Research Report
KTC-07-11/SPR272-04-1F

KENTUCKY TRANSPORTATION CENTER

# EVALUATION OF LINKING PAVEMENT RELATED DATABASES

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**Research Report**
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# EVALUATION OF LINKING PAVEMENT RELATED DATABASES

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In cooperation with

Transportation Cabinet
Commonwealth of Kentucky

And

The Federal Highway Administration
U.S. Department of Transportation



**March 2007**

| 1. Report No. KTC-07-11/SPR272-04-1F | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|

| | |
|---|---|
| 4. Title and Subtitle<br>**Evaluation of Linking Pavement-Related Databases** | 5. Report Date<br>March 2007 |
| | 6. Performing Organization Code |
| 7.Author(s)<br>Yuhong Wang and David L. Allen | 8. Performing Organization Report No.<br>KTC-07-11/SPR272-04-1F |
| 9. Performing Organization Name and Address<br>Kentucky Transportation Center<br>College of Engineering<br>University of Kentucky<br>Lexington, KY 40506-0281 | 10. Work Unit No. (TRAIS) |
| | 11. Contract or Grant No.<br>KYSPR-04-272 |
| | 13. Type of Report and Period Covered<br>Final |
| 12. Sponsoring Agency Name and Address<br>Kentucky Transportation Cabinet<br>State Office Building<br>Frankfort, KY 40622 | 14. Sponsoring Agency Code |

**15. Supplementary Notes**

Publication of this report was sponsored by the Kentucky Transportation Cabinet and the U.S. Department of Transportation, Federal Highway Administration, with the U.S. Department of Transportation, Federal Highway Administration.

**16. Abstract**

In general, the objectives of this study were to identify and solve various issues in linking pavement performance related database. The detailed objectives were: to evaluate the state-of-the-art in information technology for data integration and data mining, to review the existing KyTC databases and study their potentiality for being linked for pavement performance evaluation, to prepare data linking alternatives for the KyTC's review, to prepare an implementation plan for linking pavement related databases. The study reviewed the current practices of data integration by other organizations that face the similar challenges as KyTC. In addition, a review was conducted of the current major data sources in KyTC for possible integration. By using an example to examine the requirement for pavement performance modeling, the study identified pieces of important information currently missing.

The following recommendations were made: the missing critical information should be added to the existing or future databases; it is recommended that whenever a database is updated in the future, the existing data should be well archived; data integrity and consistency should be checked when an engineer or operator adds data to a database; based on the status of current data in KyTC, it is recommended that an offline separate database can be made by extracting critical information from historical and existing data sources to serve the purpose of pavement analysis; the data processing method used in this study may be used to update other existing data sources; the basic information of a pavement section can be queried through a GIS map. In the future, the GIS map, along with the concise offline database, can be posted online for reviewing and downloading.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Databases GIS<br>Linking<br>Pavement related Databases | Unlimited |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | | |

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# Executive Summary

The idea of linking various pavement related databases may seem intuitive at the first glance. However, there are a number of barriers to implementation of such a scheme. As with other state DOTs, different divisions within the KyTC developed their own individualized application systems to meet their specific needs. Unfortunately, these databases were not designed to be compatible with one another. Every year, various types of data is collected, processed, and stored by different divisions in Kentucky Transportation Cabinet (KyTC). The data forms a valuable source of information to track and study pavement performance. By investigating traffic, materials, and construction data, pavement failure instances can be studied in detail to prevent or reduce future premature failures. The key issue of this study was to investigate the existing data sources in KyTC, identify the barriers against integration, and find appropriate approaches to removing the barriers.

In general, the objectives of this study were to identify and solve various issues in linking pavement performance related database. The detailed objectives were:

1. To evaluate the state-of-the-art in information technology for data integration and data mining,
2. To review the existing KyTC databases and study their potentiality for being linked for pavement performance evaluation,
3. To prepare data linking alternatives for the KyTC's review,
4. To prepare an implementation plan for linking pavement related databases.

The study reviewed the current practices of data integration by other organizations that face the similar challenges as KyTC. In addition, a review was conducted of the current major data sources in KyTC for possible integration. By using an example to examine the requirement for pavement performance modeling, the study identified pieces of important information currently missing. The study also extracted pavement design, construction, and performance related data from different sources and compiled them into a single database. The irrelevant information and vacant fields from the original data sources were excluded. The concise database is attached with this report. The study identified pavement projects in KMIMS and generated location identifications to facilitate data integration. Pavement performance, traffic volume, and construction project information were added to a GIS table to allow a user to query such information through the GIS map. The modified GIS table is also attached with this report.

The report recommends the following items.

1. The missing critical information should be added to the existing or future databases. The missing information includes, but not limited to, the following items: project type, location identifications for a project, for a resurfacing project, the condition of pavements before resurfacing, treatments of existing pavements before resurfacing (milling, crack sealing, etc), thickness of pavements, the initial conditions

after construction,  the historical pavement management data, Other pavement condition measurements such as cracking and rutting, separate condition measurements at different directions, traffic classification and WIM data.

2.  It is recommended that whenever a database is updated in the future, the existing data should be well archived.

3.  Data integrity and consistency should be checked when an engineer or operator adds data to a database.

4. Based on the status of current data in KyTC, it is recommended that an offline separate database can be made by extracting critical information from historical and existing data sources to serve the purpose of pavement analysis.  This database can be prepared periodically and distributed to the interested engineers.

5. The data processing method used in this study may be used to update other existing data sources.

6. The basic information of a pavement section can be queried through a GIS map.  In the future, the GIS map, along with the concise offline database, can be posted online for reviewing and downloading.

# Chapter 1. Introduction

## 1.1 Research Background

Every year, various types of data is collected, processed, and stored by different divisions in Kentucky Transportation Cabinet (KyTC). The data forms a valuable source of information to track and study pavement performance. By investigating traffic, materials, and construction data, pavement failure instances can be studied in detail to prevent or reduce future premature failures. The reverse can also be true. That is, well performing pavements can be studied for their good performance. Historical data can be potentially used by investigators to identify the scientific reasons behind well performing pavements.

The idea of linking various pavement related databases may seem intuitive at the first glance. However, there are a number of barriers to implementation of such a scheme. As with other state DOTs, different divisions within the KyTC developed their own individualized application systems to meet their specific needs. Unfortunately, these databases were not designed to be compatible with one another, which makes it difficult to use the available information in an integrated fashion.

The key issue of this study is to investigate the existing data sources in KyTC, identify the barriers against integration, and find appropriate approaches to removing the barriers. Additionally, for a large organization like KyTC, the computer programs used by different divisions keep being upgraded. Therefore, the basic requirement for compatibility of current databases should also be met by every database that will be upgraded in the future.

### 1.2 Research Objectives

To identify and solve various issues in linking pavement performance related database, detailed objectives were itemized at the beginning of this study. These objectives are:

5. To evaluate the state-of-the-art in information technology for data integration and data mining,
6. To review the existing KyTC databases and study their potentiality for being linked for pavement performance evaluation,
7. To prepare data linking alternatives for the KyTC's review,
8. To prepare an implementation plan for linking pavement related databases.

Beyond these original objectives, during the progress of this project, the investigators also performed data cleaning and data mining on existing data sources. Critical items for compatibility were added to some data sources; and irrelevant information was removed. The result of the effort is a concise database consisting of major pavement performance related items. The database is attached with this report. In addition, to make data more visually friendly, data was processed to be compatible with the current transportation Geographic Information System (GIS) in Kentucky. Some available data items, such as traffic volumes, pavement roughness in international roughness index (IRI), and construction project codes were added to the Shapefile table in a GIS program, ArcGIS$^{TM}$. The result indicated that it is feasible to integrate the current databases and present critical information on a GIS map.

# Chapter 2 Evaluation of Pavement Related Databases

## 2.1 Literature Review

Various organizations have started to consider using existing databases to investigate pavement performance and its influencing factors. To satisfy this purpose, a significant amount of well organized data is required. However, in a typical state department of transportation, data collection and maintenance are undertaken by different divisions. As in KyTC, the result is usually a heterogeneous source of databases that cannot be effectively used. For example, Texas DOT has at least five databases, including the Pavement management Information System (PMIS), the Road Life Database (RL), the Maintenance Management Information System (MMIS), the Texas Reference Marker Database (TRM), and SiteManager(SM) (Zhang, et. al, 1999). The research sponsored by Texas DOT concluded that, instead of developing a new pavement and material related database, it is more appropriate to determine what data can be "mined" from existing databases. In another study sponsored by Federal Highway Administration (FHWA), the researcher investigated the use of PMS data to monitor the performance of Superpave (Hudson, et. al, 2002). After visiting DOTs in Maryland, Indiana, Florida, Arizona and Washington, the research team found that "one of the main challenges discovered in all the states visited is the absence of a convenient link between essential data on materials characteristics used in each project on the one hand and PMS data including performance data on the other (Hudson, et. al, 2002)." The study further concluded that "the key to linking databases for performance, materials and construction is to have precise and common location identification and date/time information (Hudson, et. al, 2002)."

The problems of linking current databases may be met in their future upgrading; however, it remains an issue how to process the vast amount of existing data, which may lack the critical components for integration. No research has been found by this study focusing on processing historical pavement data to improve their compatibility. For this type of data, if the location identification information is not already available, it may need to be generated and added to the existing data structure. However, in information technology, studies have been found investigating various approaches to handling imperfect data sources (e.g,, Parsons, 1996). These studies assisted this research in handling existing pavement related data in KyTC.

Besides requirements for data structure and content, research has also been conducted on how to present the data. One common tool favored by state DOTs is the Geographical Information System (GIS), for it is more visually friendly to use comparing to traditional database queries. A NCHRP study has been completed investigating pavement management applications using GIS (Flintsch, et. al, 2004). The study made a survey on the state DOTs' intentions of integrating current pavement management system (PMS) via GIS with bridge management system (BMS), safety management system (SMS), congestion management system (CMS), public transportation facilities and equipment management system (PTMS ), intermodal transportation facilities management system (IMMS), maintenance management system (MMS), and asset management system (AMS). The summary table of the research report indicates that 22 out of 30 agencies that provide feedback to the questions have this intention.

The most comprehensive research in using real data to monitor pavement performance is the Long-Term Pavement Performance (LTPP) program. One objective of the LTPP program is to monitor more than 2,400 asphalt and Portland cement concrete pavement test sections across the U.S. and Canada (FHWA, 2006). After the data are collected, they are processed and distributed to researchers upon their requests. The difference between the LTPP database and databases in KyTC is that the former was specifically designed for pavement performance analysis, while the latter serves multiple purposes. However, both data can be used to analyze pavement performance. Since the LTPP data structures, data collection and processing protocols, and distribution methods had been carefully designed and considered, the LTPP data can serve as a benchmark of data integration for this study.

The LTPP database and its distribution methods keep being updated over the years. This is a direct result of continuous data collection; on the other hand, it reflects the development in information technology. Originally, the data was distributed by a computer application, DataPave, which is an end-user application incorporating Geographic Information System (GIS) features. A user can retrieve information of one or multiple pavement sections from the GIS map. Currently, the database is made available to the public by two ways. First, a user can ask for the database in

Microsoft Access® format and in a 5 CD-ROM set or on a single DVD-ROM (FHWA, 2006). Additionally, the DataPave is available online, which includes a user-friendly graphical interface. A user can select LTPP section of interest through an online map to "graphically view section specific pavement characterization and performance information (DataPave, 2006)", or using criteria filters to graphically view it. A user can also run SQL query through the DataPave website (http://www.datapave.com/).

## 2.2 Existing Data Sources in KyTC

Pavement performance is influenced by many different factors. Hass summarizes five major classes of predictors, including environment, structure, traffic, construction, and maintenance (Haas 2001). These predictors interact with each other and have their own sub factors. All the categories of factors, except for environment, can be found in different data sources in KyTC. Since Kentucky can be viewed as one climate zone, the environmental factors can be thought as influencing pavements uniformly.

Databases maintained by different divisions in KyTC were obtained by this research. The major sources of data reviewed by this study include Kentucky Materials Information Management System (KMIMS), Highway Information System(HIS), Pavement Management System (PMS), KyTC's Geographic Information System (State maintained and local road centerlines), and Vehicle Classification Records(VCR). These data are usually in different format and are not compatible with each other. The following subsections provide brief descriptions of these data sources, their relevance to pavement performance, and how they can be possibly improved.

### *2.2.1 Kentucky Materials Information Management System (KMIMS)*

KMIMS is a comprehensive database containing information of different types of construction projects managed by KyTC, including pavements, bridges, right-of-way maintenance, guardrail, etc. Besides basic project information such as project let date and project description, the database consists of sample data of these construction projects entered by engineers from different districts and the Division of Materials. For a typical pavement construction project, through a project identification number, one can find a wide range of material information regarding its subgrade soil, aggregate in asphalt mixture or concrete mixture, asphalt binder, asphalt mixture, and concrete cylinders. The data potentially has great value for researchers and engineers to investigate the performance of pavements in Kentucky, and if needed, to conduct forensic studies on concerned road sections.

