

**State of Wisconsin/Department of Transportation**  
**RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: June 30, 2007**

<b>Program: SPR-0010(36) FFY99</b>	<b>Part: II Research and Development</b>
<b>Project Title:</b> Database Development for a Hot-Mix Asphalt Pavement Performance Analysis System	<b>Project ID:</b> 0092-06-13 (MRUTC 07-11)
<b>Administrative Contact:</b> Jason Bittner	<b>Sponsor:</b> MRUTC
<b>WisDOT Technical Contact:</b> James McDonnell	<b>Approved Starting Date:</b> November 16, 2006
<b>Approved by COR/Steering Committee:</b> FY07, \$50,000, 12 months	<b>Approved Ending Date:</b> November 15, 2007
<b>Project Investigator (agency &amp; contact):</b> Robert Schmitt, UW-Platteville	

**Description:**

Total study budget	Current FFY budget	Expenditures for current quarter	Total Expenditures to date	Percent Complete
\$50,000	\$50,000	\$9,000	\$22,000	60

**Progress This Quarter:**

(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)

Task 1. Literature Review

The objective of Task 1 is to identify, collect, review, and synthesize literature and research to understand all relevant literature on the relationship of pavement performance to design, construction, maintenance, and environmental variables. Task 1 is 100% complete.

During this quarter, the literature review was completed in relation to the project objectives. A full literature review follows, and sections are numbered as they will appear in the report.

**2.0 Literature Review Introduction**

Pavement performance is a measure of highway deterioration and indicates the variation in the level of service provided to the pavement user over time. It is at the heart of every pavement management system (PMS) and forms the basis for determining needed maintenance and rehabilitation strategies, as well as the overall cost-effectiveness for a given highway section or network. In addition, it provides a basis for verifying design methods, in that if a pavement section performs well, more than likely the next design will follow the procedures used in the previous design to achieve the desired performance.

The purpose of this literature review is to identify pertinent performance data types collected for PMS, data integration, and analytical methods applied, as well as corresponding outputs.

**2.1 Pavement Management System Data Needs**

AASHTO (1993) defines a pavement management system (PMS) as a “set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time.” PMS data needs and uses have been discussed by Haas et al (1994) and can be summarized as in Table 2.1. With the exception of the policy and cost related data, all categories provide background information for pavement performance modeling and analysis, and are discussed in the following sections.

**TABLE 2.1 Major Classes and Component Types of Pavement Data** (Haas et al., 1994)

Data Category (1)	Components (2)	Primary Uses (3)	
		Rehabilitation	Maintenance
Section reference and description	-	X	X
Performance Related Data	Roughness	X	
	Surface distress	X	X
	Deflection	X	
	Friction	X	X
	Layer material properties	X	
Historic Related	Maintenance history	X	X
	Construction history	X	X
	Traffic	X	X
	Accidents		
Policy Related	Budget	X	X
	Available alternatives	X	X
Geometry Related	Section dimensions	X	
	curvature	X	
	Cross slope	X	
	Grade	X	
	Shoulder/ curb	X	X
Environment Related	Drainage	X	X
	Climate (temperature, rainfall, freezing)	X	
Cost Related	Construction costs	X	
	Maintenance costs	X	X
	Rehabilitation costs	X	
	User costs	X	

### 2.1.1 Section reference and description

Historically, different divisions within an agency often have data collection and use needs that are not totally compatible with the needs of other divisions. It is therefore, not uncommon to see multiple methods of referencing the location of pavement sections within a highway network. The construction division, for example, may use construction project numbering scheme, while the operations division may use route milepost method for scheduling maintenance operations. These functions need to be coordinated to create a permanent referencing system for a functional PMS. NCHRP Synthesis 335 reported a survey in which 96% of highway agencies indicated using the milepost/logpoint method for referencing, while 15% use landmarks for referencing. The milepost referencing method requires each roadway to be given a unique name and/or number, and a distance along the route from a given origin to define points along the route. The increasing use of Geographic Information System (GIS) and Global Positioning System (GPS) technology however, is propelling the use of coordinate-based referencing system to identify points along routes. NCHRP Synthesis 335 identified 35% of surveyed agencies using longitude and latitude, and 13% using state plane coordinate or other systems.

