamic segment boundaries from the database and establishing these as a set of fixed boundaries. Following this, the assessment data from each dynamic segment is assigned to each of the fixed segments that it spans. Thus, a performance history for each fixed segment is constructed.

However, this conversion does not solve the underlying statistical problem with the use of dynamic segments, which is that the performance information may have been collected (and therefore averaged) over different sections of pavement, and thus does not necessarily reflect the real performance of the converted “fixed” segment. While this is unlikely to introduce statistical bias into any models developed from the data, it will mask the true performance of each fixed segment, reducing the possibility of extracting meaningful models from the data.

2.2 Problems Encountered

While trying to convert the data to fixed segments and merge all of the databases together, a number of problems were uncovered. This section outlines these problems according to which of the five original databases contained the problem while describing the structure of the original databases and the manipulations performed to clean them.

2.2.1 General Problems with the Caltrans PMS database

The biggest problem with extracting pavement performance information from the database is that the only information contained in the database that relates to the pavement structure is whether the pavement surface is flexible (asphalt concrete) or rigid (portland cement concrete). This is a major problem, which it was hoped could be solved by relying on the fact that Caltrans has used the same procedures for designing and rehabilitating their pavements for most of the time period spanned by the databases. In particular, it was assumed that Caltrans has used one strategy for overlaying PCC pavements with asphalt concrete (AC), as shown in Figure 1.

It was also assumed that the year the overlay was constructed would be obvious in the database because the surface would change from PCC to AC. It was later learned that Caltrans occasionally also applied 30 to 45 mm (0.1 to 0.15 ft.) maintenance AC overlays that were indistinguishable in the database from the thicker rehabilitation overlays.

In all analyses, we had to assume that the pavements are a homogenous population that can be expected to have the same performance except for external factors. However, there are differences in the construction quality and materials across the state.

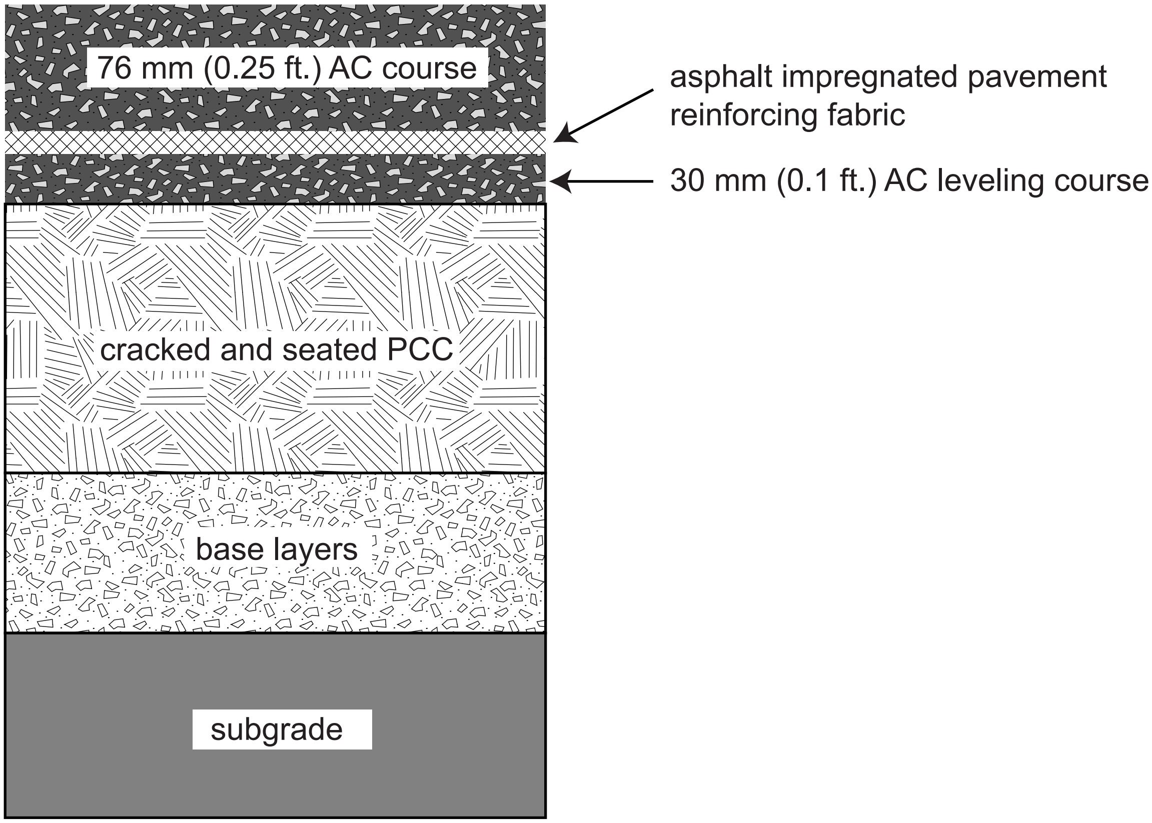


Figure 1. Standard Caltrans rehabilitation design for AC overlay of PCC pavement.

To develop performance models, it is necessary to know the performance of a fixed section of pavement over time and also the values of any explanatory variables for that segment, such as the traffic.

All of the Caltrans databases are tied to one another and to the physical pavement network by the milepost information. However, the handling of this information is different in each database and the milepost information for the network is not fixed. When changes are made to the network, such as realignment or route extensions, Caltrans makes use of prefixes to indicate that the mileposts have been changed from their original layout. This means that the milepost system is not linear or consistent, making it very difficult to manipulate. For example, it is not possible to simply subtract the beginning mileage from the end mileage to determine the length of a section. This problem is compounded by the use of dynamic segmentation, because if the milepost system is changed for a section of road, then the surveys from before the change are relative to the old mileposts, while future surveys are relative to the new mileposts.

While it should be possible to relate all of the databases through the milepost system, the prefix information is often missing, so that it is not possible to determine which set of mileposts apply. Also the databases use different precision to store the mileage – some use one decimal place, others two and others three, which prevents direct comparison within the database software because of rounding. This problem is compounded by the dynamic segmentation, which results in very short segments across time so that rounding of mileposts can move a section from one segment to another over time.

2.2.2 1978-1992 Pavement data

This section of the database was contained in two separate databases, which were not linked together. The first (pave.dbf) contained information about the various pavement sections during this period, including the route numbers, the county and district, and the milepost information. Also included in this database was climatic and geographic information, along with some other basic information and maintenance history. The section condition information was contained in another database (lane.dbf), which contained one record for every lane that was rated.

Because of the age of these databases, many of the fields were not formatted with the appropriate data types (real, integer, date, or text), and the databases did not contain primary indices, resulting in the records in the database not being unique. Also, there were no defined relationships between the pavement sections and their condition ratings. The field types had also been modified over time with the result that the database contained a large amount of redundant information that is no longer synchronized.

The first stage of the processing of these databases was to convert the data types to the appropriate formats for the data (such as converting text strings containing dates into date data types). During this process, a number of redundant and empty fields were also removed. Appendix A contains the database field definitions for the original databases and the resulting structures. In this appendix, the original descriptions and data types are shown, along with any revisions based on the processing of the data. As a result of the data type conversions, the size of the lane database (lane.dbf) was reduced by 50 percent and the pavement database (pave.dbf) by around 30 percent.

The second stage of processing was to remove any duplicate records from the database so that a primary index could be established. The original databases contained some fields that were a concatenation of several other fields, which were the original indices. However, these indices contained incorrect data and also contained duplicates, and so a new index had to be constructed.

The condition information was linked to the pavement information by a "sequence number," which should have been unique for each pavement section. These numbers were assigned at the time that data was collected. However, there were two problems encountered with these sequence numbers. The sequence number format was changed in 1985, however for 1985 and 1987, the pavements were rated with both sets of numbers. The result is that for these years, many pairs of pavement segments have the same old style sequence number but inconsistent new numbers, or alternatively, the same new style numbers but inconsistent old style numbers. Thus both sets of sequence numbers proved to be necessary and had to be retained in the database to maintain the continuity over time necessary for performance modeling.

The sequence numbers were also not unique for a particular route, which was the minimum information available within the table to look up condition information for a pavement.

If the pavement type changed from flexible to rigid (or visa versa) along a route, then the sequence numbers were restarted, and thus the pavement type also needed to be stored. If the sequence numbers had been a continuously increasing series along a route, then they could have been more effectively used to resolve conflicting milepost information. Also, the sequence numbers normally started at a new value in each county. The sequence numbers should have been unique to the entire route, rather than just the portion of the route in a particular county. However, this was not strictly enforced, so the sequence numbers often started at the same value in two or more counties.

The final index for the pavement table was the route, two sequence numbers, the year of assessment, and the pavement type (flexible or rigid). The final index for the lane table was the index for the pave table plus the lane direction and number. It took approximately three person-months to manually resolve all of the conflicting sequence numbers in the two tables and to try to resolve the milepost information so that the sequence numbers and the mileposts both incremented in the same direction.

This still did not provide enough information to build a relationship between the pavement and the lane tables sufficient to match the condition information to the milepost information. Once the two tables had been cleaned, and the keys listed above established as unique keys, there were still a large number of keys that existed in only one of the two tables. For the database software to establish a relationship between the tables, it requires the full (unique) index from one of the two tables and that other table only contains these values and no additional values. Another two person-months was spent reconciling these values between these two tables. This task was made more complex by the nature of the lane table, since it contained no location information (other than the suspect sequence numbers).

After processing, the pavement database contained 80,999 records (i.e., unique sections), and the lane database contained 309,965 individual condition assessments. Originally the pave.dbf table contained 99,190 records, and the lane.dbf table contained 538,082 records. The majority of the difference can be attributed to the fact that lane.dbf contained assessments for ramps and other auxiliary pavements, which were deleted. The remainder of the difference was in duplicate records.

The pavement table contained traffic information in the form of AADT (average annual daily traffic) counts for the section, but upon preliminary inspection, it was found that these counts were not reliable. The values were often very high, and the counts for a particular section changed dramatically (sometimes by up to three orders of magnitude) from year to year.

2.2.3 1992-1997 Pavement Data

This database consisted of a single table containing both the information about pavement sections and condition information (all_dbs.dbf). The data types were mostly the appropriate types for the data they contained, and so this table required far less preprocessing. The structure of this database was different from the earlier database in that it is divided by lane and mileposts, as opposed to the earlier data in which all of the lanes are grouped under one set of milepost information per survey. This not only made the database very big, but also meant that it was much more difficult to detect problems in the milepost information because the mileposts for one lane might stop and start as the lane is added/dropped in hilly topography or as the route passes through more densely/sparsely populated areas.