However, to find the right information at this time, one has to be very familiar with the definitions of data tables and their relationships. Another factor that adds to the complexity of this database is that some data, taken by previous specifications, are no longer required by later specifications. On the other hand, new columns are added to allow data entries for newer specifications; or existing columns are used to host data other than their original purpose. Consistency is also an issue when extracting data from the KMIMS database. For example, there are instances that engineers use different units when entering the data.

The researchers of this study have met with engineers and database administration personnel in KyTC to clarify the historical transition of the database tables and to identify data items most relevant to pavement performance. Throughout the process, a concise database was generated by extracting pavement related data items from KMIMS. The data tables and fields can be found in Appendix I.

### *2.2.2 Highway Information System (HIS)*

The Highway Information System (HIS) database contains information collected and maintained by different divisions, and provided by the planning division. There are different tables in the database; and the relevant data includes traffic and pavement conditions. The data can be accessed through remote database connection or by following the link, http://transportation.ky.gov/planning/data/his_extracts/his_extracts.asp. The data in the HIS database is updated to the most current ones every year, but historical data is not kept. However, in pavement performance studies, the trends of pavement conditions and accumulated traffic volumes are always interested. In order to effectively use HIS, one has to extract data from the HIS each year and archive it separately. The planning division also provides traffic volume data through the CTS program, which contains historical traffic counts of different pavement sections. The data integrity of HIS depends upon both the accuracy and frequency with which the data is updated by other divisions. The HIS databases also include the visual display and analysis of the HIS data using Geographic Information Systems (GIS).

The detailed description of the HIS data is provided in Appendix II.

### *2.2.3 Pavement Management Data*

The pavement management data can be accessed through the database provided by the Pavement Management division. Ideally, the PMS should comprise comprehensive pavement conditions such as distress and roughness as well as pavement structures and treatments. However, the pavement management data in KyTC is in different format and at different levels of detail.

The most detailed data is that from interstates and parkways, which includes pavement structures (thickness of pavements), treatment types, time of maintenance, and condition evaluations for distress and roughness. The historical data on interstates and parkways had been recorded annually in text format from the early of 1960s' to the year of 2000. After the year of 2000, the data are recorded in Microsoft Access files; and data in each year was assigned in a separate file. All the pavement management data files are in the process of transiting to a newer pavement management system. When doing so, caution should be taken on the consistency of the data and the compatibility of existing data structures with those for the newer PMS. In the future, if automatic distress collection device is purchased by KyTC and used to evaluate cracking and rutting conditions, the data table structures should be updated correspondingly.

The researchers have processed the pavement condition file before the year of 2001 and transformed it to an Access data file. In addition, separate data files after the year of 2001 are imported from data provided by the Pavement Management Division. In the future, the separate tables recorded annually for interstates and parkways may be combined into one single table to reduce redundancy. Additionally, a start and an end mile point may be added to the table to facilitate the integration of this table with the others.

#### *2.2.4 Traffic Data*

As mentioned before, traffic volume data can be found from several sources. HIS is updated annually and contains the most recent traffic data in a snapshot. The traffic count data in CTS is updated each month and contains the historical records as well. The third type of traffic data is the vehicle classification records, which are obtained from many traffic stations and are divided into 14 classifications. With a trend toward mechanistic pavement analysis, these traffic classification data can be potentially useful. However, to achieve higher level requirement on traffic data, weigh-in-motion (WIM) data should also be included. If not available, default weigh-in-motion distribution can be used.

#### *2.2.5 Geographic Information System (GIS)*

Kentucky Division of Geographic Information, or DGI, provides GIS files for KyTC's State maintained and local road centerlines (http://dgi.ky.gov/data/transp.htm). The GIS files are referenced as KY GIS in the following descriptions. For each section of roads, the GIS table includes a unique identification code of that road as well as its start mile point and end mile point, along with surface type codes and other information. HIS tables also include necessary information for GIS applications: each category of data extracted from the HIS database consists of an Arcview project, a database, a shape file, and other tables. The HIS information can be conveyed in a GIS map directly. Although the GIS tables in HIS share the same road identification name with that in the Kentucky GIS system, the start and end mile points are not the same. For example, the KY 1104 in Adair county is represented in a table called Pavement Rating from HIS by a section from mile point 0 to 5.14, while the same route in KY GIS is represented by several finer sections, as shown in Table 2.1.

| Begin Mile Point | End Mile Point |
|---:|---:|
| 0 | 0.08 |
| 0.08 | 0.905 |
| 0.905 | 1.34 |
| 1.34 | 2.604 |
| 2.604 | 3.088 |
| 3.088 | 3.977 |
| 3.977 | 4.08 |
| 4.08 | 5.14 |

Table 2.1 An Example of Definition of Pavement Sections in KY GIS

Because of the different lengths in pavement sections, the HIS information cannot be transferred into KY GIS directly.

**2.3 Evaluation of Existing Data Sources**

Two criteria can be used to judge the potentiality of linking pavement performance related databases. The first one is whether the existing data recording is sufficient and the information provided is comprehensive enough for performance investigation. The second one is whether the data from different sources are organized in compatible formats. Based on these two criteria, the sufficiency and shortcomings of existing data are evaluated through the following example.

When using the pavement related data, different investigators may have different directions in data mining. A material engineer may want to investigate the performance of a new type of mixture. The starting point of this investigation will be to find the projects that use the materials. The second step is to identify the locations of these projects. The next step is to find the performance of the sections of roads. And the last step is to find other influencing factors other than materials such as traffic, construction quality, and the conditions of existing roads, if the projects are rehabilitation projects. A pavement management engineer may choose a section of road first and look at its conditions, and then investigate the construction history of the road, the material characteristics of the pavements, traffic volume, and other relative information.

Assume that data mining is from a material engineer's perspective. And further assume that the project using a new asphalt mix design is located on US60, Union County. The procedure of data mining on this project is used as an example. First, the project engineer can extract data from the KMIMS database. The following table, obtained from the KMIMS, provides a brief description of the project.

| CPNCODE | CPNDESC | CPNTERM | CPNADCTY | CPNLETDT |
|---|---|---|---|---|
| CPES02200 10411 | STP 60-1 (132), FD52 113 0060 015-018 | MORGANFIELD BYPASS (US 60) FROM KY 56 AT WESTERN CITY LIMITS EXTENDING EASTERLY TO US 60 | UNION | 25-May-01 |

Table 2.2 Description of a Project Located on US 60, Union County

The second step of the investigation is to find out what types of asphalt mixture samples are related to this project. Using the project code number, CPNCODE, the following tables can be obtained from the KMIMS database. If the investigator is interested, he or she can also obtain other material information from the database such as aggregate gradation, asphalt binder, subgrade, etc. Only asphalt mixture information is presented here. Since the table has many columns, they are broken into two parts in Table 2.3.

| PRIM_SAM_KEY | P_APPROV | P_CLASS | P_DTSAMP | P_INSNAM | P_INSPID | P_INSTYP | P_LAB | P_LABTYPE |
|---|---|---|---|---|---|---|---|---|
| 2001AM02-00625 | PASS | Superpave 19 | 19-Oct-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00629 | PASS | Superpave 19 | 18-Dec-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00568 | PASS | Superpave 19 | 28-Aug-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00607 | PASS | Superpave 9.5 | 01-Nov-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00520 | PASS | Superpave 19 | 22-Aug-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00605 | PASS | Superpave 19 | 10-Nov-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00554 | PASS | Superpave 19 | 17-Aug-18 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00551 | PASS | Superpave 19 | 12-Sep-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00608 | PASS | Superpave 9.5 | 29-Aug-31 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00536 | PASS | Superpave 19 | 02-Oct-04 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00595 | PASS | Superpave 9.5 | 30-Aug-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00371 | COMPLETE | Superpave 0.75 Base | 20-Jul-01 | Sullivan, Randy | 999-13-3279 | VERIFY | AM | DO |
| 2001AM02-00467 | PASS | Superpave 19 | 13-Aug-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00373 | COMPLETE | Superpave 0.38 Surfa | 20-Jul-01 | Sullivan, Randy | 999-13-3279 | VERIFY | AM | DO |
| 2001AM02-00468 | PASS | Superpave 19 | 20-Aug-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00372 | COMPLETE | Superpave 0.75 Base | 20-Jul-01 | Sullivan, Randy | 999-13-3279 | VERIFY | AM | DO |
| 2001AM02-00466 | PASS | Superpave 19 | 09-Aug-01 | Collins, Carroll | 999-13-3299 | PRJ_ACPT | AM | DO |
| 2001AM02-00470 | COMPLETE | Superpave 0.38 Surfa | 29-Aug-01 | Collins, Carroll | 999-13-3299 | VERIFY | AM | DO |

Table 2.3a, Asphalt Mixture Sample Information for the Example Project (Part A)

| PRIM_SAM_KEY | P_MTCODE | P_MTDESC | P_MTUNIT | P_NAME | P_PRJCHG | P_QTYINS | P_SAMTYP |
|---|---|---|---|---|---|---|---|
| 2001AM02-00625 | 2525 | Superpave 19 | M ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00629 | 2525 | Superpave 19 | M ton | Roger's Group (Asphalt) | No | 963.48 | Plant-Mix |
| 2001AM02-00568 | 2525 | Superpave 19 | ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00607 | 2575 | Superpave 9.5 | M ton | Roger's Group (Asphalt) | No | 1375.86 | Plant-Mix |
| 2001AM02-00520 | 2525 | Superpave 19 | ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00605 | 2525 | Superpave 19 | M ton | Roger's Group (Asphalt) | No | 1345.58 | Plant-Mix |
| 2001AM02-00554 | 2525 | Superpave 19 | ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00551 | 2525 | Superpave 19 | ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00608 | 2575 | Superpave 9.5 | M ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00536 | 2525 | Superpave 19 | ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00595 | 2575 | Superpave 9.5 | M ton | Roger's Group (Asphalt) | No | 3215.87 | Plant-Mix |
| 2001AM02-00371 | 2525 | Superpave 0.75 Base | M ton | Roger's Group (Asphalt) | Yes | 26691 | Mix Design |
| 2001AM02-00467 | 2525 | Superpave 19 | M ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00373 | 2575 | Superpave 0.38 Surface | M ton | Roger's Group (Asphalt) | Yes | 3397 | Mix Design |
| 2001AM02-00468 | 2525 | Superpave 19 | M ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00372 | 2525 | Superpave 0.75 Base | M ton | Roger's Group (Asphalt) | Yes | 9079 | Mix Design |
| 2001AM02-00466 | 2525 | Superpave 19 | M ton | Roger's Group (Asphalt) | No | 3600 | Plant-Mix |
| 2001AM02-00470 | 2575 | Superpave 0.38 Surface | M ton | Roger's Group (Asphalt) | Yes | 4564 | Mix Design |

Table 2.3b, Asphalt Mixture Sample Information for the Example Project (Part B)

The table reveals comprehensive information regarding the asphalt mixture samples, including the sample identification number (PRIM_SAM_KEY), material code (P_MTCODE) and material names(P_CLASS), the measuring quantity (P_QTYINS), the name of inspector (P_INSNAM), the type of inspection (P_INSTYP), material producer’s name (P_NAME), material quantity (P_QTYINS), and sample types (P_SAMTYP), etc.