### 2.1.2 Performance Data

Performance data relates to the current and historical condition of the pavement. Four key indicators are commonly used to characterize the condition of the pavement and include roughness, surface distress (e.g. rutting, cracking, and faulting), deflection, and surface friction (as related to safety). The four indicators are the variables that can be measured to determine whether the pavement is functioning satisfactorily. These indicators would originally be predicted at the design stage and then periodically evaluated while the pavement is in service. A survey of 51 state agencies revealed that approximately 55% of agencies used both manual and automated methods in performance data collection while 27% use automated methods only for the same purpose (NCHRP 335). The automated data involves multipurpose data collection vans that employ technologies such as Global Positioning System (GPS), laser sensors, and video cameras to capture inventory and centerline information. Day and Lewis (2002) have summarized best practices in automated highway collection equipment.

### 2.1.3 Historic data

Historic data primarily involve construction, maintenance, and traffic data. Construction data includes information on the as-built quality of the materials, such as density and permeability characteristics of asphalt concrete. Significant variability in construction quality can result in poor performance, compared to pavements with uniform quality. Pavement maintenance data involve maintenance activities that impact performance (e.g. crack sealing, patching). A high level of maintenance can result in an extended life of the pavement beyond the expected service life.

Traffic data is critical for performance prediction and for priority assignment in the selection of rehabilitation projects. Performance modeling requires an estimate of the heavy vehicle traffic that causes the majority of the pavement deterioration. The estimate is adjusted to reflect traffic growth rate for the performance period under consideration. Twenty-one of 37 agencies surveyed indicated using both automated and manual methods in traffic volume data collection (NCHRP 335).

### 2.1.4 Environmental data

Pavement performance can be seriously affected by environmental and drainage conditions. The common measures used as indices of environmental conditions include freeze-thaw cycles, freezing index, seasonal rainfall, Thornthwaite index, drainage quality, and regional factors developed by an agency (Haas et al., 1994).

## 2.2 Data Integration

Analytical models involving structural or functional pavement performance requires information about the indicator of performance (e.g. roughness, distress type), as well as the potential variables that affect the performance indicator (e.g. traffic loads, climate, material characteristics, maintenance and rehabilitation history, and construction history). This required information is generally associated with pavement management systems (PMS) and are often kept in separate databases managed by different divisions or offices within an agency. For example, the planning division keeps traffic records, while construction and maintenance records are maintained respectively by the construction and operations divisions. The problem is further compounded by the use of different referencing systems and data formats that may be used by some divisions within an agency. An ideal PMS will have this information centralized so that all divisions have ready access to the needed data and also minimize duplication. One of two main methods can be used for data integration namely, data fusion and interoperable or federated databases (FHWA 2001). Data fusion combines data from multiple sources into a single database, whereas federated databases employ multi queries to relate data residing in different databases. Although data integration is considered very important, NCHRP 335 reported on the basis of a survey that the number of agencies that have actually completed or are close to completing a full integration of the systems is very limited.

GIS has been identified as an effective tool for data integration. According to AASHTO (2001), the Illinois DOT has used GIS to integrate information from disparate databases to provide information for PMS activities. Roadway, structure, and rail crossing inventory systems are tied to a link/node base, and allow the use of multiple referencing schemes of route and milepost designations.

## 2.3 Performance Data Analysis and Presentation

Two main types of performance data analyses are common in the literature. The first type involves description of the present status of the network, while the second type involves prediction of the future condition of the network.

### 2.3.1 Performance Analysis Formats for Describing Present Network Condition Status

A wide range of formats have been used in expressing the condition status of pavement networks. These include:

a) Color-coded maps indicating in a categorical manner, the condition of all pavements in the network. This is facilitated using GIS as a tool. Petzold and Freund (1990) produced one of the earliest GIS applications to display and analyze the Highway Performance Monitoring System. The Virginia Department of Transportation has used GIS to display the general pavement conditions for its road network by county, as well as showing sections that are above, near, or below established condition threshold values.

b) Graphical representations of pavement condition involve the use of histograms and pie charts to show the percentages of pavement in some particular condition (e.g. good, fair, or poor). These can be broken down by highway class, political jurisdiction etc.

c) Tabular summaries are very useful when information is sought on a specific pavement section. Tables can be used to display, for example, the sequential listing of all pavement sections based on the performance indicator values, or listings sorted by the common highway name.