This table also contained duplicate records that needed to be identified and removed before a primary index could be established. A number of predefined indices, one of which should have been the primary index, were included as additional data fields.

Besides the duplication in data caused by storing the segment specific information for each lane, this database also contained a large amount of redundant information. In particular, it contained the same section information in every lane record. It also contained two complete sets of milepost information, two sets of odometer readings from when assessments were performed, and four pavement length descriptions. After a great deal of data processing, it was decided that the second set of milepost information was the most reliable and also best matched the route lengths from the older data. The remainder of this redundant data was thus discarded. Additionally, all of these lengths were stored in miles, to a precision of three decimal places, or a resolution of 1.6 m (5.2 ft.), with a very large number of pavement sections less than 100 m (328 ft.) long. The milepost information in the other data was only stored to one decimal place.

After processing, this database contained 104,927 condition assessments, of which approximately 40,000 (40 percent) have conflicting milepost information and conflicting sequence numbers or other details required to establish a primary index. Processing of this database was stopped at this point because of the fact that data was segmented on a lane-by-lane basis, combined with the large number of very small sections, would have resulted in a very large number of fixed sections when the database was processed to remove the dynamic segmentation. Because merging this data with the 1978-1992 data would have required applying this new set of fixed segments along with those obtained from the earlier data, this would have resulted in too short and too many and segments to be handled effectively.

This database contains different condition rating fields from those in the older data, so a consistent set of statistical variables could not be extracted anyway. It would appear that Caltrans has standardized on this new method of condition assessment and database format, and so any more recent data needs to be joined with past data, and a method needs to be devised to extract fixed segments.

2.2.4 Awards Information

This spreadsheet contained information about the contracts awarded, organized by route and milepost. However, because the information was contained in a spreadsheet and not a database, the data integrity was even worse then that of that of the databases. Although there is a great deal of financial information, there is very little information about the actual maintenance or rehabilitation treatment performed, so the only real use of this database is to establish the dates when maintenance might have taken place on various sections. However, upon inspection of the data, none of the awards appear to match when there have been changes in the condition of sections — this implies that either the award dates are not close to the actual dates of maintenance or rehabilitation activities, or that the milepost information in the awards database is not accurate. Only some preliminary inspection of this data, and conversion to a Microsoft Access table was thus performed.

2.2.5 Traffic database

A single database table, containing traffic information from 1980 to 1997 was also obtained from Caltrans. This table had a fairly simple structure, consisting of traffic information at a particular milepost on a route for a particular year. This data also uses dynamic segments, so that the mileposts at which traffic counts are performed need not be the same from year to year.

The quality of the traffic information was not verified in this study. It may be that many of the traffic data are incorrect or out of date. It is not certain when the traffic database was last subjected to a comprehensive audit and field check. It is known that Weigh-In-Motion (WIM) traffic counts and axle weights are not included in the traffic database.(*3*)

Relatively little processing of the traffic database was needed; only some minor corrections for mistyped county names or route numbers were required. The primary index for this table should be the route, the county, the sequence number (different from that in the other databases), and the year in which the count was performed. However, this key has not yet been established because there are 7,450 records of the 67,243 records where the sequence number is missing. All of these data points are from 1996 and 1997. These records should be fairly easy to resolve once the milepost information is cleaned.

The problem with using this database is that it stores different milepost information from the other databases. Not only are miles stored to two decimal places, the prefixes are also different. To match this data to the fixed segments determined for the 1978-1992 data requires working through every data point in this file to establish its true mileage along the route so that it can be added into the fixed segment boundaries. This would be easy to automate if the milepost prefixes were the same in both databases, but because of discrepancies the data, automatic processing isn't possible.

3.0 RESTRUCTURED DATABASE

The final outcome of the data processing was a single database containing pavement and condition information based on fixed sections. This database is being delivered to Caltrans with this draft report.

The database is only based on the 1978-1992 data and consists of a number of tables linked by various relationships. The entry point into the database is the Roads table, which contains one record per road within the state, broken up by route and county. There are 541 "roads" in the database.

Below the Roads table is the Sections table, which contains the fixed beginning and ending mileposts for each section in the database's milepost system, and in terms of the Caltrans milepost system (the milepost that occurred most frequently was used to populate this table), along with the number of lanes in each direction. There are 17,701 fixed "sections" in the database. Below the Sections table is a Lanes table, which adds the direction and lane number to the index, and represents a single lane of the pavement. Below this table is a Condition table, which contains the annual condition information for each of the lane segments.

Currently the Condition table holds a link to the corresponding Lane table entry, which holds the original condition data. In the future, the condition data will be held in this table directly, and the original data tables removed from the database.

The relationships between these tables is shown in Figure 2.

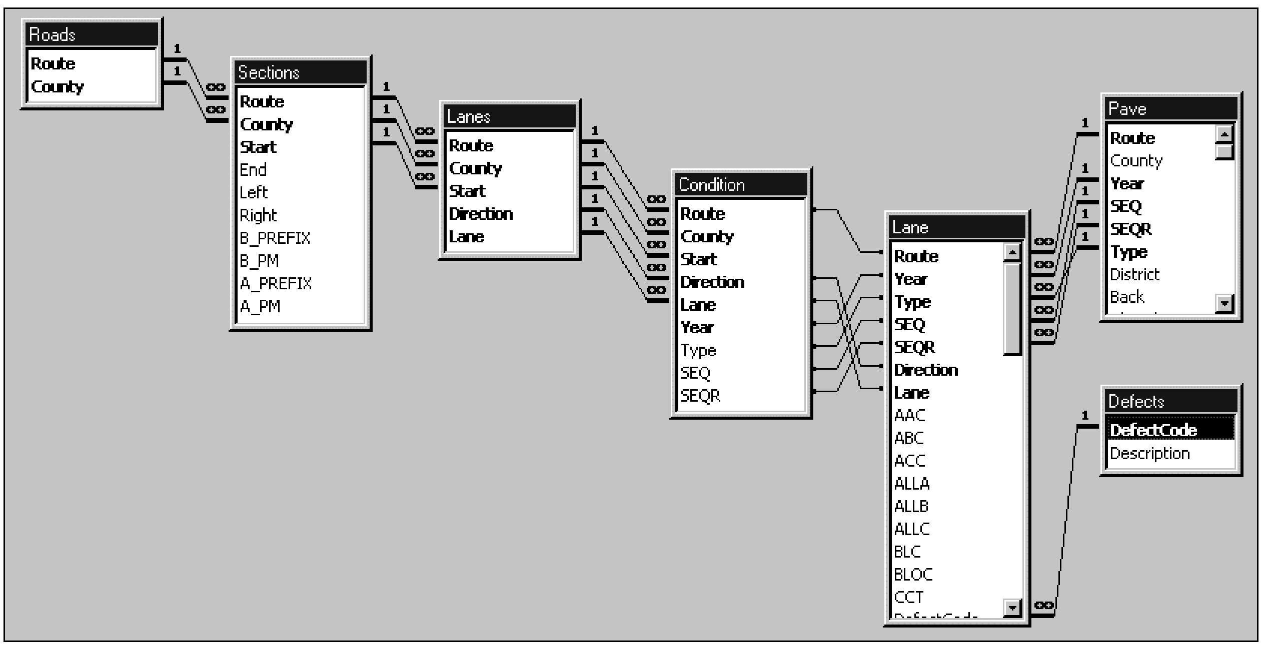


Figure 2: Reconstructed database structure.

Future work on this database will be to link the roads and Caltrans mileposts to the Caltrans state highway GIS coverage. This will involve the determination of the actual mileages along each road (from the GIS data) and linking these to the Caltrans highway log to establish a transformation from the milepost system to a physical location. Once this has been performed, the traffic data and the condition data from 1992 onwards can be linked into the structure above.

This work needs to be performed using GIS because it is designed to handle physical location referencing systems, and so can perform analyses that are impossible in a relational database.

4.0 DATA ANALYSIS

The processed database has sufficient information to perform some basic queries about the performance of pavements within the state, albeit only from 1978 to 1992. For the development of the Caltrans mechanistic-empirical pavement design method, the two most pressing queries were to establish the performance of asphalt overlays on existing cracked PCC pavements, and the differences in performance of pavements in the various climate regions in the state.

4.1 Reflection Cracking Performance of AC Overlays on PCC

One of the standard Caltrans maintenance practices is to overlay cracked PCC pavements with asphalt. While these overlays are designed with a 10-year design life, it was suspected that the actual performance of the overlays was considerably less. One of the primary reasons for the analysis of the database was to determine if a transfer function could be developed for reflection cracking of asphalt overlays. However, the various statistical problems described in other sections of this report prevented a proper statistical analysis.

What has been performed is an analysis of the expected life of an asphalt overlay, based on Bayesian updating of the original statistical analysis.(*4*) In this analysis of 61 sections, the mean life was 7.33 years, with a standard deviation of 1.76 years. This standard deviation was split into a deviation of the mean of 0.29 years and a sample deviation of 1.74 years.

To obtain a data set, a series of database queries were executed, which extracted all sections where the surfacing changed from concrete to asphalt. The time from this change to the last condition assessment where no cracking was observed, and the time until the first condition assessment where cracking was observed was determined. Thus, expected life was defined as the point when cracking is visible. Observed time to reflection cracking is shown in Table 1.

As can be seen, the range is normally four years: two years from the last assessment when the pavement was concrete and the first when it was asphalt, and then another two from the last assessment without cracks and the first assessment with cracks.

Table 1 Observed Time to Reflection Cracking

Observed Life (Years)	Number of Sections	Lane Length (miles)
>1	4	0.4
>2	21	9.1
>3	485	309.5
>4	3	2.1
>5	380	198.9
>7	467	217.1
>9	60	35.1
>11	5	1.5
>12	12	2.0
0-1	70	15.3
0-2	469	191.8
0-3	195	48.2
0-4	562	284.9
0-5	16	8.7
1-5	53	28.4
2-5	37	12.9
2-6	253	120.1
2-7	52	27.7
3-7	32	10.2
4-7	44	13.4
4-8	18	9.0
4-9	99	57.5
5-9	30	14.7
6-9	2	0.2
7-11	8	1.4
8-12	2	0.7

Based on the original distribution (which is what is assumed by the Caltrans design method), the likelihood that these various lives would be computed is calculated and this is used to update the distribution to obtain a new distribution for the mean life.