After knowing the sample identification number, the investigator can then find which tables contain the sample information.  One can decide from the following table (by looking at the column TABLE_N) that some samples are in a table called "amix10_i," while the rest are in a table called "amix7_i."

| PRIM_SAM_KEY | SAM_DATE | TABLE_N | WORK_N | INST_N | WRK_DATE | TEST_N |
|---|---|---|---|---|---|---|
| 2000AM02-00154 | 25-May-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-1 |
| 2000AM02-00154 | 25-May-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-2 |
| 2000AM02-00154 | 25-May-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-3 |
| 2000AM02-00155 | 25-May-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-1 |
| 2000AM02-00155 | 25-May-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-2 |
| 2000AM02-00155 | 25-May-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-3 |
| 2000AM02-00197 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-1 |
| 2000AM02-00197 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-2 |
| 2000AM02-00197 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-3 |
| 2000AM02-00198 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-1 |
| 2000AM02-00198 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-2 |
| 2000AM02-00198 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 13-Jul-00 | supr2k-3 |
| 2000AM02-00199 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 19-Jul-00 | supr2k-1 |
| 2000AM02-00199 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 19-Jul-00 | supr2k-2 |
| 2000AM02-00199 | 13-Jun-00 | amix10_i | DIST_02 | AMIX10 | 19-Jul-00 | supr2k-3 |
| 2001AM02-00070 | 13-Feb-01 | amix10_i | DIST_02 | AMIX10 | 13-Feb-01 | supr2k-1 |
| 2001AM02-00070 | 13-Feb-01 | amix10_i | DIST_02 | AMIX10 | 13-Feb-01 | supr2k-2 |
| 2001AM02-00403 | 30-Jul-01 | amix7_i | DIST_02 | AMIX7 | 07-Aug-01 | mix_acc1 |
| 2001AM02-00403 | 30-Jul-01 | amix7_i | DIST_02 | AMIX7 | 07-Aug-01 | mix_acc2 |
| 2001AM02-00404 | 30-Jul-01 | amix7_i | DIST_02 | AMIX7 | 07-Aug-01 | mix_acc1 |
| 2001AM02-00404 | 30-Jul-01 | amix7_i | DIST_02 | AMIX7 | 07-Aug-01 | mix_acc2 |
| 2001AM02-00466 | 27-Aug-01 | amix7_i | DIST_02 | AMIX7 | 27-Aug-01 | mix_acc1 |
| 2001AM02-00466 | 27-Aug-01 | amix7_i | DIST_02 | AMIX7 | 27-Aug-01 | mix_acc2 |
| 2001AM02-00467 | 27-Aug-01 | amix7_i | DIST_02 | AMIX7 | 27-Aug-01 | mix_acc1 |
| 2001AM02-00467 | 27-Aug-01 | amix7_i | DIST_02 | AMIX7 | 27-Aug-01 | mix_acc2 |
| 2001AM02-00468 | 27-Aug-01 | amix7_i | DIST_02 | AMIX7 | 27-Aug-01 | mix_acc1 |
| 2001AM02-00468 | 27-Aug-01 | amix7_i | DIST_02 | AMIX7 | 27-Aug-01 | mix_acc2 |
| 2001AM02-00470 | 29-Aug-01 | amix10_i | DIST_02 | AMIX10 | 29-Aug-01 | supr2k-1 |
| 2001AM02-00470 | 29-Aug-01 | amix10_i | DIST_02 | AMIX10 | 29-Aug-01 | supr2k-2 |
| 2001AM02-00470 | 29-Aug-01 | amix10_i | DIST_02 | AMIX10 | 29-Aug-01 | supr2k-3 |
| 2001AM02-00490 | 12-Sep-01 | amix7_i | DIST_02 | AMIX7 | 12-Sep-01 | mix_acc1 |
| 2001AM02-00490 | 12-Sep-01 | amix7_i | DIST_02 | AMIX7 | 12-Sep-01 | mix_acc2 |
| 2001AM02-00520 | 04-Oct-01 | amix7_i | DIST_02 | AMIX7 | 10-Oct-01 | mix_acc1 |

Table 2.4, Indication of Tables Containing Sample Information for the Example Project

The table “amix7_i” is the primary table hosting Superpave asphalt mixture information. The investigator can use the sample identification number “PRIM_SAM_KEY” to obtain the sample information from the asphalt mixture table.

The table “amix7_i” is a very large table in KMIMS. It comprises more than 100 columns; therefore, it is difficult to show the complete table in this report. Only a portion of the data is shown in table 2.5. From the asphalt mixture table, the engineers can obtain the binder content, air voids, voids in mineral aggregate(VMA), density, and other volumetric characteristics.

| PRIM_SAM_KEY | REP_NUM | AMLOTNO | AMDTSPAV | AMMTONS | AMDENOPT | AMJMFBC | AMSLBC | AMSLAV | AMSVMA |
|---|---|---|---|---|---|---|---|---|---|
| 2001AM02-00403 | 1 | 1 | N.M. | 1906.19 | Option A | 4.8 | 4.8 | 3.3 | 13.9 |
| 2001AM02-00403 | 2 | | | | | 4.8 | 4.8 | 2.7 | 13.7 |
| 2001AM02-00403 | 3 | | | | | | | | |
| 2001AM02-00403 | 4 | | | | | | | | |
| 2001AM02-00403 | 5 | | | | | | | | |
| 2001AM02-00384 | 1 | 1 | N.M. | 3600 | Option A | 4.4 | 4.4 | 4.7 | 14.2 |
| 2001AM02-00384 | 2 | | | | | 4.4 | 4.4 | 4.6 | 14.2 |
| 2001AM02-00384 | 3 | | | | | 4.4 | 4.4 | 4.2 | 14 |
| 2001AM02-00384 | 4 | | | | | 4.4 | 4.4 | 3 | 13.1 |
| 2001AM02-00384 | 5 | | | | | | | | |
| 2001AM02-00466 | 1 | 1 | N.M. | 3600 | Option A | 4.4 | 4.4 | 3.7 | 13.2 |
| 2001AM02-00466 | 2 | | | | | 4.4 | 4.4 | 3 | 12.9 |
| 2001AM02-00466 | 3 | | | | | 4.4 | 4.4 | 3.9 | 13.3 |
| 2001AM02-00466 | 4 | | | | | 4.4 | 4.4 | 3.7 | 13.6 |
| 2001AM02-00466 | 5 | | | | | | | | |
| 2001AM02-00468 | 1 | 3 | N.M. | 3600 | Option A | 4.4 | 4.4 | 4 | 13.7 |
| 2001AM02-00468 | 2 | | | | | 4.4 | 4.4 | 4.6 | 14.2 |
| 2001AM02-00468 | 3 | | | | | 4.4 | 4.4 | 4.2 | 14.1 |
| 2001AM02-00468 | 4 | | | | | 4.4 | 4.4 | 4.1 | 13.9 |
| 2001AM02-00468 | 5 | | | | | | | | |
| 2001AM02-00467 | 1 | 2 | N.M. | 3600 | Option A | 4.4 | 4.4 | 4.8 | 14.4 |
| 2001AM02-00467 | 2 | | | | | 4.4 | 4.4 | 3.4 | 13.2 |
| 2001AM02-00467 | 3 | | | | | 4.4 | 4.4 | 3.9 | 13.3 |

Table 2.5, Example of Asphalt Mixture Sample Information from Table amix7_i

From the table extracted from KMIMS, one can see that, in general, the information about material characteristics in both design and construction can be easily obtained. However, if the engineer wants to further examine the performance of the constructed pavement section, he or she may encounter some difficulties. Since both road names and the start mile points and end mile points are not given explicitly, one has to read the text descriptions to figure out where the pavement section is located. The issue may become more severe if the engineer wants to investigate several projects at the same time.

Assume that the engineer has known from reading the project description that the pavement section is located on US 60, from mile point 15 to mile point 18. The next step is to review the performance of the section. Since this section is not on interstates or parkways, the available information is limited. The only available data about pavement performance is the international roughness index (IRI). Table 2.6 provides the IRI data for this section, extracted from the HIS database.

| COUNTY | COUNTY_NAME | RSE_UNIQUE | BEGIN_MP | END_MP | IRI | TEST_DATE |
|---|---|---|---|---|---|---|
| 113 | Union | 113 US-60 | 14.997 | 15.097 | 92.6 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.097 | 15.197 | 103.3 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.197 | 15.297 | 83.51 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.297 | 15.397 | 109 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.397 | 15.497 | 118.5 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.497 | 15.597 | 96.62 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.597 | 15.697 | 121 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.697 | 15.797 | 80.74 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.797 | 15.897 | 91.57 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.897 | 15.997 | 104.9 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 15.997 | 16.097 | 81.01 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 16.097 | 16.197 | 102.8 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 16.197 | 16.297 | 111.3 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 16.297 | 16.337 | 118.6 | 14-Aug-03 |
| 113 | Union | 113 US-60 | 16.339 | 16.439 | 124.6 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 16.439 | 16.539 | 87.23 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 16.539 | 16.639 | 186.7 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 16.676 | 16.768 | 113.4 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 16.772 | 16.872 | 73.18 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 16.872 | 16.972 | 128.7 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 16.972 | 17.072 | 92.52 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.072 | 17.172 | 70 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.172 | 17.272 | 129.2 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.272 | 17.372 | 112.7 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.372 | 17.472 | 77.69 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.472 | 17.572 | 118.8 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.572 | 17.672 | 79.43 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.672 | 17.772 | 95.45 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.772 | 17.872 | 94.88 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.872 | 17.972 | 95.16 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 17.972 | 18.051 | 98.67 | 19-Aug-03 |
| 113 | Union | 113 US-60 | 18.051 | 18.151 | 78.4 | 19-Aug-03 |

Table 2.6 IRI of Pavement Sections Covered by the Example Project

From the KMIMS database, one cannot tell the exact mile point at which the construction project starts or ends, except for knowing that it starts approximately around mile point 15 and ends around 18. There are 32 finer sections with different IRIs. The plot of the IRIs on these sections in August, 2003 is shown in Figure 2.1.

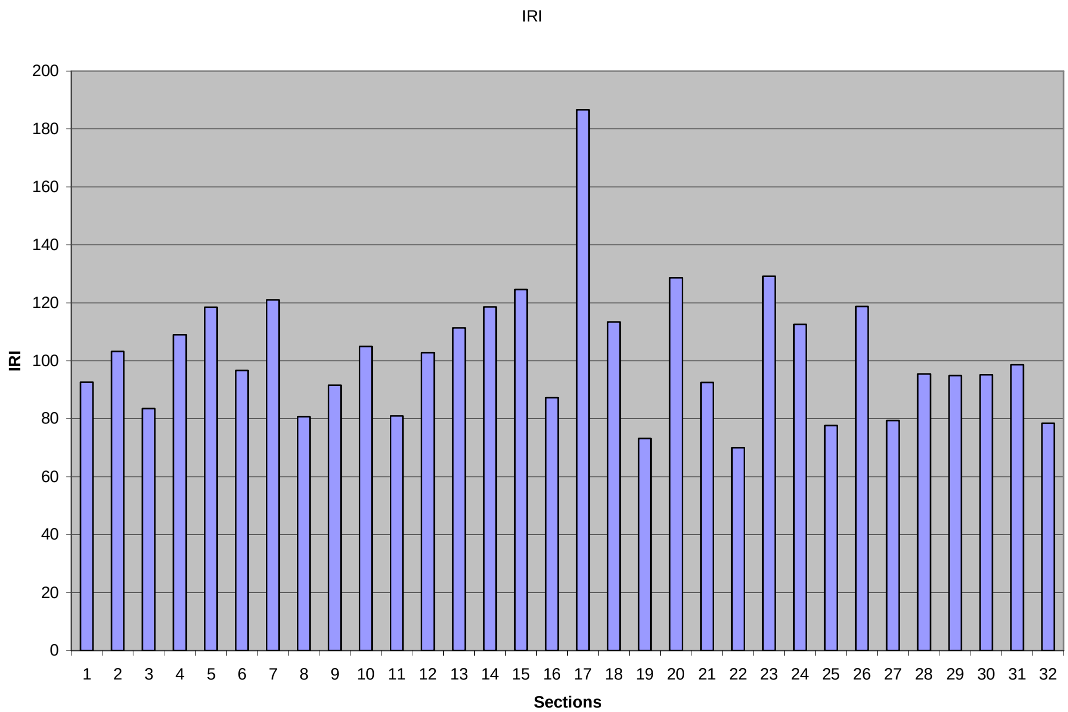



Figure 2.1 Plot of IRIs of Pavement Sections Covered by the Example Project

From Table 2.6, one can calculate that after 2 years, the average IRI for this section is 102.3 and the standard deviation is 22.82, which gives a general indication of the pavement performance for the construction project using the new mix design. However, the HIS database only provides the most recent IRI, not all of the historical records. In addition, no information can be obtained about the initial IRI, cracking, and rutting on those sections.