### 2.3.2 Performance modeling for describing future condition Status of Network

Knowledge of the future condition of the pavement network allows agencies to determine maintenance and rehabilitation needs, prioritization schemes, and anticipated costs to bring the network condition to a predetermined acceptable level. The future condition is determined through prediction models. The requirements for developing reliable performance prediction models have been outlined by Darter (1980) and include:

- having an adequate database for the pavements in service
- consideration of all variables that affect performance
- selection of the appropriate functional form of the model to represent the prevailing pavement condition
- measures to assess the model precision and accuracy

Several different types of prediction models have been discussed in the literature but they can be grouped into the following categories:

- a) Mechanistic models: According to Lytton (1987), mechanistic models predict changes in some primary mechanistic response of the pavement such as strain, deflection, or stress caused by factors such as load, temperature, and pavement support.
- b) Mechanistic-empirical models: For mechanistic-empirical models, a response parameter such as strain, stress, or deflection is related to measured structural or functional deterioration, such as distress or roughness.
- c) Empirical models relate the change in condition to the age of the pavement, loadings applied, or some combination of both. Empirical models are commonly developed through the use of regression analysis. However, newer generation of methods including artificial neural networks, genetic algorithms, and fuzzy sets has also been used for empirical model development (AASHTO 2001).
- d) Probabilistic models describe the probability that a pavement in a known condition state at a known time will change to some other condition state in the next time period. Three types of probabilistic models have been used in the literature to develop condition models (Lytton 1987) and include: Markov models, survivor curves, and semi-Markov models.

Table 2.2 summarizes sample performance models with corresponding factors found significant in explaining the variations in a particular performance indicator. Although the mechanistic and mechanistic-empirical models use the strain or stress properties of the asphalt concrete, they do not relate the ultimate performance measure (e.g. roughness) to the mix design characteristics that produced the strain or stress. Such information will be important in defining mix specifications for yielding a certain performance output.

**TABLE 2.2 Sample Performance Outputs and Input Variables**

Model Type (1)	Performance Output (2)	Performance Inputs (3)	Pavement Type (4)	Model Source (5)
Probabilistic (survivor curves)	NYS DOT Condition Rating ranging from 1 (poor) to 10 (excellent)	Age	Rigid	DeLisle et al, 2003
Empirical based on Artificial Neural Network	FDOT pavement condition Rating (PCR)	Age, maintenance cycle, crack index, rut index, ride index	Flexible, Rigid	Yang et al, 2003
Empirical based on regression	Present serviceability rating (PSR)	Transverse joint faulting, number of transverse cracks per mile, number of deteriorated joints per mile, number of full-depth repair per mile.	Rigid (jointed plain concrete)	Huang, 2004
Empirical based on regression	Rutting Rate	Surface deflection, vertical compressive stress, ESAL	Flexible	Huang, 2004
Mechanistic	Allowable load applications	Tensile strain at bottom of asphalt layer, dynamic modulus of asphalt mixture	Flexible	Asphalt Institute, 1981
Mechanistic	Tensile strain at bottom of asphalt layer	Asphalt layer thickness, deflection difference at 305 and 600 mm of the radial distance from load plate center.	Flexible	Park and Kim, 2003
Mechanistic-empirical	Roughness	Age, roadway surface type, rehabilitation state, Strain energy at bottom of asphalt layer, cumulative equivalent single axle load	Flexible	Queiroz, 1983
Mechanistic-empirical	Percent pavement area cracked	Horizontal tensile strain at bottom of asphalt layer, cumulative equivalent single axle load	Flexible	Queiroz, 1983

## 2.4 Summary and Conclusions

A review was conducted regarding pertinent PMS data types generally collected for modeling pavement performance. In addition, data organization and integration issues were examined, as well as analytical methods for modeling and presenting performance related data. Based on the review, the following observations are made:

- Data types collected for performance evaluation and modeling vary from agency to agency depending on needs but the most common ones include inventory, condition, traffic volume, and maintenance and rehabilitation.
- Adoption of common referencing systems between various data collection systems can facilitate data integration for pavement performance modeling. There is evidence in the literature to suggest that a major barrier for achieving full data integration by agencies is lack of common referencing systems compounded by the use of different data formats.
- A Geographic Information System is an effective tool for data integration among various divisions within an organization.

Major types of performance models include mechanistic, mechanistic-empirical, empirical, and probabilistic. Although the mechanistic and mechanistic-empirical models use the strain or stress properties of the asphalt concrete, they do not relate the ultimate performance measure (e.g. roughness) to the mix design characteristics that produced the strain or stress. Such information will be important in defining mix specifications for yielding a certain performance output.