Given that all of the sections have different lengths, the likelihood function was weighted by the section length. A “weight” of 50 miles was assigned to the original distribution. Based on preliminary analysis of the likelihood, it was observed that there appear to be two distinct groups in the data: pavements that have failed and pavements that have not. In the analysis, these were split into “poor” and “good” groups, respectively. This might not be the best grouping as some of the pavements that had not failed only had very short service, and some of the pavements that had failed had much longer service lives.

The results of the analysis are shown in Figure 3, where the likelihood functions, the probability density functions of the mean, and the expected life can be seen. It is fairly obvious from this figure that the “poor” pavements have an expected life considerably less than the mean life expected by the Caltrans design method, while the “good” pavements are performing fairly well compared to the design. It is thus likely that there are two statistical populations: pavements for which the overlay was successful and pavements for which the overlay failed prematurely. It has been suggested that the short-lived overlays may be predominantly “maintenance” overlays of 30 to 45 mm, and are not “rehabilitation” overlays of 106 mm shown in Figure 1. The difficulty of using a PMS database with no structural information is illustrated by this case.

It is possible to determine which sections had short lives and which had long lives in order to establish a data set for further investigation to determine which factors contributed to the differences in life. For example, construction records could be found to determine the crack and seat method used, the type of asphalt used, and whether a membrane was used.

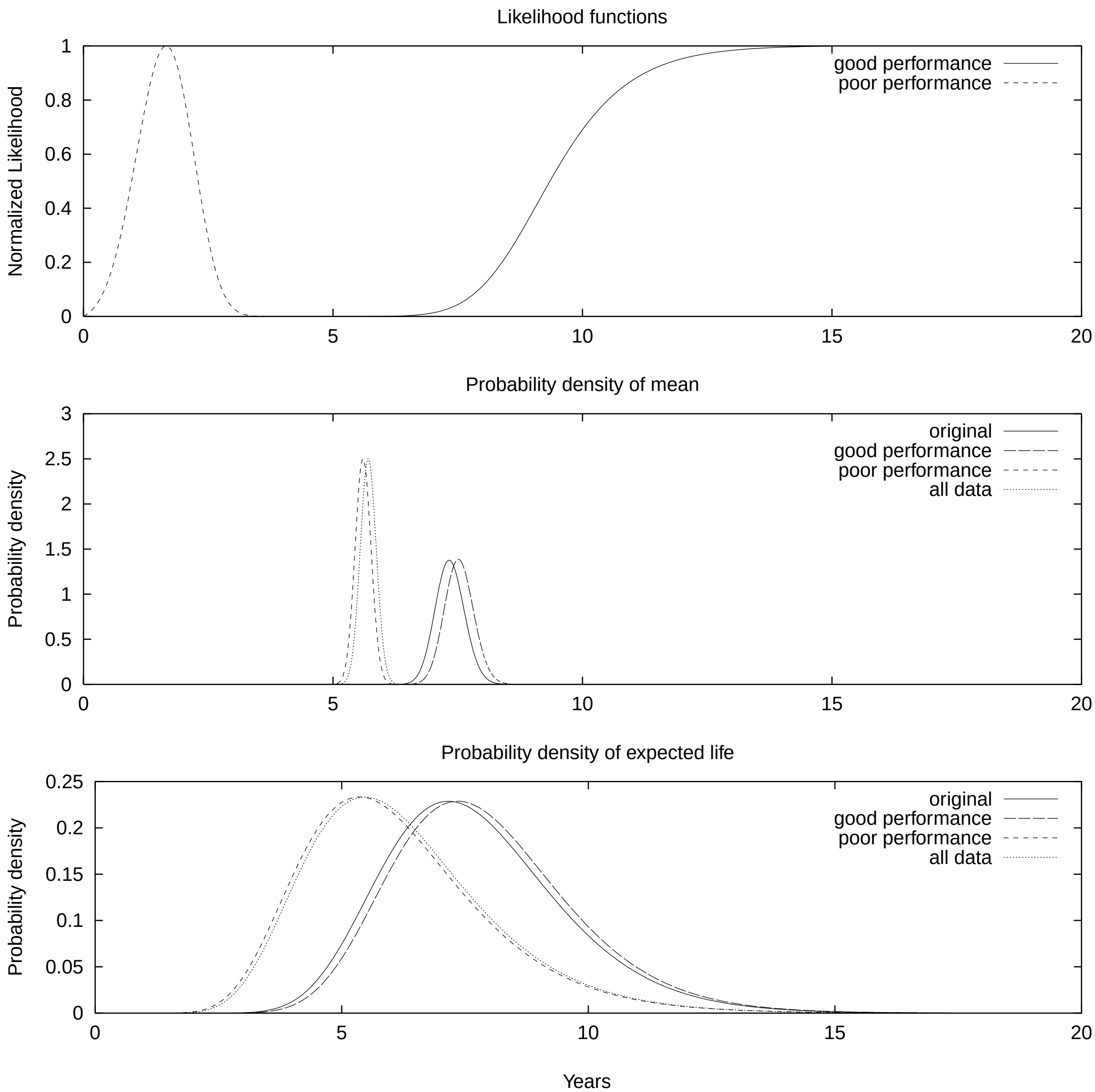


Figure 3. Bayesian analysis of expected pavement life for reflection cracking in AC overlays of PCC pavements.

The most obvious explanatory variable in any pavement is traffic, and so the traffic data from the 1978-1992 PMS database was used to determine three traffic categories for these sections based on the average annual daily vehicles per lane. As has been mentioned previously, this data does have several problems, but due to the inadequacies of the milepost system, the traffic database cannot be related to the PMS sections and so the this data had to be used despite its problems. The traffic was broken into three traffic classes: light, medium, and heavy. These classes were further split at 2000 and 10000 vehicles per lane per day. The breakdown on section lengths is shown in Table 2.

Table 2 Time to Reflection Cracking Based on Traffic Class

Observed Life (Years)	Low	Medium	High
>1		0.4	
>2	2.0		7.1
>3	15.8	105.5	188.2
>4			2.1
>5	13.5	89.9	95.5
>7	7.2	99.6	109.9
>9		2.6	32.5
>11		0.1	1.4
>12	0.2	0.1	1.7
0-1	2.4	9.1	3.8
0-2	6.5	143.5	41.8
0-3	2.7	15.2	30.3
0-4	3.9	192.5	88.5
0-5	0.5	7.3	0.9
1-5		3.2	25.3
2-5		11.7	1.2
2-6	0.4	51.6	67.8
2-7	3.0	18.1	6.6
3-7		5.7	4.5
4-7		9.9	3.5
4-8		0.9	8.1
4-9		48.6	8.9
5-9		6.2	8.5
6-9		0.2	
7-11		0.2	1.2
8-12		0.8	

Few pavements fell into in the low traffic class because these pavements tend to be flexible pavements, and secondly, seldom require an asphalt overlay if they were constructed as rigid pavements. The results of the Bayesian analysis are shown in Figure 4, where it can be seen that although the traffic does have a significant influence, the sections with between 2000 and 1000 vehicles/lane/day have the lowest mean time to reflection cracking, followed by the high traffic pavements; the low traffic pavements have the highest mean. There are three possible reasons for this, other than some real effect from traffic on reflection cracking. The first is that the data set for low traffic volumes is very small. The second is that, as mentioned, the traffic counts from the PMS database may not be valid. The third is that the "maintenance" overlays may have been primarily placed on the medium (2,000 to 10,000 vehicles/lane/day) sections.

4.2 Comparison of Climate Regions for AC Overlay of AC

With accelerated pavement testing, it is difficult to include the effects of climate on pavement performance. It was hoped that the PMS data could be used to develop calibration factors for the various climate regions in the state, and to obtain some idea of the relative performance of pavements within the various areas. A sample of all of the single lane asphalt roads from across the state was taken, and all of the roads classified by the climate zone into which they fell. The climate zones were those determined for the new Caltrans Mechanistic-Empirical design method,(*1*) which divides the state into seven climate regions: North Coast, High Desert, Mountains, Bay Area, Central Valley, Desert, and South Coast. Once this subset of the data had been extracted, the time between a condition of no distress and the occurrence of stage three alligator cracking was determined. These results are shown in Table 3.