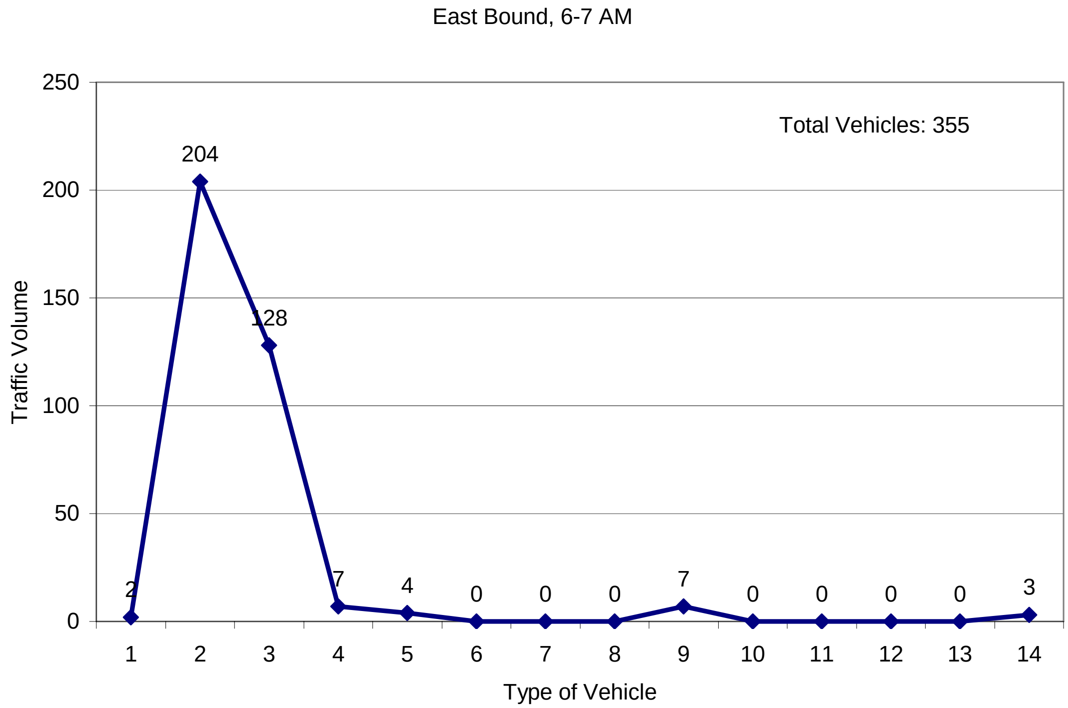
Another category of influencing factors on pavement performance is traffic. The most recent traffic counts can be obtained from the HIS database, while the historical data can be obtained from the traffic counts program CTS. The traffic counts (in Annual Average Daily Traffic, AADT) from mile point 12.15 to 18.05 are summarized in the following table.

| Start MP | End MP | Year | | | | |
|---|---|---|---|---|---|---|
| | | 2001 | 2002 | 2003 | 2004 | 2005 |
| 12.15 | 15.41 | 6910 | | 7720 | 7220 | 6140 |
| 15.41 | 16.34 | 9850 | | 9050 | 6230 | 6420 |
| 16.34 | 16.68 | | 11700 | 10700 | 12500 | 12100 |
| 16.68 | 18.05 | | 100000 | 11400 | 9880 | 13000 |

Table 2.6 Traffic Counts (in AADT) on Pavement Sections Covered by the Example Project

In Figure 2.1, one can see that the IRI from MP 16.539 to MP 16.639 (the section number 17) is much higher than the rest of the sections. The higher traffic volumes on this section may be partially responsible. However, without knowing the construction data in this small section and preexisting conditions, one cannot reach a conclusion on why the IRI is high.

Besides traffic counts, the vehicle classification data can also be found on this section. Figure 2.2 show counts of 14 vehicle types recorded at 6 AM, on September 10, 1992 for east and west bound, respectively. The data is more than 10 years old from now. One can see that both volumes and the distribution of 14 types of vehicles are significantly different. How this affects the pavement performance is unclear at this time, since the IRI data does not report two directions separately.



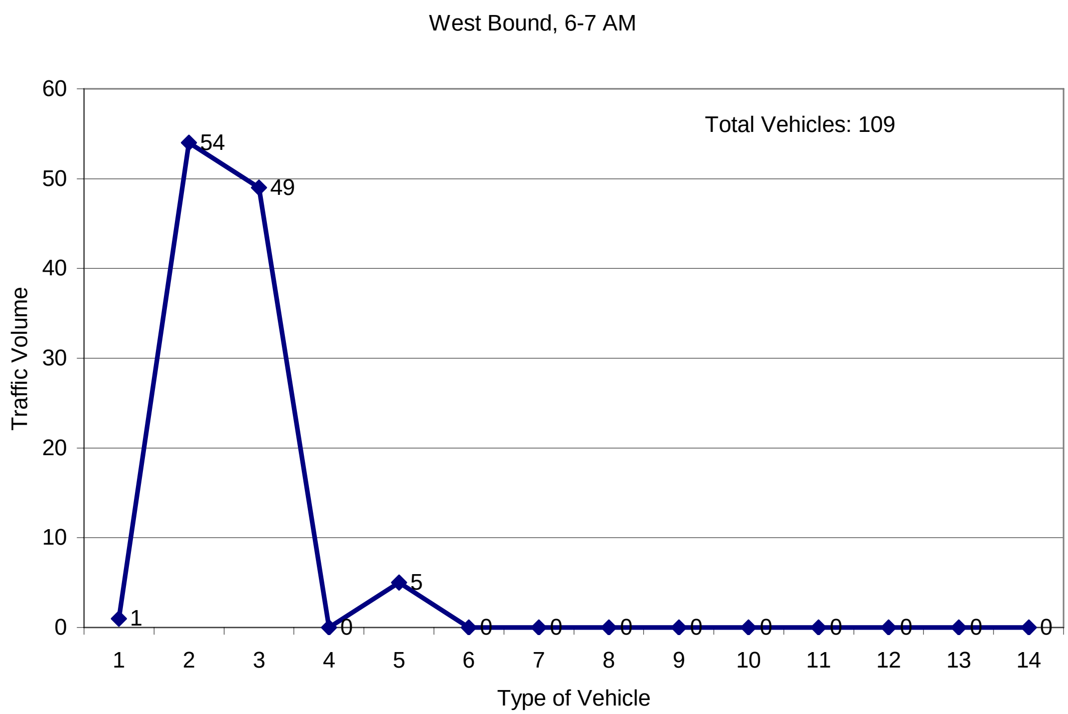




Figure 2.2 Plot of Vehicle Classification Data on Two Directions of a Pavement Section Covered by the Example Project

In summary, at the current time, the engineer can obtain relatively comprehensive information concerning the project material samples. The IRI also provides the engineer a general indication of the pavement condition. In addition, the traffic volume and classification data allow the engineer to understand the level of loading of vehicles.

However, there are at least several pieces of information are missed from modeling performance point of view:

1. Whether a project in KMIMS is a pavement project or other types of project,
2. Whether a project is a new construction project or a resurfacing project,
3. The exact start mile point and end mile point of each project,
4. If it is a resurfacing project, the condition of pavements before resurfacing,
5. The treatments of existing pavements before resurfacing (milling, crack sealing, etc),
6. The thickness of existing pavements,
7. The thickness of overlays,
8. The initial IRI after construction,
9. The historical IRIs after construction , not just the most recent one,
10. Other pavement condition measurements such as cracking and rutting,
11. The pavement condition indicators at different directions,
12. The more recent traffic classification data.

Certain data items can be obtained from the KyTC's current practices with minimum additional efforts, such as data items 1, 2, 3, 4, 5, 7, 8, 9, while others require more.

It would be more financially advantageous to concentrate on those requiring minimum additional efforts.

It should also be emphasized that the quality of data for pavement performance modeling depends on the weakest link of data collection and reporting. Facilitating the linkage of data sources should first be placed on the weakest link, such as the existing condition, thickness of pavement, initial IRI, etc.

# Chapter 3 Linking Current Data Sources

As shown in Chapter 2, it is promising to link the current various data sources in KyTC for evaluating and analyzing pavement performance. This chapter examines how these data sources can be linked. The integration of these data depends on two aspects: the compatibility of data structures and the communication of computer applications that present the data.

## 3.1 Data Structures

After discussing with the research advisory committee, the study found that the best way to link the major categories of data sources is through location identification, which includes a unique identification number for a specific route as well as the start mile point and the end mile point of a pavement section on that route. The major challenge of this approach is that the pavement segment lengths defined by different sources may be different; however, this can be overcome by appropriate querying method. There may be multiple tables under each category, within which the data source manager can freely use his or her own method to link these tables. For example, for tens of tables in KMIMS, the sample information can still be obtained by project code and sample code. To link the KMIMS project description table with other data sources, columns on project start mile point and end mile point should be added.

Figure 3.1 shows the major data sources and the proposed linking mechanism within these sources.

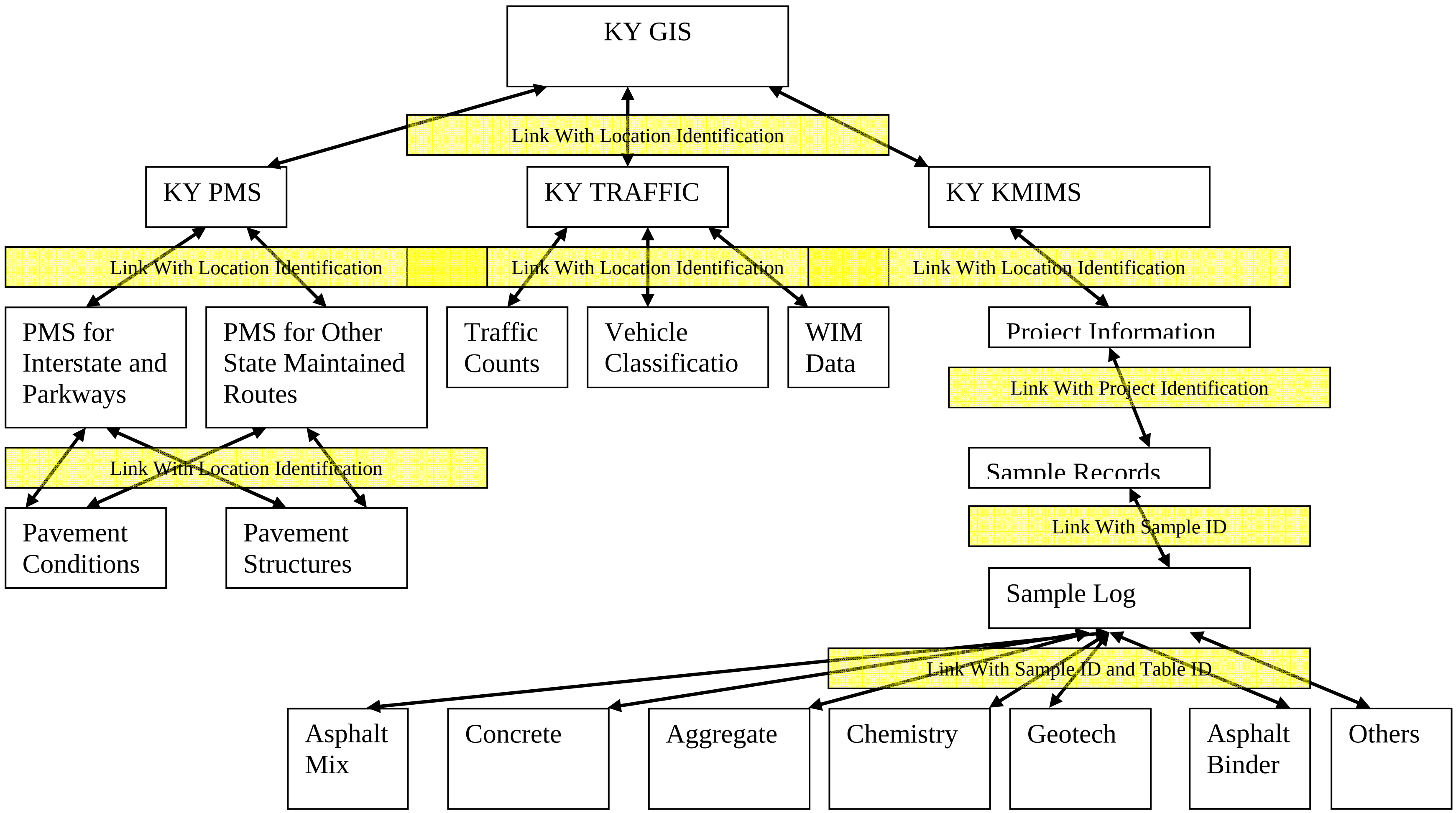



Figure 3.1 Linkage of Current Pavement Related Data Sources in KyTC

For data sources without location identification columns, revisions should be made to add these columns. Additionally, some historical data, like PMS data on interstates and parkways, are valuable to understand pavement performance and to know pavement structure in Kentucky. Location identification should also be added to these data.

### 3.2 Computer Programs

After location identifications have been added to certain critical data items, the next task is to physically bring them together. The current data are stored in different formats and hosted by several computer programs such as Oracle, Microsoft Access, PDF, and text files. Some data provides life link to the database, while others can be downloaded through the KyTC's website or distributed by the organization that maintains the data.

One solution of linking these data sources, as illustrated by Figure 3.2 , is to ask the different divisions always post their data online and allow users to access the data sources. An end-user program can be developed to make it convenient for users to query and acquire the data they are interested in.