## References:

- Haas R., Hudson W. R., and Zaniewski J., "Modern Pavement Management", Krieger Publishing Company, Malabar, FL., 1994
- Transportation Research Board, "Pavement Management Applications Using Geographic Information Systems", NCHRP Synthesis 335, Washington, D.C. 2004.
- Day, J. and Lewis S., "Automated Highway Data Collection: Best Practices Field Review," Presented at the GIS for Transportation Symposium, Atlanta, Ga., Mar. 25-27, 2002.
- FHWA, "Data Integration Primer," Office of Asset Management, Federal Highway Administration, Washington, D.C., August 2001
- Petzold, R.G. and Freund, D.M., "Potential for Geographic Information Systems in Transportation Planning and Highway Management," Transportation Research Record 1261, TRB, National Research Council, Washington, D.C., 1990.
- VDOT, "State of the Pavement—2002", Interstate and Primary Highways, Maintenance Division, Pavement Management Program, VDOT, Richmond, June 2002
- AASHTO, "Pavement Management Guide", AASHTO, Washington, D.C., 2001
- Lytton, R.L., "Concepts of Pavement Performance Prediction and Modeling." Vol. 2, Proceedings, Second North American Conference on Managing Pavements, Ontario Ministry of Transportation, Toronto, Canada, 1987.
- Darter, M.I., "Requirements for Reliable Predictive Pavement Models", Transportation Research Record 766, Transportation Research Board, Washington, D.C., 1980.
- DeLisle, R.R., Sullo, P., and Grivas D.A., "Network-Level Pavement Performance Prediction Model Incorporating Censored Data", Transportation Research Record 1853, TRB, National Research Council, Washington, D.C., 2003.
- Yang, J., Lu, J.J., Gunaratne, M., and Xiang Q., "Forecasting Overall Pavement Condition with Neural Networks-Application on Florida Highway Network", Transportation Research Record 1853, TRB, National Research Council, Washington, D.C., 2003.
- Asphalt Institute "Thickness Design—Asphalt Pavements for Highways and Streets", Manual Series No. 1, 1981.
- Park, Hee M., and Kim, Y.R., "Prediction of Remaining Life of Asphalt Pavement with Falling-weight Deflectometer Multiloading-level Deflections Transportation Research Record 1860, TRB, National Research Council, Washington, D.C., 2003.
- Huang, Y.H., "Pavement Analysis and Design", Prentice Hall, Upper Saddle River, NJ, 2004.
- Queiroz, C., "A Mechanistic Analysis of Asphalt Pavement Performance in Brasil," J. of Assoc. of Asphalt Paving Technology, Vol. 52, 1983

## Task 2. Survey and Review of Pavement Management Systems

The objective of Task 2 is to survey state highway agencies to acquire information on their pavement management systems. Task 2 is 100% complete.

From the literature review in Task 1 it was learned that a synthesis of current practices from all states was published in 2004, as NCHRP Synthesis Report #335. Thus, the survey was suspended.

During the previous quarter, the latest available WisDOT HMA databases were broken down for performance, design, traffic, and construction data. Then, each database was broken down by field name, field length, and whether the field was spatial or not (See previous quarterly report for details).

During this quarter, each database was further reviewed to understand their potential for data integration. and a full textual description follows using section numbering that will appear in the report.

### **3.0 REVIEW OF WISCONSIN FLEXIBLE PAVEMENT RELATED DATABASES**

The major databases for Wisconsin flexible pavements include construction, design, performance, and Meta-manager. Each of the databases is briefly described in the following sections.

#### **3.1 Construction Database**

The construction database consists of Microsoft Excel spreadsheets organized by year from 1997 to 2004. There are two key files, a design/test log file (*GeneralLogs 1997-2004.xls*) and a mix design data file (*data 1997-2004.xls*). The design/test log file contains 2,380 records that show fields representing the highway type (STH, local, CTH, etc.), highway number or letter, surface year, aggregate sources, project location (by descriptive start and end points), county, district, project identification number, contractor, PRE, test number, mix type, and ESAL category (E0.3, E1, E3, etc) for 2001-2004. The mix design data file shows mix design data for 2,402 records. The mix design data consist of %AC, %VMA, aggregate size distribution in mix (3/4", 1/2", 3/8", #4, #8, #16, #30, #50, #100, #200), %RAP, Gse, Gsb, Gmm, Gmb, dryback correction, flow, stability, TSR, blows, anti-strip agent, and asphalt cement characteristics (type, source, specific gravity). In addition, the latter file lists contractor name, PRE, test number, type ( which shows either ESAL category together with nominal maximum aggregate size (e.g. E3-12.5, E3-19.0R ) or mix type (e.g. MV-3, SPPV, etc.) for various records.