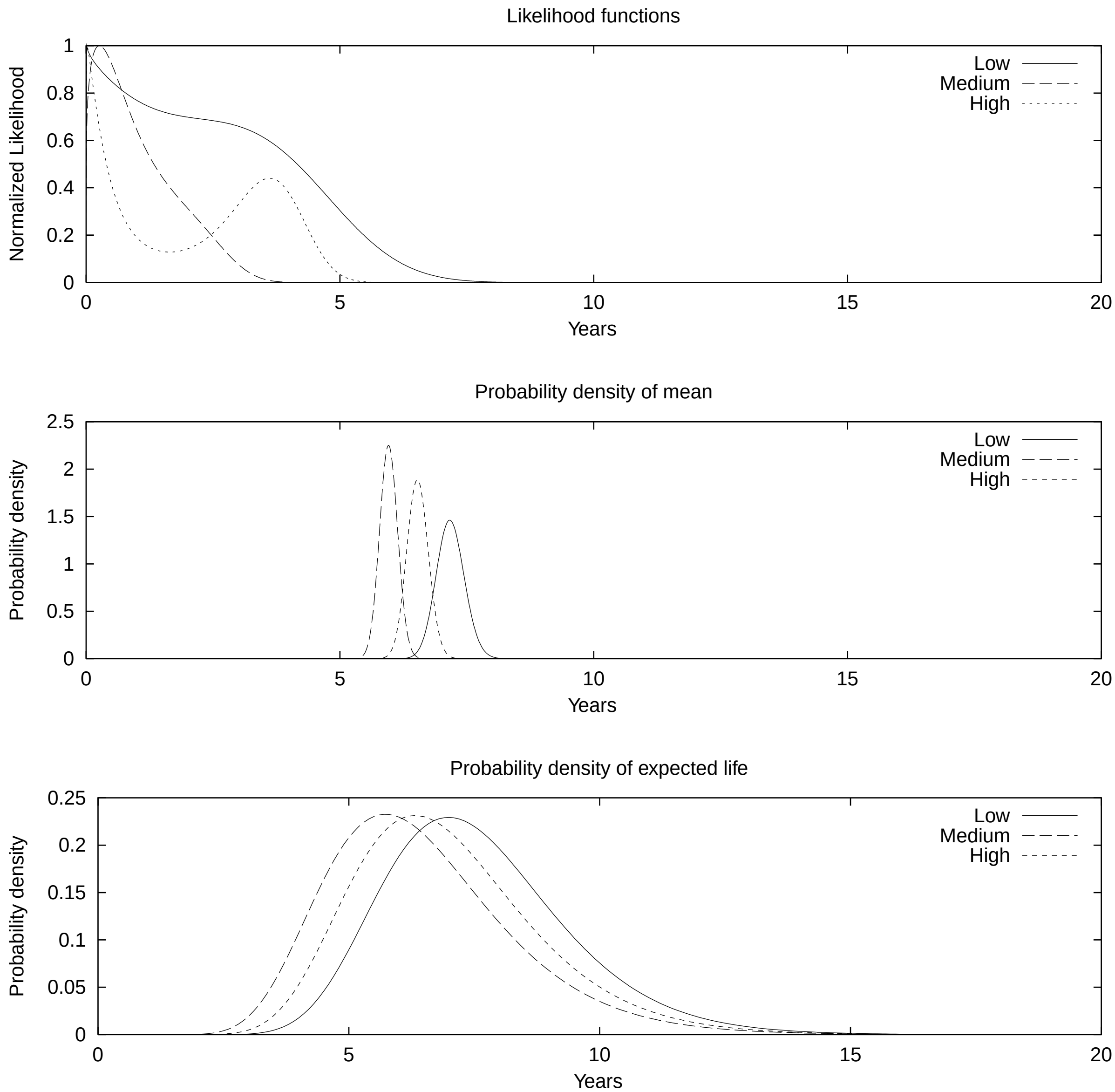


Figure 4. Baysiean analysis of time to reflection cracking based on trafic class.

Table 3 Time to Stage Three Cracking by Climate Zone

Observed Life	Climate Zone						
	Bay Area	Central Valley	Desert	High Desert	Mountain	North Coast	South Coast
>2	40.8	307.5	165.0	2.4	79.0	12.2	16.6
1-3	1.9	27.8	0.8	10.9	81.2	4.4	17.8
2-3	2.7	15.8	1.7		15.7		0.4
>3	71.7	162.9	17.8	10.4	162.3	0.2	35.0
2-4		15.9	0.3	1.0	34.4		0.2
3-5		44.4	20.9	29.7	36.2		1.2
4-5		3.5	1.4		3.1	3.6	
>5	237.6	200.5	272.2	30.4	186.1	9.8	64.5
4-6	2.2	11.2			8.4		
5-7	10.6	38.1	3.7	11.6	28.4		
6-7		7.5			9.6		0.1
>7	148.6	421.0	369.2	14.9	144.0	30.4	49.0
6-8			0.1		4.5		0.2
7-9	0.1	59.8		9.0	31.3	0.1	6.6
8-9		28.8			0.2		0.3
>9	119.9	459.1	138.5	13.0	87.1	14.7	93.4
9-11	0.2	31.1	5.4		16.4		1.9
>11	116.7	652.4	172.3	29.9	83.9	56.4	138.6
>12	5.2	119.9	12.6	16.8	19.5	55.5	7.5
>14	300.9	1977.6	423.5	30.4	405.2	358.7	227.3

Several things are apparent from the data in Table 3. The first is that the sample sizes from the various regions differ significantly, ranging from about 200 lane miles in the High Desert to 4600 miles in the Central Valley. Also, there are large differences in observed life between the various climate regions: In the North Coast 66percent of the roads have >14 years (the full survey period) without any observed stage three cracking, while in the High Desert this is only 15 percent, and nearly 50 percent fail before 5 years.

The same Bayesian analysis technique was applied to this data set except that a mean initial life of 7 years 4 months was assumed to match Caltrans AC rehabilitation overlay expected life and the initial distribution was weighted by 200 miles. A sample standard deviation of 1.74 years and a mean standard deviation of 4 months was used. These where chosen based on the Caltrans practice of designing overlays for a 10-year design period. The results of this analysis are shown in Figure 5.

It appears that in the Bay Area, Central Valley and North Coast climate zones, the overlays have good performance, while in the other climate zones, the performance is poor. The South Coast and High Desert zones appear to be bimodal.

The reflection cracking data set analyzed previously was also broken into climate zones. To do this, all of the roads that passed through more than one climate zone had to be discarded thereby reducing the total length of pavement considered. The data is shown in Table 4.

The same Bayesian technique was applied as in the initial analysis, and the results are shown in Figure 6. In this case, all of the posterior distributions fall below the original probability distribution function.

Although there are differences in the resulting probability distributions for the various climate zones, these do not appear to be large compared to one another, with the means ranging over just more than a year. Given all of the other factors that might influence this analysis, especially traffic levels between regions, it is unlikely that there are significant climatic influences on reflection cracking of AC overlays on PCC.

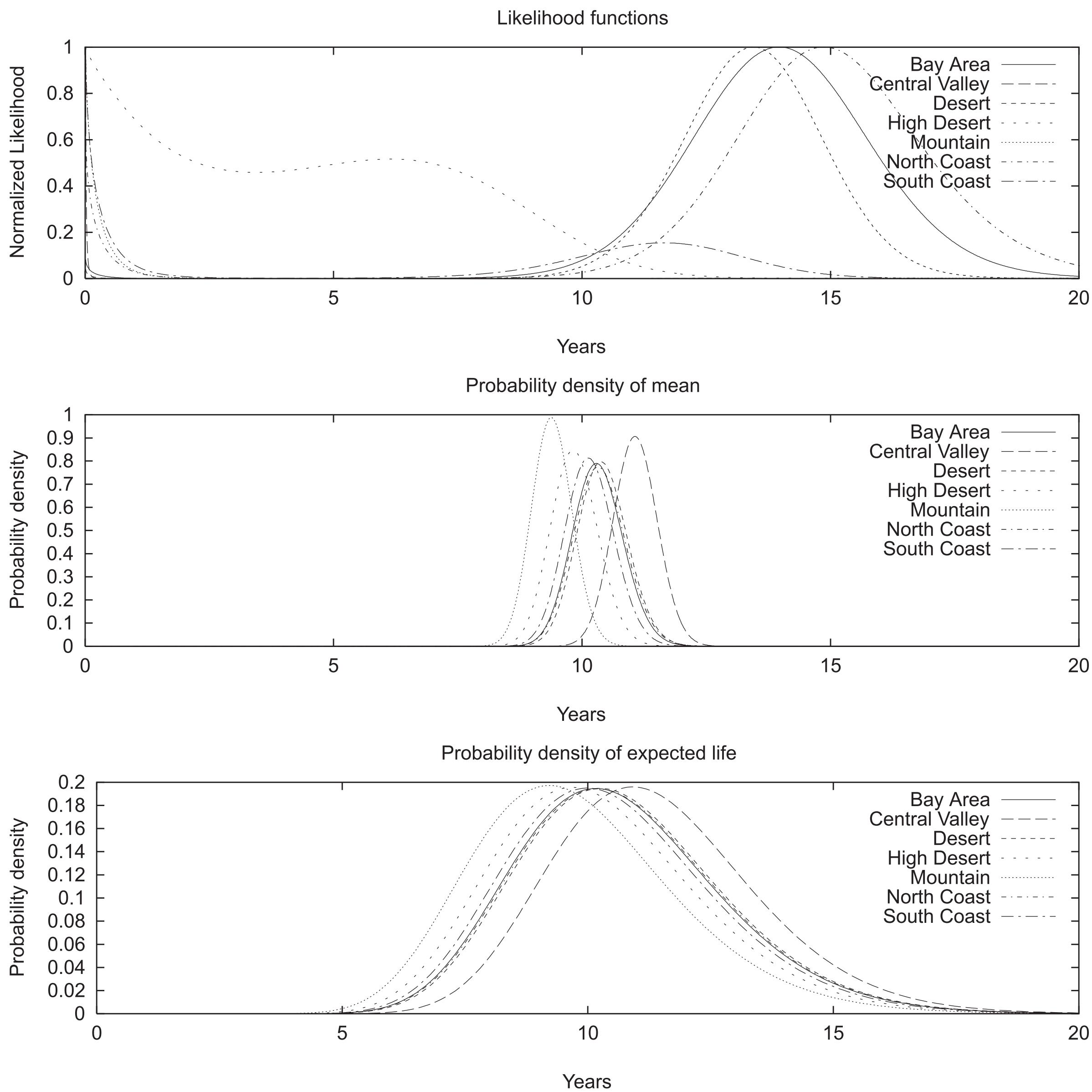


Figure 5. Bayesian analysis of stage three cracking of AC overlay of AC pavements.

Table 4 Time to Reflection Cracking of AC Overlays on PCC by Climate Zone

Time to Cracking (Years)	Bay Area	Central Valley	Desert	Mountain	South Coast
>2	0.6			1.2	2.9
>3	6.9	11.8	21.6	22.0	118.5
>4	0.9				
>5	40.2	53.0		6.7	14.3
>7	14.3	21.5		42.8	44.8
>9	9.9	7.2			4.0
>11	0.6		0.5		0.4
>12		0.2			1.7
0-1	0.2	3.4			4.0
0-2	8.6	34.2		56.4	26.8
0-3	18.8	3.7	4.5		16
0-4	16.0	21.2		41.6	59.0
0-5					1.2
1-5	8.8	1.1		0.2	12.3
2-5		7.1		0.6	1.4
2-6	10.2	19.4		4.8	34.4
2-7		5.9		4.0	5.1
3-7	0.2	4.1			4.7
4-7	4.3	4.4	0.5		1.3
4-8	8.1	0.9			
4-9	5.3	2.8			8.5
5-9	8.6	6.0			
6-9	0.2				
7-11	1.3				
8-12	0.8				