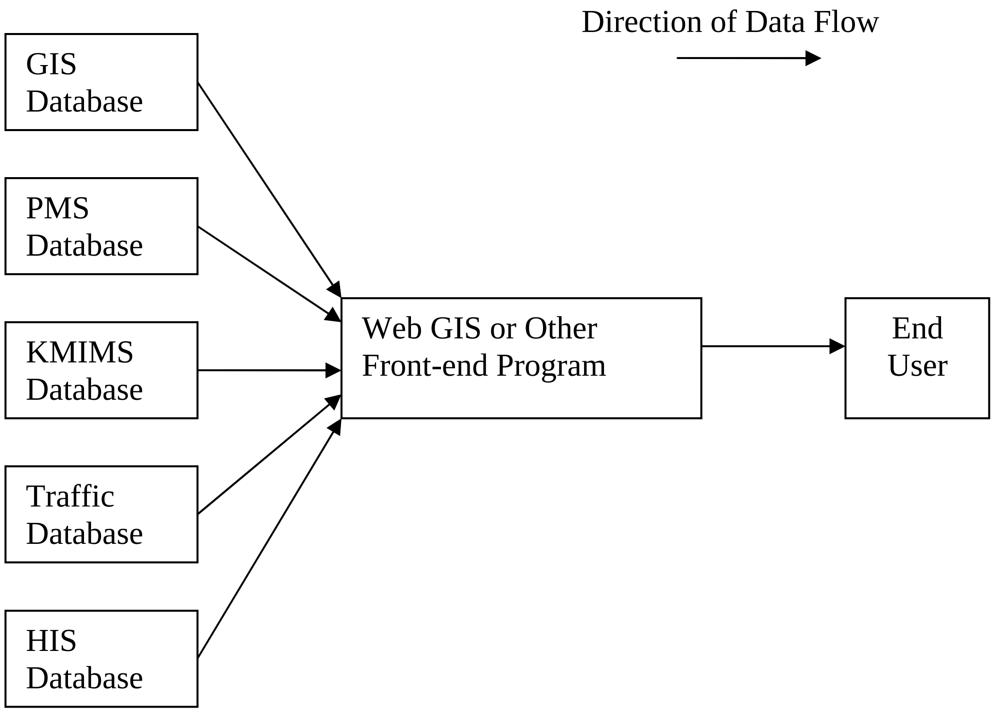



Figure 3.2 The First Option of Linking the Current Databases

The advantage of this approach is that data sources are maintained by the owner and accessed by the user directly. It does not need additional resources to extract the data from these different sources. Another advantage is that the user always receives the most updated information. The disadvantage of this approach, however, is that existing data must be transformed to a compatible format and made available online. Whenever the database programs are changed, the user applications need to be modified correspondingly. Also, depending on the user-end program, the flexibility of data query may be limited. Another disadvantage is that the transfer of large data file over several sources may depend on data downloading speed.

After discussing with the advisory committee, an alternative approach is adopted by this study, as illustrated in Figure 3.3. It is proposed that pavement related data is extracted from the current different sources and historical data files and is then incorporated into a standalone database file. This database file, along with a possible user-end program, can be distributed to engineers and researchers. The advantage of this approach is the disadvantage of the previous approach. By employing this approach, the coordination between the different data sources is kept to a minimum, and the data owners have the maximum freedom to maintain and upgrade their data, as long as they keep the location identification in their key data files. Another advantage is that during data processing process, errors in source data files may be caught and revised.

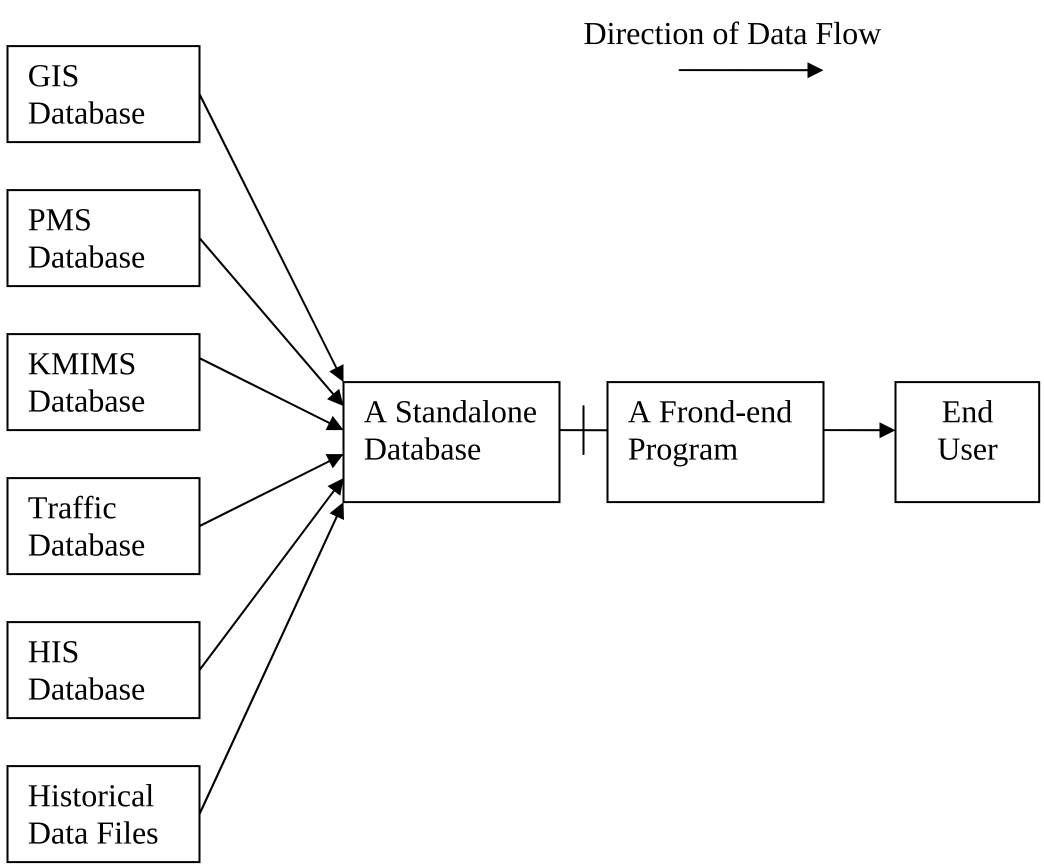



Figure 3.3 The Second Option of Linking the Current Databases

The disadvantage of this approach is that someone has to make access to the data sources, extract and revise the relevant data, and distribute the data periodically. Additionally, the data that the end user receives may not be the most updated ones.

# Chapter 4 Processing of Existing Data for GIS Applications

Data integration requires that each data source provides location identifications, which are also necessary if the data is presented in a geographic information system (GIS). However, certain data source like KMIMS, does not provide location identifications. Even for the data source with such information, their start and end positions do not match with each other. This chapter discusses the techniques for generating location identifiers, integrating data with unmatched locations, and incorporating data in a GIS system.

## 4.1 Generating Location Identifiers

There are three issues in KMIMS that hinder the effort of data integration. First, the project type is not explicitly given; one has to read the project description to identify it. The project can be a pavement, or can be a bridge, lighting, right-of-way maintenance, painting etc. The second issue is that the road name is not given. The third issue is that both the start and end mile points are hidden in the project description or project ID. Therefore, the objectives of data processing are to identify those pavement projects, generating three columns to hold road name, start mile point, and end mile point, respectively.

There are thousands of projects in KMIMS. To process these data manually would be too time consuming. After reviewing the project descriptions, the researcher found that there are certain patterns in the semantic description of a project which may allow generating desired properties automatically. To further identify the patterns, the research randomly selected 100 records from the whole database and analyzed them. Different types of projects from the 100 records are shown in Figure 4.1.

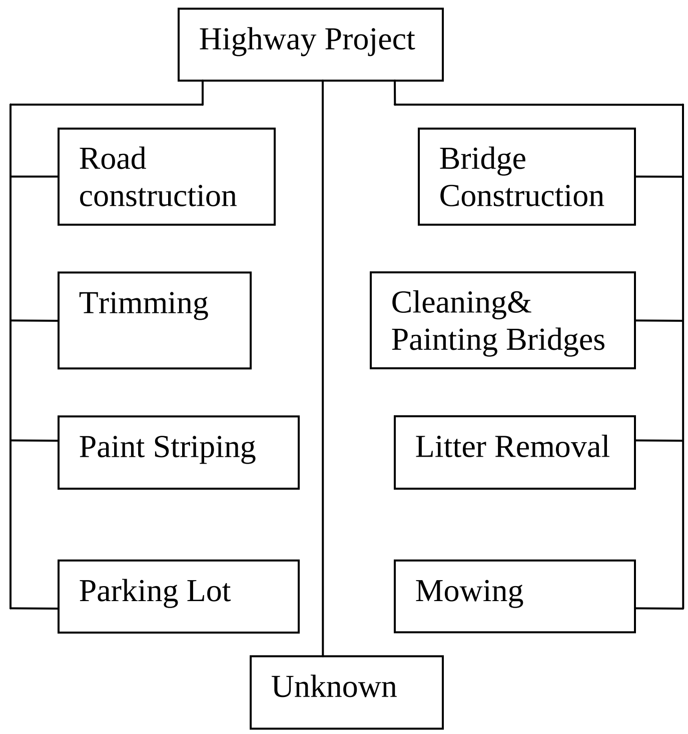



Figure 4.1 Different Types of Projects from 100 Randomly Selected Samples

The key words in project descriptions were analyzed by this study. It was found that only a limited number of key words are used to describe the different types of projects. For example, if it is a pavement project, the key words are likely to be "road", "from", "to." "From" and "to" commonly indicate a linear project. If it is a bridge project, the key words are likely to be "bridge," "approach," "over, " or "at. " "Over " or "at " usually indicates a point project. If it is a road side maintenance project, the key words are "mowing," "trimming," "clearing," or others. These different key words are used to separate different types of projects. More than 80% of projects can be separated with these key words. Then, the separated projects are reviewed to ensure they are truly the project type they mean to belong to. The rest projects were examined manually. Since the interest of this study is pavement related data, only pavement construction projects are included.

The more challenging task is to find the start mile point and end mile point of each project. A typical project description is like the following:

"WILLISBURG ROAD (KY 53) FROM THE WASHINGTON COUNTY LINE (MP 1.192) EXTENDING NORTHERLY TO 0.100 MILE NORTH OF THE BLUEGRASS PARKWAY (MP 1.334)"

The start mile point, 1.192, and end mile point, 1.334, can be extracted from the description.

However, not all of the projects are described this way. For example, here is the description for another project.

"TATES CREEK ROAD (KY 169) FROM DANIEL BOONE ROAD ( MP 0.087) EXTENDING TO PRIVATE ENTRANCE."

For this example, the start mile point is known, but the end mile point has to be found from the project identification number, "FE01 003 0053 001-002, " which means the project may start from any point between 0.01 to 1 and ends from any point from 1.01 to 2. Although the start mile point can be extracted from the project description, the end mile point has to be assumed in this example.

Another difficulty in extracting mile point happens when a project extends more than one county, as the example shown below:

"US 31W FROM THE BEGINNING OF PCC PAVEMENT IN HARDIN COUNTY (MP 30.310) EXTENDING TO THE END OF PCC PAVEMENT IN MEADE COUNTY (MP 0.750)"

The mile point changes when the road crosses the county line. In the previous example, the project can actually be divided into two parts: from 30.31 to 34.00 (The end mile point in Hardin county) in Hardin county and from 0 to 0.75 in Meade county. The mile point 34 has to be manually added.

## 4.2 Integrating Data with Unmatched Locations

When integrating GIS data with pavement management data, traffic data, and project information, the researcher found that the definitions of pavement sections do not match with each other.  For example, one GIS section may cover several pavement management sections.  In selecting this GIS section, one has to decide what pavement management or project information to convey.  In an attempt by this research, the IRI value for a GIS section was taken as the average of IRI values of all pavement management sections that overlap with the GIS section, the detailed method is shown in Table 4.1.

| Overlap Situations of the GIS Section and IRI Section | Contribution of Section 2 to the Average IRI Value |
|---|---|
| _________ GIS (1)<br>______ IRI (2) | (End Mile Point of 2 –Start Mile Point of 1)/ Length of Section 1 |
| ________ GIS (1)<br>______ IRI (2) | Length of Section 2/ Length of Section 1 |
| ________ GIS (1)<br>______ IRI (2) | (End Mile Point of 1 –Start Mile Point of 2)/ Length of Section 1 |
| ________ GIS (1)<br>____________ IRI (2) | 100% |

Table 4.1 Methods for Calculating IRI for a GIS Section

The treatment of traffic counts is similar to IRI; however, most sections with valid traffic counts are longer than the IRI sections.

For a construction project in KMIMS, whenever the project overlaps partially with the GIS section, the project unique identification number is included in GIS. From the project identification number, one can find the samples related to that project.

**4.3 Querying Data in GIS**

GIS provides a visually friendly way to query spatial information. The basic GIS table for state roads was modified by this research to include three pieces of information: the most recent average IRI value of each pavement section, the most recent traffic counts, and all KMIMS projects that ever happened on that section. In analyzing the data, this research found that the maximum number of projects that ever happened on a pavement section is six. Therefore, one column was added to the basic GIS table for IRI, one column for traffic counts, and six columns for project identification codes.