#### **3.2 Design Database**

The design database is a set of Microsoft Access files organized by year from 2000 to 2004. Each file has two key datasheets, namely, *ACOffice* and *ACField*. The *ACOffice* datasheet has a total of 544 records, which show pavement location (rural or urban, district, county, termini by descriptive start and end points), construction style (reconstruction, resurfacing, rehabilitation), contract identification numbers (*contract1*, *contract2*), project length, pavement surface thickness (*Pvtthick*), milling depth, base type (DGBC, CABC, OGBC2), pavement surface paved over (*Pvdovr*), flexible pavement type, surface year (*pvmnty*), mix type denoted by *HvMvLv* (now *Superpave E-series ESAL designation*), case type (standard, superpave, SMA, AC warranty), and design ESAL magnitude. The *ACField* datasheet has a total of 5620 records that show fields representing site identification number (site), sequence number (*Sqno*), beginning reference point (RP) e.g. 60 0.94, contract identification number (*contract2*), highway name by direction for all years except 2002, survey length (Survlen), lane, direction, A or P (Asphalt or PCC), Set value, measured IRI, and rut depth (Rut) immediately after construction.

#### **3.3 Performance Database**

The performance database is a Microsoft Access file, commonly referred to as the pavement information (PIF) file. The file has various customized forms to facilitate data entry. In addition, it has several datasheets for tabular summaries of data. The key datasheets include the descriptive (DESC), pavement distress index history file, and the IRI data.

The descriptive file identifies pavement segments by sequence numbers, county name, county number, district, from-to reference points, from feature, highway number, highway direction, functional class number, national highway system designation, surface year and original construction year. In addition, the datasheet has fields for the segment length, cumulative mileage, and roadbed soil type.

The IRI datasheet contains 153,461 records representing segments tested between 1980 and 2005. Approximately 77% of the records pertain to flexible pavements. The datasheet lists fields representing the sequence number, inverse year, day-month- year segment was tested, the surface year, surface type, air temperature, average values for IRI, PSI, and Rut. In addition, it lists the speed at which tests were conducted.

The PDI history datasheet has 65,535 records for flexible pavement segments tested between 1985 and 2005. It lists the segment sequence number, inverse year, test day-month- year, surface year, distress type severity and extent for quantifying PDI.

### **3.4 Meta-Manager Database**

Meta-manager is a comprehensive system comprising of independent databases organized by region for all five regions in Wisconsin. Each region consists of one Excel spreadsheet workbook with multiple datasheets, as well as, ArcGIS shape files and ArcInfo GIS coverage files that can be used for geographic analysis. The workbook datasheets include the base, roadway, unimproved pavement condition, improved pavement condition, safety, pavement treatment scoping, mobility, unimproved bridge condition, and improved bridge condition.

The mobility and roadway datasheets contain projected traffic volume data relevant to pavement performance modeling. Both datasheets identify pavement segments using sequence numbers, traffic segment identification numbers, and from-and-to reference points. Other relevant fields include highway number by direction, projected 2-way AADT, and percent trucks for 1, 5, 10, 15, and 20-year periods from a base year.

### Task 3. Database System Development.

The objective of Task 3 is the development of a database system including several elements, such as the overall purpose of the system, data types and formats to be collected and managed, software and hardware requirements, as well as institutional issues involved in the implementation and use of the system. Task 3 is 50% complete.

During the previous quarter, the research team obtained GIS Base Maps of WisDOT's original 8 districts. These base maps were capable of illustrating the Wisconsin highway network by user-defined fields, such as HMA or PCC pavement, or by type of pavement (i.e., HMA Type 1 over PCC, Type 3 over HMA/CABC, etc.). A GIS ties information to location; it allows specific attributes regarding the location to be retrieved and visualized on a dynamic map. In addition, it allows basic statistics and charts to be created from specific queries about the data for presentation purposes, and can display photos of the location of interest. To enable the data categories to operate in a GIS, separate simple tables or flat files for elements or attributes in each category will be developed and related to a dynamic map that shows the network of pavements in Wisconsin.