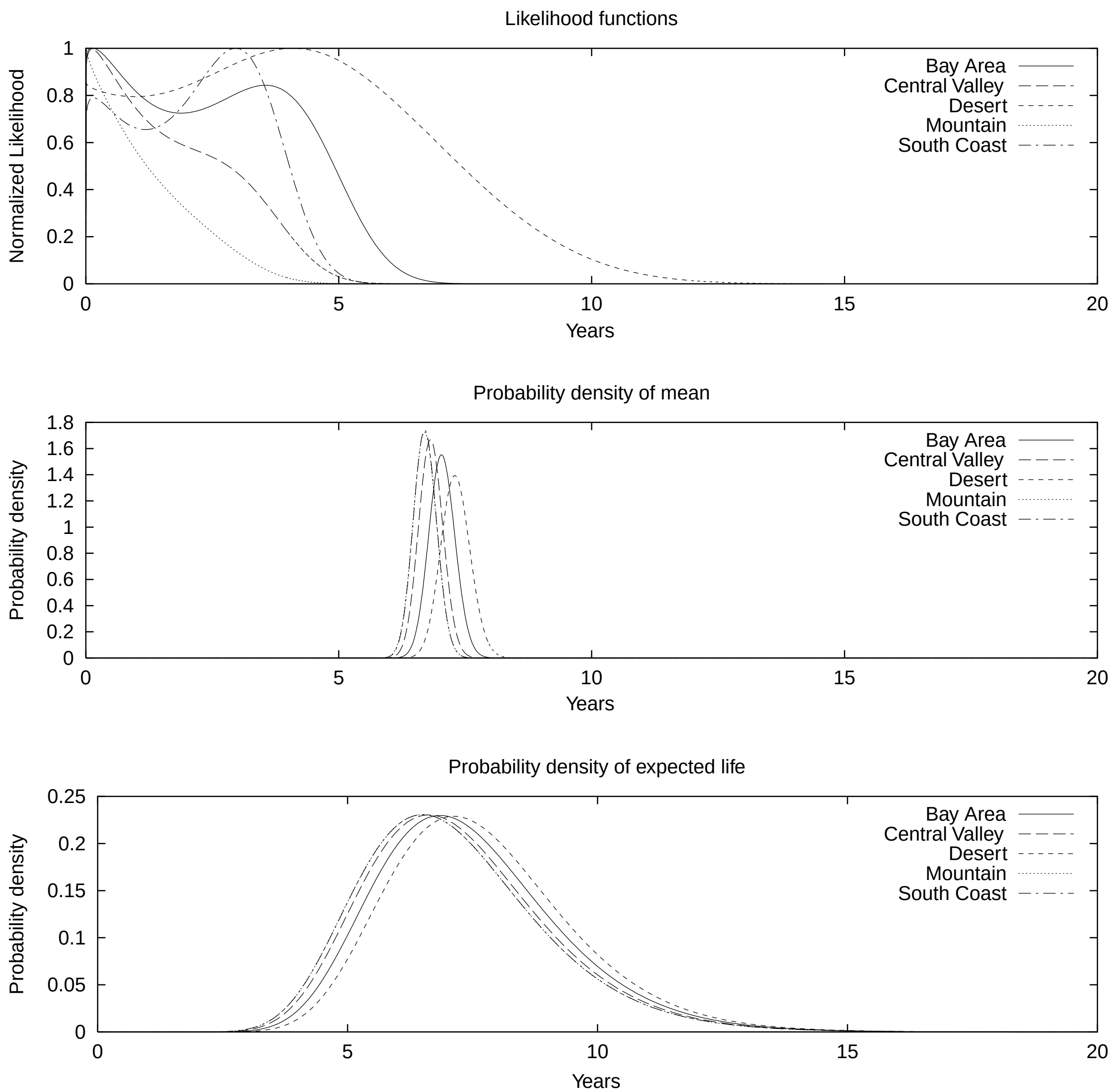


Figure 6. Bayesian analysis of reflection cracking by climate zone.

5.0 CONCLUSIONS

Caltrans has been collecting pavement management data for the past twenty-three years, although the systems that have been used to collect this data have changed a number of times during this period. The data collected, as with all data, reflects the purpose for which it was collected, which was to aid in the project-level maintenance of the network. Because of this, it has been difficult to organize the data into a useful format for statistical analysis.

Several major hurdles have arisen in the process of organizing the data. The first is that the Caltrans milepost system is not a fixed reference system, but changes from year to year. This has made it almost impossible to correctly link the survey, traffic, and maintenance activity data on a year-by-year basis. The second factor is that within this changing milepost system, the surveyed sections changed from year to year. This has necessitated a major restructuring of the database. Finally, the databases do not include any information concerning pavement structure, which is vital for the accurate statistical modeling of pavement performance.

In spite of these difficulties, the databases were cleaned and manipulated sufficiently to make it possible to extract some performance information. In particular, the data provided enough information to address two problems: reflection cracking of AC overlays of PCC and the performance of AC overlays of both AC and PCC pavements within each of the climate regions in the state.

It was found that the mean expected life of an asphalt overlay on a concrete pavement (whose predominant failure mode is reflection cracking) is just over seven years, about two and a half years less than the estimated design life. Also, two populations appear to exist within these overlays: one group that has performed as designed, and one group that has failed prematurely. These two groups may alternatively represent thin “maintenance” overlays and thicker “rehabilitation” overlays. In future studies, this data can be used to determine sections for further investigation and field testing to determine why some overlays failed while others performed satisfactorily.

There appears to be a strong influence of traffic on mean time to reflection cracking, but until the traffic database is linked to the performance information, it is not possible to explore this effect in more detail. The WIM database (*3*) offers extensive traffic data for a selected set of links, but has not been included or used to cross check the traffic database.

The modeling of climate effects has not produced such conclusive results. Although a subset of the data was extracted and processed, it is not easy to explain the reasons for differing performance for the various climatic regions in the state. It is thus likely that this factor includes influence from factors such as the regional economics, differences in truck traffic, and differences in construction quality, maintenance practices, and materials among the various regions in the state.

If any further work is to be carried out on these databases, then the major problem of incorrect milepost information needs to be overcome. To this end, the data needs to be linked with a GIS coverage of the state roads and the milepost system needs to be linked with a fixed reference system, so that the year-to-year data can be correctly related. Doing so would allow traffic data to be linked to condition data, allowing traffic to be used as explanatory variable.

6.0 RECOMMENDATIONS

The recommendations from this research can be grouped into two sets: 1) advice for Caltrans on improvements to pavement management strategy with the goal of increasing the value of the data collected, not only for research purposes, but for the day-to-day management of the network, and 2) recommendations for further research.

To continue this research requires that the PMS database be linked to the traffic database, and that the newer condition survey data also be incorporated into the database. This will require the use of a GIS to link the highway log to true distances along each route. The final outcome of this process will be a GIS coverage of all of the state highways, split at each of the points where there is a discontinuity in the milepost system. This will enable each milepost, with its associated prefix and suffix information, to be linked to an absolute distance from the start of the route as well as geographic coordinates.

Once this has been accomplished, it will be possible to link the milepost information from each database to the true mileage, and hence compare the databases and determine new fixed evaluation sections. The historical condition and traffic information can then be determined over these new fixed sections.

The problems noted in this report are already being faced on a daily basis by Caltrans engineers and pavement managers, who are attempting to use the condition survey information to maintain the network. Issues with the milepost system and with the type of data being captured have been repeatedly raised by Caltrans Maintenance staff during meetings over this work, and so it is felt that some recommendations for resolving these issues in the future should be made. The primary recommendations are detailed below:

- Development of a new milepost system.
- Inclusion of structural information into the PMS database.
- Use of fixed evaluation segments for the condition survey, and development of dynamic segments through post-processing.
- Rationalization of the database structures used to store pavement related data.
- Quality checking of the traffic database using the Weigh-In-Motion database.

While the development of a new milepost system may seem excessive, it is the key to easing management of the road network. The current system conflicts with the basic nature of a road network and has resulted in a great deal of unneeded complexity within the entire organization. There has been a significant amount of research published on normalized rational milepost systems, and the primary finding of this research has been that any linear referencing system needs to be built around the basic node and link structure of a road network rather than around arbitrary boundaries such as county or district boundaries. Also, the entire motivation for using a linear referencing system, as opposed to geographic coordinates, is the ability to easily determine distances along the link. This doesn't mean a total abandonment of the existing system because there is always a one-to-one mapping between any two location referencing systems, but a gradual shift to the new system as systems are updated and developed and routine maintenance on the network occurs.

To manage pavements requires knowing something about the pavements themselves. While condition information can and is used to understand pavement performance, it is not particularly useful for predicting future performance without at least knowing something about the pavement structure. Thus, it is important for the PMS to include at least rudimentary structural information and information on past maintenance and rehabilitation actions.

While dynamic segmentation is very useful for maintenance planning, it prohibits using any form of performance prediction, which is vital for true pavement management. Therefore, the PMS database should be restructured around fixed segments. It is a simple task to extract dynamic segments from fixed segments, especially in GIS-based software.

Finally, the PMS database structures currently in use are not correctly designed for the storage of the information. In particular, properties of the pavement, such as its structure (flexible or rigid) should not form part of any primary key for tables, since these change with time.

Future research using the PMS database requires implementation of the previous recommendations.

Once these recommendations have been implemented, it is recommended that the database be used to develop more sophisticated models than those that could be developed with the current database. These models can look at additional distress mechanisms and ride quality as measured using the International Roughness Index. More sophisticated models should include:

- more distress mechanisms
- more explanatory variables, including materials types, rehabilitation strategies, maintenance strategies, and if connected to the database, construction quality.

7.0 REFERENCES

1. Harvey, J. T., A. Chong, and J. Roesler. *Climate Regions for Mechanistic-Empirical Pavement Design in California and Expected Effects on Performance (Draft)*. Pavement Research Center, Institute of Transportation Studies, University of California, Berkeley. June 2000.

2. University of California at Berkeley CAL/APT Project Contract Team. *Strategic Plan for Partnered Pavement Research.* University of California Pavement Research Center, Institute of Transportation Studies. December 2000.

3. Q. Lu, J. Harvey, T. Le, J. Lea, R. Quinley, D. Redo, J. Avis. *Truck Traffic Analysis using Weigh-In-Motion (WIM) Data in California (Draft).* University of California Pavement Research Center, Institute of Transportation Studies. June 2002.

4. Murray, B. D. *Establish Criteria for Rehabilitation of California Pavements.* Report No. FHWA-CE-TL-78-36. Sacramento, California: California Department of Transportation. February 1979.