Figure 4.2 shows a part of the GIS map. The unique road identification number is used to label each pavement section (the first three digits represent a county code, followed by road name).

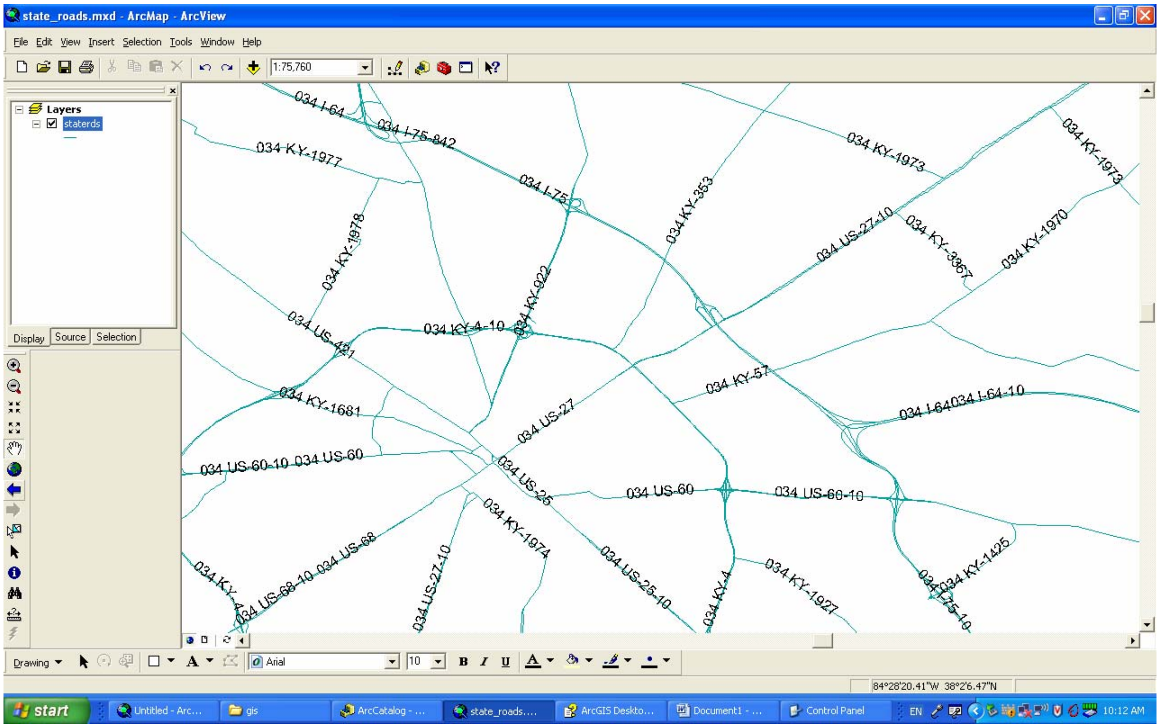



Figure 4.2 Part of the GIS Map for State Maintained Road

If clicking a pavement section on the map, one can obtain the basic information of the road. An example of the section information is shown in Figure 4.3. One can see that the road is Harrodsburg Road, the pavement section starts at 9.324 and ends at 10.883, and the surface type code is 52. Furthermore, one can also acquire information added by data integration. The most recent IRI of this pavement section is 115.8. The current AADT is 12800; the AADT of the previous year is 12600; and the AADT of the last count is 11952. Only one project can be found on this pavement section, with a unique project code CPES0719990036. Using this code, one can find the following project description from KMIMS:

| CPNCODE | CPNDESC | CPNTERM | CPNADCTY | CPNLETDT |
|---|---|---|---|---|
| CPES0719990036 | FD05 057 0068 007-011 | FROM KY 169 (MP 7.314) EXTENDING NORTHERLY TO 0.310 MILE SOUTH OF KY 1980 (MP 10.800) | JESSAMINE | 22-Jan-99 |

Table 4.2 Description of a Project on Harrodsburg Road

One can see that this pavement section is only a part of a construction project, which actually started at MP 7.314 and ended at MP 10.8. Project material samples can also be obtained by following the project code.

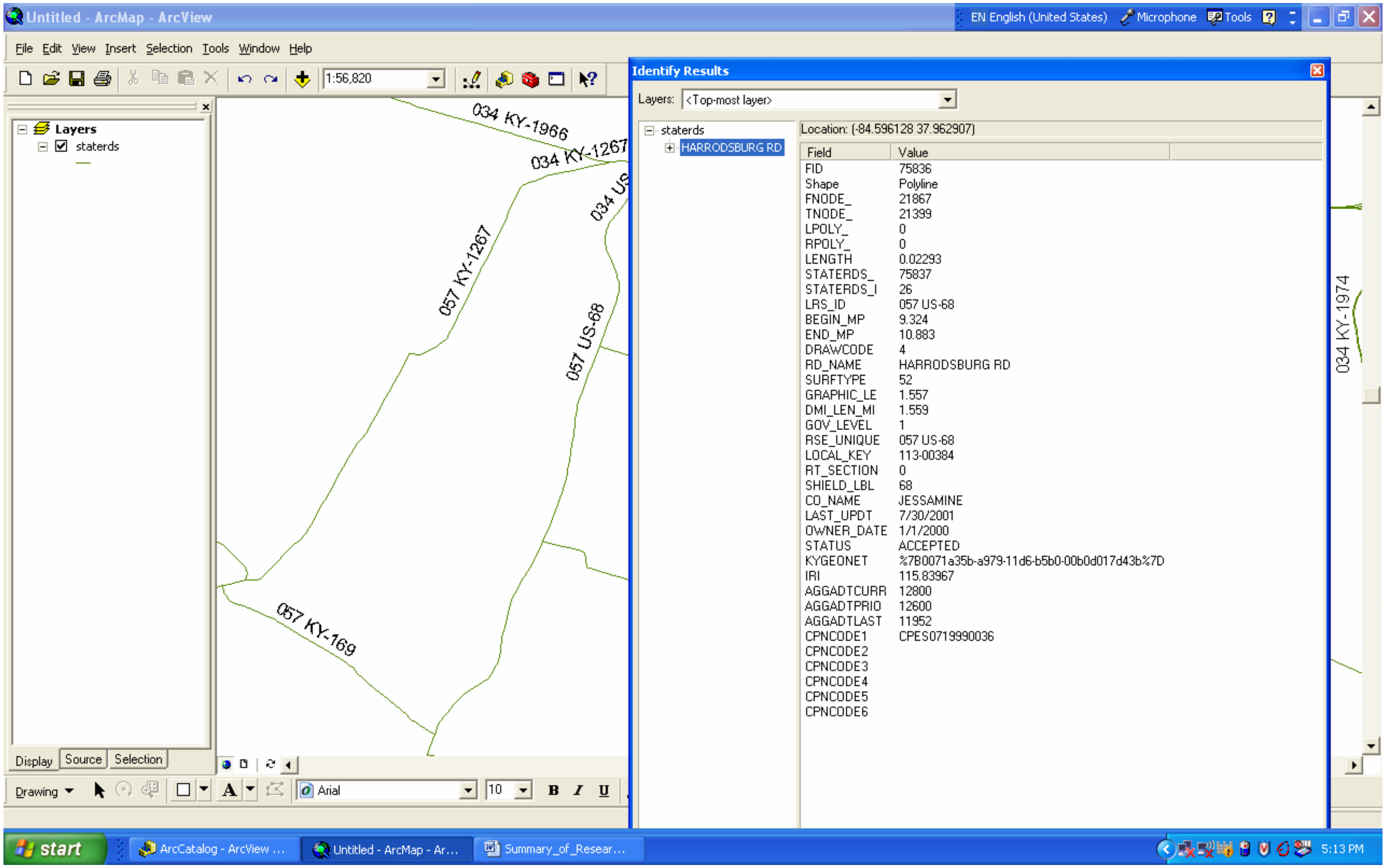



Figure 4.3 Information of a Pavement Section on the GIS Map

# Chapter 5 Summary and Recommendations

## 5.1 Summary of the Research

If databases from different sources in KyTC are fully integrated, they will provide a useful resource for engineers in KyTC, Kentucky Transportation Center (KTC), and other organizations to study the performance of pavements in Kentucky. After reviewing these data sources, the study found that these data are valuable, yet changes are required to make them more compatible.

The study reviewed the current practices of data integration by other organizations that face the similar challenges as KyTC.

The study also reviewed the current major data sources in KyTC for integration. By using an example to examine the requirement for pavement performance modeling, the study identified pieces of important information currently missed.

The study also extracted pavement design, construction, and performance related data from different sources and compiled them into a single database. The irrelevant information and vacant fields from the original data sources were excluded. The concise database is attached with this report.

The study identified pavement projects in KMIMS and generated location identifications to facilitate data integration. Pavement performance, traffic volume, and construction project information were added to a GIS table to allow a user to query such information through the GIS map. The modified GIS table is also attached with this report.

**5.2 Recommendations**

To fully realize the benefits of data integration, it is recommended that the following actions are taken.

1. The missed critical information should be added to the existing or future databases. The missed information includes, but not limited to, the following items:

- Project type
- Location identifications for a project
- For a resurfacing project, the condition of pavements before resurfacing
- Treatments of existing pavements before resurfacing (milling, crack sealing, etc)
- Thickness of pavements
- The initial conditions after construction
- The historical pavement management data
- Other pavement condition measurements such as cracking and rutting
- Separate condition measurements at different directions
- Traffic classification and WIM data

It is recommended that data integration effort should initially be focused on the weakest link and data items with minimum additional input.

2. It is recommended that whenever a database is updated in the future, the existing data should be well archived. Ideally, the existing data should be processed to make it meet data integration requirement as well as compatible with the future data structure.

3. Data integrity and consistency should be checked when an engineer or operator adds data to a database.

4. Based on the status of current data in KyTC, it is recommended that an offline separate database can be made by extracting critical information from historical and existing data sources to serve the purpose of pavement analysis. This database can be prepared periodically and distributed to the interested engineers.

5. The data processing method used in this study may be used to update other existing data sources.

6. The basic information of a pavement section can be queried through a GIS map. In the future, the GIS map, along with the concise offline database, can be posted online for reviewing and downloading.

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Appendix A Items Extracted from KMIMS

**Module:** KMIMS

**Table name:** KMIMS_ ALL_PROJECTS

**Description:** General pavement project information.

**Field name and description:**

| Name | Description |
|---|---|
| CPNCODE | Project Code |
| CPNDESC | Project ID |
| CPNTERM | Project description |
| CPNADCTY | County |
| CPNLETDT | Let date |
| CPNADATE | |
| CPNATIME | |
| CPNP | |
| CPNY | |
| CPNSERN | |
| | |

**Table name:** KMIMS_AGGR1

**Description:** Aggregate Table 1

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag112cpf | % Friable particles in fine agg. | AASHTO T112 |
| agp33apv | Avg. % uncompacted void content of fine agg. | AASHTO T304 |

**Table name:** KMIMS_AGGR2

**Description:** Aggregate Table 2

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag160exp | Carb Alk Bm Expan. | AASHTO T160 |
| ag23pi | Pore index | Kentucky Method 64-623-04 |

**Table name:** KMIMS_AGGR3

**Description:** Aggregate Table 3

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag666exp | Avg. expansion of 2 beams (for limestone or other agg. source) | ASTM C666 |
| agft3ae | Avg. expansion of 3 beams (for gavel) | ASTM C666 |

**Table name:** KMIMS_AGGR4

**Description:** Aggregate Table 4

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag00pfae | % of flat and elongated agg. | ASTM D4791 |
| ag19se | Results of sand equivalent test | AASHTO T176 |

**Table name:** KMIMS_AGGR5

**Description:** Aggregate Table 5

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag06p | % of material finer than a No. 200 sieve | Kentucky Method 64-606-03 |
| ag104ft6 | % loss of fine agg. after soundness test | AASHTO T104 |
| ag14wear | % loss due to wear by abrasion and impact | KM 614, AASHTO T96 |
| agpetro | Petrograph | |