During this quarter, the ability to use flexible pavement databases for performance modeling was investigated. The following sections describe the results of the investigation.

#### **4.1 General Observations about Flexible Pavement Databases for Performance Modeling**

Integration of information from disparate databases for performance modeling requires that semantic discrepancies within and between databases be identified and alleviated. In addition, key fields must be identified within and across the databases to enable simple or complex queries to be performed in order to relate data residing in the different databases.

The semantic discrepancies between the databases are summarized in Table 4.1 and include the use of different field names or labels that represent the same information, inconsistent formats for data entry, and redundant fields for some databases.

Roadway segment identification varies from database to database. While the performance and Meta-manager databases use sequence numbers and reference points to identify segments, the construction and design databases use descriptive words to define the start and end points of whole projects, which in most cases may include multiple segments or sequence numbers. The design and construction databases lack consistency in project identification based on format for entering identification numbers. "Proj#" and "contract1" are identical in format but not "contract2". One format is necessary to relate the two databases. This would require a redundant identification field (either contract1 or contract2) in the design database to be removed to save valuable computer space and time for data entry.

Fields designated to help identify highways have varying interpretations. In the construction database, two fields are required to completely identify a highway without an associated direction. The design database identifies highways in a variety of ways including, specifying the highway with or without direction (e.g. 090E, 90). In both cases, an exclusive field is also provided to indicate direction (e.g. N). While meta-manager uses a single field to completely identify a highway by number and direction, the performance database uses two fields (one for the highway number and the other exclusively for direction). From efficiency and time-saving considerations, it may be appropriate to identify a highway using the Meta-Manager format, which uses one field for both highway number and direction.

There is no clear distinction between ESAL and mix type as they pertain to the construction and design databases. ESAL is considered a specific value (e.g. 6 million) for design but sometimes considered as a category (e.g. E-10) representing a type of mix. Mix types have also been specified alongside NMAS (e.g. SPPV-19.0). From performance modeling point of view, the NMAS value may be required. Hence, it is appropriate to have separate fields to denote mix type and NMAS values to facilitate data retrieval for performance analysis.

Formats for entering time events e.g. pavement surface year tend to vary between the construction database and the other databases. While the construction database uses two digits to indicate a particular surface year, the performance and design database use four digits (e.g. 07 versus 2007)

One method of integrating the as-built construction data is to use the existing lot and subplot system by overlaying the measured lot or subplot property(s) across the established RP within the project limits. This approach would require translating tonnage and station referencing to the RP referencing. The feasibility of this approach will continue to be investigated in the next quarter using actual construction data.

**TABLE 4.1 Database Discrepancies**

Database (1)	Field name/label (2)	Intended meaning (3)	Comments (4)
Construction	Proj #	Project identification number	Proj # is an 8-digit number of the form YYYY-YY-YY
Design	Contract1 Contract2	Project identification number	Contract1 is an 8-digit number of the form YYYY-YY-YY; Contract2 is same as Contract1 without the dashes (i.e. YYYYYYYY)
Performance	Sequence No.	Identification number to locate field measurement sample segments	A unique number or field for relating all PIF components
Meta-Manager	ISEQNO	PIF segment ID number	
Construction	START	Project beginning point e.g. USH 61	
	END	Project end point e.g. East Co. Line	
Design	Gen_loc	Project termini	Project termini specifies beginning and ending points e.g. Siren-CTH D
	RP	Starting point for Iri and rut measurements e.g. 323T 1.2?	
Performance	From RP From Plus	Identification of segment start location based on a beginning reference point (BRP) plus some distance from the BRP	
	To RP To Plus	Identification of segment end location based on an ending reference point (ERP) plus some distance from the ERP	
	From Feature	Feature denoting beginning of segment over which measurement is to be taken e.g. Catlin Ave Intersection	