APPENDIX A

lane.dbf

Column Name	Description	Range
AAC	Alligator A Cracking %	0 - 99
ABC	Alligator B Cracking %	0 - 99
ACC	Alligator C Cracking Exists	X = Exists at this location
ALLA	Alligator A Cracking Strategy Code	2 Letters
ALLB	Alligator B Cracking Strategy Code	2 Letters
ALLC	Alligator C Cracking Strategy Code	2 Letters
BLC	Block Crack %	0 - 99
BLOC	Block Cracking	2 Letters
CCT	Caltrans Cost Center	3 Digits Code
DEFECT	Dominant Defect Description	12 Letters
DIR	Direction	L, R
DIS	District	1 - 12
DPN	District Project Number	1 - 500
DRIP	Drip Track Raveling	2 Letters
FLT	Faulting	S(Severe), L(Light)
FSC	First Stage Cracking %- Rigid Pavement	0 - 99
JDP	Joint Displacement	U(Up), D(Down)
JSP	Joint Seperation	Y or blank
LAN	Lane Number	1 - 6
LANSTR	Dominant Lane Strategy	2 Letters
LEX	Longitudinal Cracking Extent	1 Letter
LIF	?	
LONG	Longitudinal Cracking Strategy	KL or blank
LSV	Longitudinal Cracking Severity	1 - 4 for crack size in 1/4"
PAT	Patches %	0 - 99
PAV	Pavement Type	F, R, A
PCC	Percent Corner Cracking	0 - 99
PCO	Patch Condition	1 Letter
PRG	Program for Repair	HM12, HM1, HA22, HM11
PSI	Pavement Servicability Index	1 - 5
RAVEL	Raveling - F or C plus % value	0 - 99
RAVL	Raveling Strategy	2 Letters
RDP	?	
RDS	Ride Score	IRI 95+
RDT	Ride Date	Date
RIDE	Ride Strategy	2 Letters
RTE	Route	Route Number
RUT	Rutting %	0 - 99
RUTT	Rutting Strategy	TD or blank
S	Route Suffix	1 Letter
SEQ	Sequence Number for 1978 - 1985	Number
SEQR	Sequence Number for 1987 - 1992	Number
SHD	Shoulder Condition	Good, Fair, Poor, Missing

Column Name	Description	Range
SHDSTR	Shoulder Strategy	2 Letters
SKD	Skid Resistance	0 - 99
SP_D	Special Designation Number - (District+Counter)	7 Letters
STSL	Strategy code	2 Letters
STSN	Strategy code	2 Letters
STSS	Strategy code	2 Letters
TEX	Transverse Cracks Extent	1 Letter
TRAN	Transverse Cracks	KP or blank
TSC	Third Stage Cracking %	0 - 99
TSV	Transverse Cracking Severity	1 Letter
VEL	Velocity - speed for ride score collection	0 - 55

pave.dbf

Column Name	Description	Range
M_KEY	Key	
M_SURKEY	Alt Key 1	
M_ALTKEY	Alt Key 2	
M_ADT1	Average Daily Traffic 2	8 Digits
M_ADT	Average Daily Traffic	7 Digits
M_ADTCAT	Average Daily Traffic Catagory	H, M, L
M_AFY	Awarded Fiscal Year	2 Digits
M_AHPM	Ahead Post Mile with 1 Decimal	1 Decimal
M_AHPM2	Ahead Post Mile with 3 Decimals	3 Decimals
M_AMO	Awarded Month	1 - 12
M_AVEABC	Average Alligator A, B, C Cracking	0 - 99
M_AVEPAT	Average Patches	0 - 99
M_AVERDS	Average Ride Score	3 Digits
M_AVETSC	Average Third Stage Cracking	0 - 99
M_AWY	Awarded Sequence	4 Digits
M_AYR	Awarded Year	2 Digits
M_B	Back Post Mile Prefix	1 Letter
M_BKPM	Back Post Mile	1 Decimal
M_BKPM2	Back Post Mile 2	3 Decimals
M_CL_LEN	Distance Between Ahead and Back PM	1 Decimal
M_CO	County	3 Letters
M_CS	County Sequence	2 Digits
M_CST	Cost	Amount
M_CST2	Cost	Amount
M_DAT	Date	Date
M_DESC	Location Description	Description
M_DIS	District	1 - 12
M_F	Ahead Post Mile Prefix	1 Letter
M_F_LT	?	1 Letter
M_F_RIDE	Triggered Ride	1 Letter
M_F_RT	?	1 Letter
M_FED	?	1 Letter
M_FEDI	?	1 Letter
M_FUN	?	3 Characters - Alphanumeric
M_FY	Fiscal Year	2 Digits
M_GNDLT	Ground Left Lane	0 - 9
M_GNDRT	Ground Right Lane	0 - 9
M_H2O	Rainfall	3 Digits
M_LAMI	Triggered Lane Mile	1 Decimal
M_LAMI2	Actual Triggered Lane Mile	1 Decimal
M_LANEMILE	Lane Mile	1 Decimal
M_LEN	Length in Miles	1 Decimal
M_LNS	Lanes	0 - 16
M_LT	Number of Left Lanes	1 - 9

Column Name	Description	Range
M_LT_T	Triggered Left Lane	0 - 9
M_MAXABC	Maximum Alligator A, B, C Cracking %	0 - 99
M_MAXTSC	Maximum Third Stage Cracking %	0 - 99
M_MC	Maintenance Cost Per Mile	Amount
M_MC1	Maintenance Cost Per Mile Year 1	Amount
M_MC2	Maintenance Cost Per Mile Year 2	Amount
M_MC3	Maintenance Cost Per Mile Year 3	Amount
M_MO	Survey Month	1 - 12
M_MSL	Maintenance Service Level	1, 2, 3
M_NALLOT	Partial Contract Allotment (by length)	4 Digits
M_OCC	?	0 - 99
M_PALLOT	Allotment	Amount
M_PAV	Pavement Type	F, R, A
M_PI	Priority Index	2 Decimals
M_PPN	Project Priority Number	0 - 99
M_PRG	Program	HA22, HA21, HA43, HM1, etc.
M_PS	Post Mile Sequence	0 - 99
M_PST82	Sorted Sequence Number	4 Digits
M_RT	Number of Right Lanes	1 - 9
M_RT_T	Triggered Right Lane	0 - 9
M_RTE	Route Number	Route Number
M_S	Route Suffix	1 Letter
M_SEQ	Pavement Condition Sequence	7 Digits
M_SEQOLD	?	4 Digits
M_SEQP	PMS Sequence Number	5 Digits
M_SEQR	Sequence Number	7 Digits
M_STR	Strategy	2 Letters
M_TRIG	Trigger Lanes	Left, Right, or Both
M_TRK	Truck	0 - 99
M_TVS	Low ADT	3 Letters
M_TYP	Road Type	1, 2, 3, 4, 5, 6, B
M_TYP2	Lane Type	MLD, MLU, 2LN, BA, BL, City
M_WRK	Program - Work Type	HA22, HA21, HA43, HM1, etc.
M_XREF	Cross Reference	0 - 99
M_YEAR	Year	Year
M_YR	Servey Year	2 Digits
M_Z	Main Year	2 Digits
M_ZONE	Geographic Zone	3 Characters - Alphanumeric

all_dbs.dbf

Column Name	Description	Range
PTCH_PCT	Patching %	0 - 99
SIDE_LNS	Side Lanes	Not In Report
DMG_DIR	Damage Direction	Not In Report
DMG_LN	Damage Lane	Not In Report
TRIG_LNMI	Trigger Lane Miles	Not In Report
DISTRICT	District	1 - 12
BEG_PRFX	Begin Prefix	1 Letter
END_PRFX2	End Prefix	1 Letter
BEG_PM	Begin Post Mile	3 Decimals
END_PM2	End Post Mile	3 Decimals
ACT_LEN	Actual Length	3 Decimals
STRT_ODOM	Start Odometer reading	Numeric
END_ODOM	End Odometer reading	Numeric
NEW_PRIOR	New Priority Index Number	1 - 15
MSL_96	Maintenance Service Level for 1996	1, 2, 3
RSU	?	
FED_SYS	?	
FUN_CLS	Functional Classification	
DIS_PRE_95	District Boundaries Changed July 1996	District Pre 1995 1 - 12
COUNTY	County	3 Characters
ROUTE	Route	Route Number
MSL_A	MSL Class	1, 2, or 3
BEGIN_PRFX	Begin Post Mile Prefix	1 Letter
BEGIN_PM	Begin Post Mile	3 Decimals
END_PM	End Post Mile	3 Decimals
LENGTH	Length between begin and end post mile	3 Decimals
ODOMETER	Odometer reading of distance	3 Decimals
LANE_NUM	Lane number	L or R + 1 - 6
RD_TYP	Road type	MLD, MLU, 2LN, BA, BL, City
SRF_TYPE	Surface type	2 Letters
PVMNT_TYPE	Pavement type	F=Flex, R=Rigid
SHLDR_COND	Shoulder condition	G, M, F, P
ASCNDNG_PM	Ascending Post Mile when collect data	T or F
HOV	High Occupancy Vehicle Lane	T or F
NUM_LEFT	Number of Left lanes	1 - 6
NUM_RIGHT	Number of Right lanes	1 - 6
DATE_CMPLT	Date Complete Project	Date
SEQ_NUM	Sequence Number	6 Numbers
ADJ_RS	Adjust Ride Score	0 - 999
NO_DSTRSS	No Distress pavement	Date
NOT_RATED	Not Rated pavement	T or F
RCNT_CONST	Recent Construction	T or F
RCNT_MAINT	Recent Maintenance	T or F
UDR_CONST	Under Construction	Date
UNABLE_RTE	Unable to Rate Route	Date