**Table name:** KMIMS_AGGR6

**Description:** Aggregate Table 6

**Field name and description:**

| Field Name | Field Description |
|---|---|
| ag23p125 | #23 % PASSING 12.5MM |
| ag23p25 | #23 % PASSING 25MM |
| ag23p50 | #23 % PASSING 2 IN |
| ag23p75 | #23 % PASSING 75MM |
| ag23stwt | #23 START WEIGHT |
| ag2gstwt | #2 START WEIGHT |
| ag2p19 | #2 % PASSING 19MM |
| ag2p375 | #2 % PASSING 37.5MM |
| ag2p50 | #2 % PASSING 2 IN |
| ag2p63 | #2 % PASSING 63MM |
| ag2p75 | #2 % PASSING 75MM |
| ag35p125 | #357 % PASSING 12.5MM |
| ag35p25 | #357 % PASSING 25MM |
| ag35p475 | #357 % PASSING 4.75MM |
| ag35p50 | #357 % PASSING 2 IN |
| ag35p63 | #357 % PASSING 63MM |
| ag35stwt | #357 START WEIGHT |
| ag3gstwt | #3 START WEIGHT |
| ag3p125 | #3 % PASSING 12.5MM |
| ag3p25 | #3 % PASSING 25MM |
| ag3p375 | #3 % PASSING 37.5MM |
| ag3p50 | #3 % PASSING 2 IN |
| ag3p63 | #3 % PASSING 63MM |
| ag4gstwt | #4 START WEIGHT |
| ag4p19 | #4 % PASSING 19MM |
| ag4p25 | #4 % PASSING 25MM |
| ag4p375 | #4 % PASSING 1.5 IN |
| ag4p50 | #4 % PASSING 50MM |
| ag4p95 | #4 % PASSING 9.5MM |

**Table name:** KMIMS_AGGR7

**Description:** Aggregate Table 7

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag04pshl | % shale | Kentucky Method 604 |
| ag46p19 | #467 % PASSING 19MM | |
| ag46p375 | #467 % PASS 1.5 IN | |
| ag46p475 | #467 % PASSING 4.75MM | |
| ag46p50 | #467 % PASSING 50MM | |
| ag46p95 | #467 % PASSING 9.5MM | |
| ag46stwt | #467 START WEIGHT | |
| ag5gstwt | #5 START WEIGHT | |
| ag5p125 | #5 % PASSING 12.5MM | |
| ag5p19 | #5 % PASSING 19MM | |
| ag5p25 | #5 % PASSING 1 IN | |
| ag5p375 | #5 % PASSING 37.5MM | |
| ag5p95 | #5 % PASSING 9.5MM | |
| ag61p125 | #610 % PASSING 12.5MM | |
| ag61p25 | #610 % PASSING 1 IN | |
| ag61p375 | #610 % PASSING 37.5MM | |
| ag61p475 | #610 % PASSING 4.75MM | |
| ag61stwt | #610 START WEIGHT | |
| ag71p19 | #710 % PASS 3/4 IN | |
| ag71p25 | #710 % PASSING 25MM | |
| ag71p475 | #710 % PASSING 4.75MM | |
| ag71p95 | #710 % PASSING 9.5MM | |
| ag71stwt | #710 START WEIGHT | |

**Table name:** KMIMS_AGGR8

**Description:** Aggregate Table 8

**Field name and description:**

| Field Name | Field Description | Standards |
|---|---|---|
| ag03_pcr | % of crushed particles | ASTM D5821 |
| ag10fp1 | % loss of fine | Kentucky Method 610 |
| ag112fp1 | % ;pss of fine | AASHTO T112 |
| ag12plw | % light weight agg. | |
| agabs | % absorbtion for coarse agg. | AASHTO T85 |
| agfabs | % absorbtion for fine agg. | AASHTO T85 |
| agprmopt | Permeability | |
| agspl7 | % loss soundness test 7 | AASHTO T104 |
| agspl8 | % loss soundness test 8 | AASHTO T104 |

**Table name:** KMIMS_AGGR10

**Description:** Aggregate Table 10

**Field name and description:**

| Field Name | Field Description |
|---|---|
| ag8gstwt | START WT #8 & 9m |
| ag8p118 | #8/9 % PASSING 1.18mm |
| ag8p125 | #8/9 % PASSING 12.5mm |
| ag8p236 | #8/9 % PASSING 2.36mm |
| ag8p475 | #8/9 % PASSING 4.75mm |
| ag8p95 | #8/9 % PASS 3/8 IN |
| agbfaswt | START WEIGHT FINE |
| agbgp118 | % PASSING 1.18mm FINE |
| agbgp150 | % PASSING150 MICRN FINE |
| agbgp236 | % PASSING 2.36mm FINE |
| agbgp300 | % PASSING 300 MICRN FINE |
| agbgp475 | ASPH FINE % PASS #4 |
| agbgp600 | % PASSING 600 MICRN |
| agbgp75 | % PASSING 75 MICRN |
| agbgp95 | % PASSING 9.5mm |
| agcfaswt | START WEIGHT CONCRETE |
| agcgp118 | % PASSING 1.18mm CONCRETE |
| agcgp150 | % PASSING150 MICRN CONCRETE |
| agcgp236 | % PASSING 2.36mm CONCRETE |
| agcgp300 | % PASSING 300 MICRN CONCRETE |
| agcgp475 | CONC FINE % PASS #4 |
| agcgp75 | % PASSING 75 MICRN CONCRETE |
| agcgp95 | % PASSING 9.5mm CONCRETE |

**Table name:** KMIMS_AGGR10

**Description:** Aggregate Table 10

**Field name and description:**

| Field Name | Field Description |
|---|---|
| ag57gswt | Start Wt. #57 |
| ag57p125 | #57 % Pass 12.5mm |
| ag57p19 | #57 % Passing 19 mm |
| ag57p236 | #57 % Pass 2.36mm |
| ag57p25 | #57 % PASSING 1 IN |
| ag57p375 | #57 % Pass 37.5mm |
| ag57p475 | #57 % Pass 4.75mm |
| ag57p95 | #57 % Passing 9.5 mm |
| ag67gswt | Start Wt. #67 |
| ag67p125 | #67 % Passing 12.5 mm |
| ag67p19 | #67 % PASSING 3/4 IN |
| ag67p236 | #67 % Pass 2.36mm |
| ag67p25 | #67 % Passing 25mm |
| ag67p475 | #67 % Pass 4.75mm |
| ag67p95 | #67 % Pass 9.5mm |
| ag68gswt | Start Wt. #68 |
| ag68p118 | #68 %Pass 1.18mm |
| ag68p125 | #68 % Passing 12.5 mm |
| ag68p19 | #68 % PASSING 3/4 IN |
| ag68p236 | #68 % Pass 2.36mm |
| ag68p25 | #68 % Passing 25mm |
| ag68p475 | #68 % Pass 4.75mm |
| ag68p95 | #68 % Pass 9.5mm |
| ag78gswt | Start Wt. #78 |
| ag78p118 | #78 % Passing 1.18mm |
| ag78p125 | #78 % PASSING 1/2 IN |
| ag78p19 | #78 % Passing 19mm |
| ag78p236 | #78 % Passing 2.36mm |
| ag78p475 | #78 % Passing 4.75mm |
| ag78p95 | #78 % Passing 9.5mm |

**Table name:** KMIMS_AGGR12

**Description:** Aggregate Table 12

**Field name and description:**

| Field Name | Field Description |
|---|---|
| agcsgswt | START WT. CSB & DGA |
| agcsp19 | % Pass 19mm  CSB & DGA |
| agcsp375 | CSB/DGA % PASS 1.5 i |
| agcsp475 | % Pass 4.75mm  CSB & DGA |
| agcsp600 | % Pass 600mcrn  CSB & DGA |
| agcsp75 | % Pass 75mcrn  CSB & DGA |
| agcsp95 | %Pass 9.5mm  CSB & DGA |

**Table name:** KMIMS_AGGR13

**Description:** Aggregate Table 13

**Field name and description:**

| Field Name | Field Description |
|---|---|
| agsbactd | Actual density |

**Table name:** KMIMS_AGGR14

**Description:** Aggregate Table 14

**Field name and description:**

| Field Name | Field Description |
|---|---|
| ag20swt | Starting Weight |
| ag20w19 | Rprtd % Pass. 19mm |
| ag20w25 | Rprtd % Pass. 25mm |
| ag20w375 | Rptd % Pass. 37.5 mm |
| ag20w475 | Rprtd % Pass. 4.75mm |
| ag20w600 | Rprtd % Pass. 600mcr |
| ag20w75 | Rprtd % Pass. 75 mcr |
| ag20w95 | Rprtd % Pass. 9.5 mm |

**Table name:** KMIMS_AMIX7

**Description:** Asphalt pavement construction material data

**Field name and description:**

| Field Name | Field Description |
|---|---|
| prim_sam_key | Sample key |
| amacpid | Acceptance Test (ID) |
| amacpnam | Accept. Test (Name) |
| amacptby | Acceptance By |
| amagcd | Agg. Code |
| amavvala | Avg. Test 50 mm (by Acceptance Test) |
| amavvalb | Avg. Test 37.5 mm (by Acceptance Test) |
| amavvalc | Avg. Test 25 mm (by Acceptance Test) |
| amavvald | Avg. Test 19 mm (by Acceptance Test) |
| amavvale | Avg. Test 12.5 mm (by Acceptance Test) |
| amavvalf | Avg. Test 9.5 mm (by Acceptance Test) |
| amavvalg | Avg. Test 4.75 mm (by Acceptance Test) |
| amavvalh | Avg. Test 2.36 mm (by Acceptance Test) |
| amavvali | Avg. Test 1.18 mm (by Acceptance Test) |
| amavvalj | Avg. Test 0.600 mm (by Acceptance Test) |
| amavvalk | Avg. Test 0.300 mm (by Acceptance Test) |
| amavvall | Avg. Test 0.150 mm (by Acceptance Test) |
| amavvalm | Avg. Test 0.075 mm (by Acceptance Test) |
| amavvaln | Avg. Test % Binder (by Acceptance Test) |
| amavvalo | Avg. Test % F.M. |
| ambcpay | Pay % BC (Lot) |
| ambidprc | Bid Unit Price |
| amcda | Core Dens. A |
| amcdb | Core Dens. B |
| amcdc | Core Dens. C |
| amcdd | Core Dens. D |
| amdav | Dev. % AV |
| amdbc | Dev. % BC |
| amdenopt | Density Option |
| amdenpay | Pay Density (Lot) |
| amdtspav | Dates Paved |
| amdvma | Dev. % VMA |
| amgsb2 | Gsb |
| amgse2 | Gse |
| amhmg | Hand-Mixed MSG |
| amhmgac | Hand-Mixed MSG % AC |
| amidver | Sublot Ver. (ID) |
| amjmfbc | JMF % BC |
| amlotno | Lot Number |
| amlotpay | Lot Pay Adjustment |
| amlotton | Lot Tonnage Adj. |

| | |
|---|---|
| ammatcd | Material Code |
| ammsg | MSG |
| ammtons | M Tons in Lot |
| ammvma | Min. % VMA |
| amnamver | Sublot Ver. (Name) |
| ampayav | Pay % AV (Lot) |
| ampayfin | Final Pay Value |
| ampaygrd | Pay Grad. (Lot) |
| ampayvma | Pay % VMA (Lot) |
| amper | Percent |
| ampggrd | PG Grade |
| ampgman | PG Manufacturer |
| amslav | Sublot % AV |
| amslbc | Sublot % BC |
| amslver | Sublot Ver. |
| amsmeq | Same Equip. |
| amsvma | Sublot % VMA |
| amtav2 | Target % AV (Approved Mix) |
| amtjmfa | Target JMF 50 mm (Approved Mix) |
| amtjmfb | Target JMF 37.5 mm (Approved Mix) |
| amtjmfc | Target JMF 25 mm (Approved Mix) |
| amtjmfd | Target JMF 19 mm (Approved Mix) |
| amtjmfe | Target JMF 12.5 mm (Approved Mix) |
| amtjmff | Target JMF 9.5 mm (Approved Mix) |
| amtjmfg | Target JMF 4.75 mm (Approved Mix) |
| amtjmfh | Target JMF 2.36 mm (Approved Mix) |
| amtjmfi | Target JMF 1.18 mm (Approved Mix) |
| amtjmfj | Target JMF 0.600 mm (Approved Mix) |
| amtjmfk | Target JMF 0.300 mm (Approved Mix) |
| amtjmfl | Target JMF 0.150 mm (Approved Mix) |
| amtjmfm | Target JMF 0.075 mm (Approved Mix) |
| amtjmfn | Target JMF % Binder (Approved Mix) |
| amtjmfo | Target JMF F.M. (Approved Mix) |
| amtr | Test Res. |
| amtrjmf | Target JMF |
| amtypadd | % & Type Additive (liquid antitrip) |
| amvav | Ver. % AV |
| amvbc | Ver. % BC |
| amver1ch | Gradation Ver. 1 Charge |
| amver2ch | Gradation Ver. 2 Charge |
| amvvma | Ver. % VMA |
| edamix7 | Entry date |
| etamix7 | Entry time |

**Table name:** KMIMS_AMIX10

**Description:** Asphalt pavement design data

## Field name and description:

| Field Name | Field Description |
|---|---|
| prim_sam_key | Sample key |
| edamix10 | Entry date |
| am21psgc | 1 Point SGC Design |
| am2abs | % Abs. AC (Mix) |
| am2abs1p | % Abs AC (Mix)(1-pt) |
| am2ac1p | % AC (1-pt.) |
| am2acrap | % AC in RAP |
| am2appcn | Contractor Design |
| am2appml | MCL Design |
| am2appnw | Approval New Design |
| am2apprf | Approval Ref. Mix |
| am2avip | % Air Voids (1-pt.) |
| am2avw | Avg. % AV with Add. |
| am2avwo | Avg. % AV w/o Add. |
| am2bndcd | Binder Code |
| am2bsgag | Bulk Sp. Grav. (Agg) |
| am2caa | Coarse Agg. Ang. |
| am2cnty | County |
| am2cpsgc | Complete SCG Design |
| am2dar | D/A Ratio |
| am2dar1p | D/A Ratio (1-pt.) |
| am2depth | Depth from Surface |
| am2desac | Design AC % |
| am2desav | % Air Voids |
| am2dsgsb | Gsb (design value) |
| am2dsgse | Gse (design value) |
| am2dsmsg | Max. Sp. Gravity |
| am2eac1p | % Eff. AC (1-pt.) |
| am2effac | % Effective AC |
| am2efgag | Eff. Sp. Grav. (Agg) |
| am2esal | ESAL Class |
| am2esl1p | ESAL Class (1-pt.) |
| am2faa | Fine Agg. Ang. |
| am2fe | Flat & Elongated |
| am2fmthk | Film Thickness |
| am2tsrwo | % TSR without add. |
| am2tsrwt | TSR Weight |
| am2uw1p | Unit Wt. (1-pt.) |
| am2vfa | % VFA |
| am2vfa1p | % VFA (1-pt.) |
| am2virac | % Virgin AC in Mix |
| am2vma | % VMA |
| am2vma1p | % VMA (1-pt.) |
| am2gsb1p | Gsb (1-pt.) |
| am2gse1p | Gse (1-pt.) |

| | |
|---|---|
| am2jf1 | Prop. JMF (1 ") |
| am2jf1_2 | Prop. JMF (0.5 ") |
| am2jf1_4 | Prop. JMF (0.25 ") |
| am2jf100 | Prop. JMF (# 100) |
| am2jf15 | Prop. JMF (1.5 ") |
| am2jf16 | Prop. JMF (# 16) |
| am2jf2 | Prop. JMF (2 ") |
| am2jf200 | Prop. JMF (# 200) |
| am2jf3_4 | Prop. JMF (0.75 ") |
| am2jf3_8 | Prop. JMF (0.38 ") |
| am2jf30 | Prop. JMF (# 30) |
| am2jf4 | Prop. JMF (# 4) |
| am2jf50 | Prop. JMF (# 50) |
| am2jf8 | Prop. JMF (# 8) |
| am2msg1p | MSG (1-pt.) |
| am2mxtyp | Type of Mix |
| am2nini | % Gmm @ Ninitial |
| am2nmax | % Gmm @ Nmax |
| am2perad | % Additive |
| am2rapac | % RAP AC in Mix |
| am2satw | Avg %In Sat with Add |
| am2satwo | Avg % In Sat w/o Add |
| am2se | Clay Content (SE) |
| am2tons | Tons of Mix |
| am2tradd | % Add. in TSR's |
| am2trmsg | MSG of TSR's |
| am2trtpa | Type Add. in TSR's |
| am2trw | % TSR with Add. |
| am2trwo | % TSR w/o Add. |
| am2tsrw | % TSR with add. |

**Table name:** KMIMS_LIQA1

**Description:** Liquid asphalt testing data

**Field name and description:**

| Field Name | Field Description | description2 |
|---|---|---|
| prim_sam_key | Sample key | |
| edliqa1 | entry date | |
| lamchang | % Change (Superpave) | % change in mass loss |
| lamval1 | m-value 1 | |
| lamval2 | m-value 2 | |
| lamvala | m-value Average | |
| laodelta | Phase Angle (O) | phase angle of the original binder |
| laogsin | G*/sin delta (O) | G*/sin delta (O) of original binder |
| lapdelta | Phase Angle (P) | phase angle of the binder after pressure aging vessel |
| lapgsin | G*/sin delta (P) | G*Xsin delta (P) |
| lardelta | Phase Angle (R) | phase angle of the binder after rolling thin film oven |
| largsin | G*/sin delta (R) | G*/sin delta (R) |
| larotvis | Rotational Viscosity | |
| lastiff1 | Stiffness 1 | |
| lastiff2 | Stiffness 2 | |
| lastiffa | Stiffness Average | creep stiffness |

**Table name:** KMIMS_CONC2

**Description:** Concrete testing data

**Field name and description:**

| Field Name | Field Description | description2 |
|---|---|---|
| prim_sam_key | sample key | |
| edconc2 | Entry date | |
| copsi7d | Average MPa 7 Day | |
| copsicy | Average MPa Cylinder | 28 days |
| coreage | | |
| coreavg | | |
| coreqact | Required Act Stngth | |
| coreqtnt | Required Detent. Str | |
| cocraged | Age of cylinder | |
| cocrair | Air content | |
| cocrpsi | Strength | |
| cocrslum | Slump | |
| cocyaged | Age | |
| cocyageh | Age in Hours | |
| cocyair | % Air | |
| cocydia | Cylinder Diameter | |
| cocylen | Cylinder Length | |
| cocyslum | Slump | |
| cocytemp | Temperature | |
| cocyunwt | Unit Mass | |

**Table name:** KMIMS_GEOTECH1

**Description:** Geotechnical data (part 1)

**Field name and description:**

| Field Name | Field Description | description2 |
|---|---|---|
| prim_sam_key | | |
| EDGTECH1 | | |
| gt_aden | Actual Density | |
| gt_lift | Lift Number | |
| gt_mstr | % Moisture | |
| gt_pden | % Reference Density | |
| gt_stati | Station | |
| gtashtcl | AASHTO Classif | |
| gtclay | % Clay | |
| gtcrssnd | % Coarse Sand | |
| gtd_50 | D 50 | minimum grain size corresponding 50% of passing |
| gtfinsnd | % Fine Sand | |
| gtgrav | % Gravel | |
| gtinpnmc | Input Nat Moist Cont | |
| gtli | Liquidity Index | |
| gtll | Liquid Limit | |
| gtpi | Plasticity Index | |
| gtpl | Plastic Limit | |
| gtpp_425 | 0.425 mm (No.40) | |
| gtpp19 | 19.0 mm (3/4) | |
| gtpp25 | 25.0 mm (1) | |
| gtpp4_75 | 4.75 mm (No.4) | |
| gtpp50 | 50 mm (2) | |
| gtpp75 | 75 mm (3) | |
| gtpp9_5 | 9.5 mm (3/8) | |
| gtrefden | Reference Density | |
| gtsand | % Sand | |
| gtsilt | % Silt | |
| gtsplc | % Silt + Clay | |
| gtunifcl | Unified Classif | |

**Table name:** KMIMS_GEOTECH2

**Description:** Geotechnical data (part 2)

**Field name and description:**

| Field Name | Field Description |
|---|---|
| prim_sam_key | |
| EDGTECH1 | |
| gtcbr | CBR |
| GT_OPTM | Opt Moist Cont |

**Table name:** KMIMS_SAM_LOG_AG, KMIMS_SAM_LOG_AM, KMIMS_SAM_LOG_CO, KMIMS_SAM_LOG_ GT, KMIMS_SAM_LOG_LA

**Description:** Sample log

**Field name and description:**

| Field Name | Field Description |
|---|---|
| prim_sam_key | |
| SAM_DATE | |
| TABLE_N | |
| WORK_N | |
| INST_N | |
| WRK_DATE | |
| TEST_N | |
| | |
| | |
| | |

**Table name:** KMIMS_SAM_RES_AG, KMIMS_SAM_RES_AM, KMIMS_SAM_RES_CO, KMIMS_SAM_RES_ GT, KMIMS_SAM_RES_LA

**Description:** Sample record

**Field name and description:**

| field name | Description |
|---|---|
| prim_sam_key | Sample key |
| p_approv | Approval |
| p_aprvid | Approved id |
| p_batch | Batch/Lot/Cylinder # |
| p_class | Classification |
| p_depth | Depth |
| p_dtsamp | Date Sampled |
| p_holeno | Hole Number |
| p_insnam | Inspector Name |
| p_inspid | Inspector ID |
| p_instyp | Inspection Type |
| p_lab | Laboratory Area |
| p_labtyp | Lab Type (CO or DO) |
| p_lotno | Lot Number |
| p_mtcode | Material Code |
| p_mtdesc | Material Description |
| p_mtunit | Material Units |
| p_mxdate | Mix Date |
| p_name | Producer Name |
| p_offset | Offset |
| p_origid | Original ID |
| p_pf | Pass/Fail |
| p_pin1 | Project ID Number 1 |
| p_pin2 | Project ID Number 2 |
| p_pin3 | Project ID Number 3 |
| p_pin4 | Project ID Number 4 |
| p_pin5 | Project ID Number 5 |
| p_prdnam | Product Name |
| p_prjchg | Tested at DO/CO Lab? |
| p_psn | Prod/Supplier Number |
| p_qtyins | Quantity Inspected |
| p_samloc | Sample Location |
| p_sampsq | Sample Sequence No. |
| p_samtyp | Sample Type |
| p_statn | Station |
| p_subtyp | Sub-Type |
| p_usage | Usage |

Appendix II

**Module:** HIS

**Table name:** HIS_IRI

**Description:** The IRI values of various routes tested in 2003.

**Field name and description:**

| Name | Description |
|---|---|
| COUNTY | |
| COUNTY_NAME | |
| RSE_UNIQUE | |
| RSE_UNIQUE_2 | |
| ROUTE_LABEL | |
| BEGIN_MP | |
| END_MP | |
| IRI | |
| TEST_DATE | |

**Table name:** HIS_PAVEMENT

**Description:** Pavement structure information.

**Field name and description:**

| Name | Description |
|---|---|
| COUNTY | |
| COUNTY_NAME | |
| RSE_UNIQUE | |
| RSE_UNIQUE_2 | |
| ROUTE_LABEL | |
| BEGIN_MP | |
| END_MP | |
| SURFTYPE | |
| SURFTHK | |
| PAVESECT | |
| PAVESN | |
| OVERLAY | |
| TYPEBASE | |
| SUBGRADE | |

**Table name:** HIS_PAVEMENT_MANAGEMENT

**Description:** Pavement management information.

**Field name and description:**

| Name | Description |
|---|---|
| COUNTY | |
| COUNTY_NAME | |
| RSE_UNIQUE | |
| RSE_UNIQUE_2 | |
| ROUTE_LABEL | |
| BEGIN_MP | |
| END_MP | |
| PM_PAVETYPE | |
| DIRECTION | |
| SURFYEAR | |
| RIDE_INDEX | |
| ROUGHNESS | |
| TESTDATE | |
| IMPTYPE | |
| SURF_THICK | |
| PAVE_THICK | |
| PAVESN | |
| HPMS_PAVE_TYPE | |
| HPMS_SN_OR_D | |

**Table name:** HIS_ RATINGS

**Description:** Comprehensive road performance ratings.

**Field name and description:**

| Name | Description |
|---|---|
| COUNTY | |
| COUNTY_NAME | |
| RSE_UNIQUE | |
| RSE_UNIQUE_2 | |
| ROUTE_LABEL | |
| BEGIN_MP | |
| END_MP | |
| CONDINDX | |
| SAFEINDX | |
| SERVINDX | |
| COMPINDX | |
| PERCENTILE | |
| CAPACITY | |
| VSFRATIO | |
| DSGNSPEED | |
| HORIZADQ | |
| VERTLADQ | |
| UDT_DATE | |
| UDT_BY | |

**Table name:** HIS_ TRAFFIC

**Description:** Average daily traffic data(ADT).

**Field name and description:**

| Name | Description |
|---|---|
| COUNTY | |
| COUNTY_NAME | |
| RSE_UNIQUE | |
| RSE_UNIQUE_2 | |
| ROUTE_LABEL | |
| BEGIN_MP | |
| END_MP | |
| ADTCURR | |
| ADTSRCE | |
| ADTPRIOR | |
| HPMSSRCE | |
| LASTCNT | |
| LASTCNTY | |
| ENDDESC | |
| ADTSTATN | |
| ADTSTYPE | |
| VCSTATN | |
| VCRCNTY | |
| PCSINGOP | |
| PCCOMBOP | |

**Table name:** HIS_ TRUCKS

**Description:** Truck information (?).

**Field name and description:**

| Name | Description |
|---|---|
| COUNTY | |
| COUNTY_NAME | |
| RSE_UNIQUE | |
| RSE_UNIQUE_2 | |
| ROUTE_LABEL | |
| BEGIN_MP | |
| END_MP | |
| COMMACC | |
| TR_SEQ | |

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