Column Name	Description	Range
UNSAFE_RTE	Unsafe to Rate Route	Date
BA_CNR_CRK	Bridge Approach Corner Crack	T or F
BA_3RD_SPL	Bridge Approach 3rd stage Crack Spalling	T or F
SHLDR_DISP	Shoulder Displacement	U or D
JNT_SEP	Joint Separation	T or F
JNT_DSP	Joint Displaced	0, 1, or Blank
SLDR_J_SLD	Shoulder Joint Sealed	T or F
SHLDR_GRND	Shoulder Grinded	T or F
SLDR_SEALD	Shoulder Sealed	T or F
SLDR_TRAFFC	Traffic on shoulder	T or F
EDGE_CRKG	Edge Cracking	T or F
PATCHING	Patching	T or F
POOR_PTCH	Poor Patching	T or F
PTCH_EXT	Patching Extent	0 - 999
ALIG_A	Alligator A Cracking	0 - 999
ALIG_B	Alligator B Cracking	0 - 999
ALIG_C	Alligator C Cracking	T or F
CRK_WIDTH	Crack Width	0, 1, 2
CRKS_SEALD	Cracks Sealed	T or F
BLCK_CRK	Block Cracking	T or F
LNG_EXT	Longitudinal Cracking Extent	1 - 9
LNG_UPDWN	Longitudinal Cracking Up Down	U or D
TRNS_EXT	Transverse Cracking Extent	1 - 9
TRNS_UPDWN	Transverse Cracking Up Down	U or D
LIT_RAVEL	Light Raveling	T or F
CRSE_RAVEL	Course Raveling	T or F
DRIP_TRACK	Drip Track Raveling	T or F
BLEEDING	Bleeding	T or F
POTHOLES	Potholes	T or F
RUTTING	Rutting	T or F
LIT_SLB_BP	Light Slab Breakup %	0 - 99
SEV_SLB_BP	Severe Slab Breakup %	0 - 99
SEV_CK_25	Severe Cracking > 25%	T or F
SEV_CK_50	Severe Cracking > 50%	T or F
CNR_CRK	Corner Cracking %	0 - 99
AC_REPL	AC Replace	
CRK_SPAL	Crack Spalling	T or F
JNT_SPAL	Joint Spalling	T or F
SPLG	Spalling	T or F
FLTNG	Faulting	T or F
SLAB_LEN	Rigid Slab Length	Feet
SLAB_CURL	Rigid Slab Curled	T or F
GRINDING	Grinding	T or F
SEV_AL_C	Severe Alligator Cracking	T or F
BA_SPLG	Bridge Approach Spalling	T or F
BA_RS	Bridge Approach Ride Score	0 - 999
COMP_LEN	?	3 Decimals
SHLDR_STAT	Shoulder Status	Good, Fair, Poor, Missing

Column Name	Description	Range
MSL	MSL Class	1, 2, 3
END_PRFX2	End Prefix	1 Letter
SRI	Skid Resistance Indicator	0 - 99
COSTS	Current year expenditures	Amount
COST_YR	Current year	Year
COSTS_1	Prior year expenditures	Amount
COST__YR1	Prior year	Year
COSTS_2	Previous Prior year expenditures	Amount
COST_YR2	Previous Prior years	Year
LT_TRIG	Left Triggered Lane	0 - 9
RT_TRIG	Right Triggered Lane	0 - 9
ICES_RTE	Intermodal Corridors of Economic Significanice Route	1 - 1000
LOS_GRADE	Level of Service Grade	A - E
LOS_SCORE	Level of Service Score	Pass or Fail

awards

Column Name	Description	Range
rte	route number	1 - 9999
ea	expenditure authorization number	5 characters - alphanumeric
work type	type of treatment	Rehab, CAMP, MM, etc...
prg	program	HA22, HA21, HM1, etc...
fy	fiscal year	2 digits
amo	awarded month	2 digits
ayr	awarded year	2 digits
allot	allotment	up to 9 digits
tot_lnmi	total lane miles	0 - 9999
original pm	original post mile	numeric/alphanumeric
b	back post mile prefix	1 letter
bkpm	back post mile	1 decimal
f	ahead post mile prefix	1 letter
ahpm	ahead post mile	1 decimal
hwy_grp	highway group (independent alignment)	R, L, or X (X=unconstructed)
beg_hwy_gr	begin highway group	R, L, or X
end_hwy_grp	end highway group	R, L, or X
pm	post mile	numeric/alphanumeric
pave_type	pavement type	flex or rigid
pt	project type	2 letters
pi	priority index	3 decimals
est	estimated amount	amount
bid	bid amount	amount
ablm	ac/ac lane mile	4 decimals
aclm	ac/pc lane mile	4 decimals
awy	award sequence	5 numbers
edmi	edge mile	0 - 105
flex	flexible pavement lane miles	3 decimals
grlm	cpr mile	3 decimals
ramplm	ramp lane mile	3 decimals
rigid	rigid pavement lane miles	3 decimals
link	?	
awadate	award date	date
comments	comments	comments
compdate	complete date	date

Dynatest PMS Data

Dynatest PMS data variable	comments	Direct import from Caltrans DB	
name	name of road could be a highway number	yes	
year	year of data ie for 2000 it would be 2000	no	
District #	typically a county or district	possible	
from mile	deliniates start of section	yes	
to mile	deliniates end of section	yes	
lane number	number of the particular lane to allow for multiple lanes	yes	
all lanes	total number of lanes in all directions	possible	
length - ft	length of section in feet	yes	
width - ft	width of section in feet	no	
area - sq ft	calculated from l*w	no	
Normal speed	typically the speed limit	yes	
description	a verbal description of the section	yes	
notes	an open field to store just about anything - contact numbers etc	multiple details	
functional class	used to separate say high speed from HOV or whatever	yes	
construction date	year of original construction or last reconstruction or overlay	yes	
maintenance Camp	used in some cases to determine maintenance group which mayt be different from district	possible	
pavement layer 1to 4	material / thickness / modulus / year - repeat for each layer	no	
TRAFFIC YEAR	date of traffic info	possible	
aadt	total traffic	possible	
esal	18 kip loads	possible	
cvpd	commercial vehicles per day	no	
survey year	for each condition data type below	possible	
iri	IRI	possible	
skid	friction value from test	yes	
rut depth	in inches	no	not as depth
visual rating	PCI or what ever	multiple details	
surface repair	resuired crack filling - may be generated from crack details	possible	generate from distress
structural repair	required patching - may be generated from distress details	possible	generate from distress
safety repair	painting, signing etc	no	

residual value	dollar value not required	no

Additional fields can be added to store just about any information.

Also need :
budgets 1 to 10 year
material types
material costs
interest rates
delay times
delay costs

Can be set up in either US or SI units, but not both

Object Definition

C:\WORK\CALAPT\CALTRA~1\pave.mdb	17 May 2004
Table: Traffic_orig	Page: 14

Properties

Date Created:	2001-05-03 11:26:52	Def. Updatable:	True
Last Updated:	2001-05-03 23:39:44	OrderByOn:	True
RecordCount:	67243		

Columns

Name	Type	Size
RTE	Number (Double)	8
CO	Text	3
SEQ	Number (Double)	8
DIST	Number (Double)	8
PREFIX	Text	1
POSTMILE	Number (Double)	8
LEG	Text	1
RTE_BRK	Text	1
CNT_YR	Number (Double)	8
DESC	Text	80
AADT	Number (Double)	8
ESAL_1WAY	Number (Double)	8
TOT_TRK	Number (Double)	8
TRK_PCT	Number (Double)	8
TWO_AX	Number (Double)	8
TWO_PCT	Number (Double)	8
THR_AX	Number (Double)	8
THR_PCT	Number (Double)	8
FOUR_AX	Number (Double)	8
FOUR_PCT	Number (Double)	8
FIVE_AX	Number (Double)	8
FIVE_PCT	Number (Double)	8
YR_VER	Number (Double)	8
EST_VER	Text	1
ICES_RTE	Yes/No	1

Properties

Date Created:	2000-08-04 11:54:03	Def. Updatable:	True
Last Updated:	2000-08-09 11:56:20	OrderByOn:	False
RecordCount:	4151		

Columns

Name	Type	Size
Route	Number (Long)	4
County	Text	3
Type	Text	1
Check	Yes/No	1
District	Number (Byte)	1
AwardDate	Date/Time	8
ea	Text	255
work type	Text	255
prg	Text	255
fy	Number (Double)	8
allot	Number (Double)	8
tot_lnmi	Number (Double)	8
original pm	Number (Double)	8
b	Text	255
bkpm	Number (Double)	8
f	Text	255
ahpm	Number (Double)	8
hwy_grp	Text	255
beg_hwy_gr	Text	255
end_hwy_grp	Text	255
pm	Text	255
pt	Text	255
pi	Number (Double)	8
est	Number (Double)	8
bid	Number (Double)	8
ablm	Number (Double)	8
aclm	Number (Double)	8
awy	Number (Double)	8
edmi	Number (Double)	8
flex	Number (Double)	8
grlm	Number (Double)	8
ramplm	Number (Double)	8
rigid	Number (Double)	8
link	Text	255
comments	Text	255

Properties

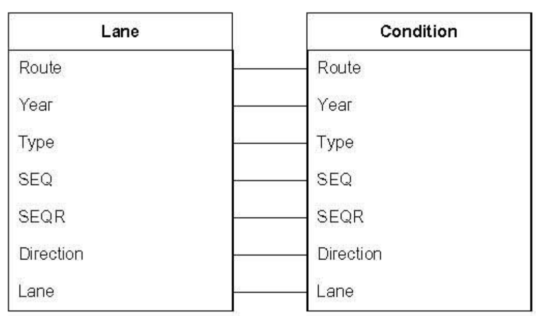
Date Created:	2000-07-06 14:14:13	Def. Updatable:	True
Last Updated:	2001-07-02 16:46:31	OrderByOn:	False
RecordCount:	496909		

Columns

Name	Type	Size
Route	Number (Long)	4
County	Text	3
Start	Number (Double)	8
Direction	Text	1
Lane	Number (Byte)	1
Year	Number (Double)	8
Type	Text	1
SEQ	Number (Double)	8
SEQR	Number (Double)	8

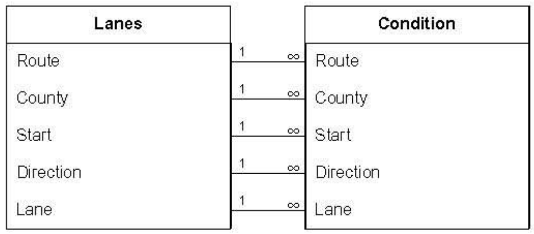
Relationships

LaneCondition



Attributes:	Not Enforced
OrderByOn:	One-To-Many

LanesCondition



Attributes:	Enforced, Cascade Updates, Cascade Deletes
Attributes:	One-To-Many

Properties

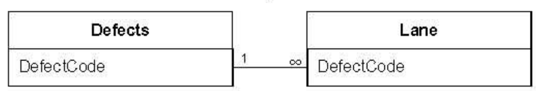
Date Created:	2000-02-17 10:08:11	Def. Updatable:	True
Last Updated:	2000-02-17 10:14:24	OrderByOn:	True
RecordCount:	21		

Columns

Name	Type	Size
DefectCode	Number (Byte)	1
Description	Text	12

Relationships

{0C732D82-E522-11D3-932C-00207811275A}



Attributes:	Enforced, Cascade Updates
OrderByOn:	One-To-Many

Properties

Date Created:	2000-02-17 10:08:12	Def. Updatable:	True
Last Updated:	2001-07-02 16:46:42	OrderByOn:	False
RecordCount:	309965		

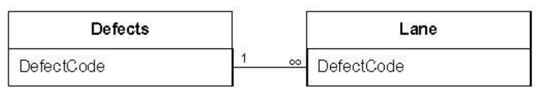
Columns

Name	Type	Size
Route	Number (Long)	4
Year	Number (Double)	8
Type	Text	1
SEQ	Number (Double)	8
SEQR	Number (Double)	8
Direction	Text	1
Lane	Number (Byte)	1
AAC	Number (Byte)	1
ABC	Number (Byte)	1
ACC	Yes/No	1
ALLA	Text	2
ALLB	Text	2
ALLC	Text	2
BLC	Number (Byte)	1
BLOC	Text	2
CCT	Text	3
DefectCode	Number (Byte)	1
DPN	Number (Integer)	2
DRIP	Text	2
FLT	Number (Byte)	1
FSC	Number (Byte)	1
JDP	Text	1
JSP	Yes/No	1
LANSTR	Text	2
LEX	Number (Byte)	1
LIF	Number (Double)	8
LONG	Text	2
LSV	Number (Byte)	1
PAT	Number (Byte)	1
PCC	Number (Byte)	1
PCO	Text	1
PRG	Text	7
PSI	Number (Byte)	1
RAVT	Text	1
RAVC	Number (Byte)	1
RAVL	Text	2
RDP	Number (Byte)	1
RDS	Number (Integer)	2
RDT	Date/Time	8
RIDE	Text	2
RUT	Number (Byte)	1
RUTT	Text	2
SHD	Text	1
SHDSTR	Text	2

SKD	Number (Byte)	1
SP_D	Number (Integer)	2
SPL	Text	1
STBA	Text	2
STATEGY	Text	19
STSL	Text	2
STSN	Text	2
STSS	Text	2
TEX	Number (Byte)	1
TRAN	Text	2
TSC	Number (Byte)	1
TSV	Number (Byte)	1
VEL	Number (Byte)	1

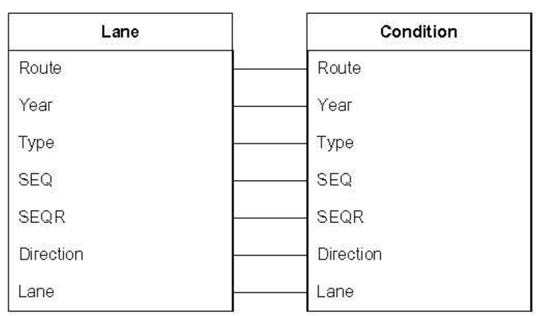
Relationships

{0C732D82-E522-11D3-932C-00207811275A}



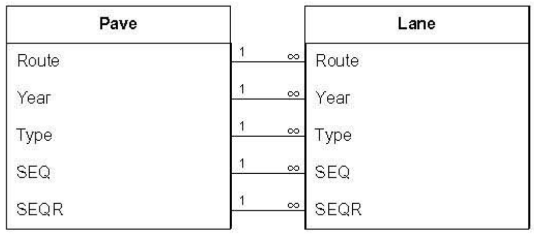
Attributes: Enforced, Cascade Updates
OrderByOn: One-To-Many

LaneCondition



Attributes: Not Enforced
Attributes: One-To-Many

PaveLane



Attributes: Enforced, Cascade Updates, Cascade Deletes
Attributes: One-To-Many

Properties

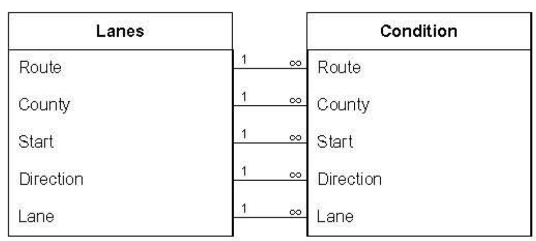
Date Created:	2000-07-06 14:11:14	Def. Updatable:	True
Last Updated:	2000-08-03 11:57:51	OrderByOn:	False
RecordCount:	70843		

Columns

Name	Type	Size
Route	Number (Long)	4
County	Text	3
Start	Number (Double)	8
Direction	Text	1
Lane	Number (Byte)	1

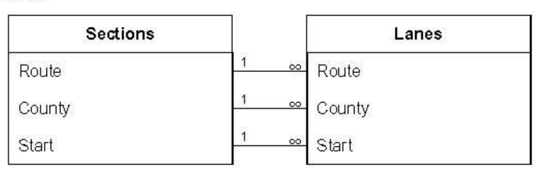
Relationships

LanesCondition



Attributes:	Enforced, Cascade Updates, Cascade Deletes
OrderByOn:	One-To-Many

SectionsLanes



Attributes:	Enforced, Cascade Updates, Cascade Deletes
Attributes:	One-To-Many

Properties

Date Created:	2000-02-03 10:44:33	Def. Updatable:	True
Last Updated:	2002-03-20 15:42:21	OrderBy:	Pave.Route, Pave.County, Pave.Year
OrderByOn:	True	RecordCount:	80999

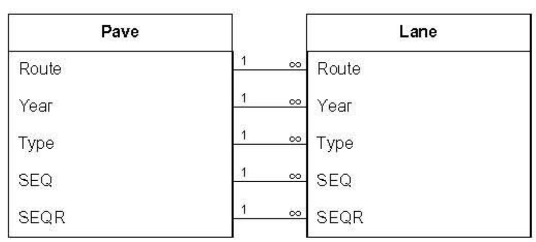
Columns

Name	Type	Size
Route	Number (Long)	4
County	Text	3
Year	Number (Double)	8
SEQ	Number (Double)	8
SEQR	Number (Double)	8
Type	Text	1
District	Number (Byte)	1
Back	Number (Double)	8
Ahead	Number (Double)	8
Left	Number (Byte)	1
Right	Number (Byte)	1
Length	Number (Single)	4
AwardDate	Date/Time	8
Date	Date/Time	8
DESC	Text	40
S	Text	1
ADT	Number (Double)	8
AWY	Number (Double)	8
CST	Number (Double)	8
CST2	Number (Double)	8
FED	Text	1
FEDI	Text	1
FUN	Text	3
FY	Number (Double)	8
GNDLT	Number (Double)	8
GNDRT	Number (Double)	8
H2O	Number (Double)	8
LNS	Number (Double)	8
MC	Number (Double)	8
MC1	Number (Double)	8
MC2	Number (Double)	8
MC3	Number (Double)	8
MSL	Text	1
NALLOT	Number (Double)	8
OCC	Number (Double)	8
PALLOT	Number (Double)	8
PI	Number (Double)	8
PPN	Number (Double)	8
PRG	Text	4
STR	Text	2
TRK	Number (Double)	8
TYP	Text	1
TYP2	Text	6

WRK	Text	6
XREF	Number (Double)	8
Z	Number (Double)	8
ZONE	Text	3
B	Text	1
BKPM	Number (Double)	8
F	Text	1
AHPM	Number (Double)	8
CL_LEN	Number (Double)	8
LAMI	Number (Double)	8
LAMI2	Number (Double)	8
LANEMILE	Number (Double)	8
LEN	Number (Double)	8
CS	Number (Double)	8
F_LT	Text	1
F_RIDE	Text	1
F_RT	Text	1
LT	Number (Double)	8
LT_T	Number (Double)	8
PS	Number (Double)	8
PST82	Number (Double)	8
RT	Number (Double)	8
RT_T	Number (Double)	8
SEQOLD	Number (Double)	8
SEQP	Number (Double)	8
TRIG	Text	1
TVS	Text	3

Relationships

PaveLane



Attributes:	Enforced, Cascade Updates, Cascade Deletes
OrderBy:	One-To-Many

C:\WORK\CALAPT\CALTRA~1\pave.mdb 17 May 2004
Table: Roads Page: 11

Properties

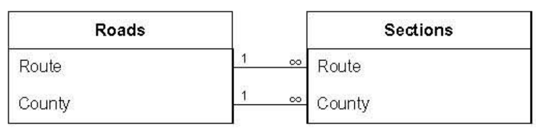
Date Created:	2000-07-06 09:07:21	Def. Updatable:	True
Last Updated:	2000-07-06 14:14:53	OrderByOn:	False
RecordCount:	541		

Columns

Name	Type	Size
Route	Number (Long)	4
County	Text	3

Relationships

RoadsSections



Attributes:	Enforced, Cascade Updates, Cascade Deletes
OrderByOn:	One-To-Many

Properties

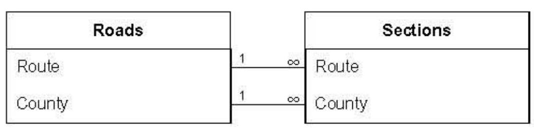
Date Created:	2000-07-06 11:50:48	Def. Updatable:	True
Last Updated:	2002-03-20 17:15:59	OrderByOn:	False
RecordCount:	17701		

Columns

Name	Type	Size
Route	Number (Long)	4
County	Text	3
Start	Number (Double)	8
End	Number (Double)	8
Left	Number (Byte)	1
Right	Number (Byte)	1
B_PREFIX	Text	1
B_PM	Number (Double)	8
A_PREFIX	Text	1
A_PM	Number (Double)	8
AADTL	Number (Long)	4
Traffic	Text	1

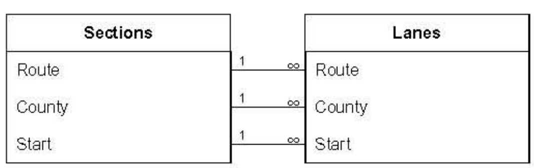
Relationships

RoadsSections



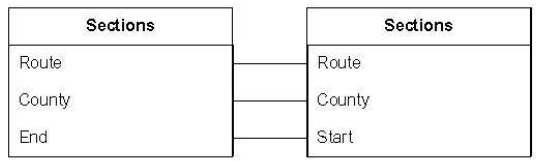
Attributes:	Enforced, Cascade Updates, Cascade Deletes
OrderByOn:	One-To-Many

SectionsLanes



Attributes:	Enforced, Cascade Updates, Cascade Deletes
Attributes:	One-To-Many

SectionsSections



Attributes: Unique, Not Enforced
Attributes: One-To-One