**TABLE 4.1 Database Discrepancies (cont.)**

Database (1)	Field name/label (2)	Intended meaning (3)	Comments (4)
Meta-Manager	PDP FRM	From RP	
	PDP TO	To RP	
Construction	HWY	Highway type e.g. STH, CTH, USH	A separate field,#, is used to denote the number or letter label associated with the highway e.g. 41 or K.
Design	HWY	Highway by direction e.g. 090E or just the highway number e.g. 90 without direction.	There is an additional field for direction (Dir), even though the HWY field has direction associated with the highway (e.g. as in 090E) for all years except 2002. Note also that the <i>AC Office</i> HWY designation field uses 2-digits (e.g. 43) compared to 3-digits (043) as in the <i>AC Field</i> HWY designation field
Performance	HWY No	Highway number without direction	A separate field exists for highway direction (Dir)
Meta-manager	HWY&DIR	Highway and direction	
Construction	Type	Mix type	This field has records with HV, MV, and LV with various designations e.g.MV-2, MV-2R. In addition, superpave mixes are labeled with their corresponding NMAS in the same field e.g. SPPV-19.0.
Design	HvMvLv	Mix type	Field label seems to suggest that only HV, MV, LV mixes are applicable but some records for the field has SMA, E-0.3 and higher mix types, as well as “warranty” labels.
Construction	ESAL	ESAL level category	Designated as E0.3, E1 or higher
Design	ESALS	Design Equivalent 18-kip single axle load value	Indicated as a specific number
Construction	YR	Pavement surface year	Year is represented as the last 2-digits of the year e.g. 04 for 2004
Design	Pvmnty	Pavement surface year	Year is represented as 4-digits e.g. 2004
Performance	Surf Year	Pavement surface year	Year is represented as 4-digits e.g. 2004

Table 4.2 shows the four main databases with component files or datasheets and corresponding key fields that are used to relate the component files. Table 4.3 on the other hand, shows the databases and potential key fields that can be used to relate the databases. The “sequence number” key field is common for the performance and meta-manager databases in relating their component files, while the construction and design databases have significantly different key fields as indicated in Table 4.2. The project identification number in the construction database may be a better key field than the “Test#” field for relating component files in the construction database. This is only possible if the identification number field can be included in the “data 1997-2004.xls” file. Table 4.3 suggests that the construction database in its present form can neither be directly related to the meta-manager nor the performance databases. This calls for a framework to be developed to integrate all databases to facilitate the performance modeling process.

**TABLE 4.2 Key Fields for Relating Database Component Files**

Database (1)	Component files/datasheets relevant to performance (2)	Key field for relating component files/datasheets (3)
Construction	GeneralLogs 1997-2004.xls data 1997-2004.xls	Test #
Design	AC Office, AC Field	Contract2
Performance	DESC, IRI , PDI_F	Sequence number
Meta-manager	Base, Roadway, Pave_Uimp, Pave_imp, Safety, Pave_Scope, Mobility, Bridge_Uimp, Bridge_imp	Sequence number

**TABLE 4.3 Potential Key Fields for Relating Databases**

Database	Construction	Design	Performance	Meta-manager
Construction	-	Contract1		
Design	Contract1	-	Sequence No	
Performance		Sequence No	-	Sequence No, From RP-To RP
Meta-manager		Sequence No	Sequence No, From RP-To RP	-

#### 4.2 Framework for Database Integration for Performance Modeling

The following are key elements that are being researched for database integration:

- a. GIS role in performance modeling
- b. Have at least construction projects termini, as well as the start of all test lots/section defined using the reference point system. In addition, test lot/sublot section length must be defined from the start reference point. Having the start of test lots/sublots sections defined may provide a basis to align performance and construction data.
- c. An alternative approach may consist of converting the reference point system to a coordinate-based system and using a GPS unit to measure construction field test measurement locations, which in turn can be more accurately related to corresponding desired performance indicators. Statistical issues associated with this approach will be researched.

##### Task 4. Numerical Modeling and Statistical Analysis

The objective of Task 4 is to develop an analysis template for aligning design and construction datasets with the pavement performance indicator datasets, and demonstrating methodologies for analyzing the data. No work was performed on Task 4 this quarter.

##### Task 5. Final Report.

The objective of Task 5 is to submit a final report documenting all findings in the project. No work was performed on Task 5 this quarter.

#### **Work Next Quarter:**

##### Task 1. Literature review

The literature review is 100% complete.

##### Task 2. Survey and Review of Pavement Management Systems

The survey and review of PMS in Task 2 is 100% complete.

Task 3. Database System Development.

Research will continue and build from the findings presented earlier in this report. It is planned that work on Task 3 will be completed this quarter, concurrent with the start of work in Task 4.

Task 4. Numerical Modeling and Statistical Analysis

Work on Task 4 is planned to begin during the next quarter after Task 3 is nearly complete.

Task 5. Final Report.

No work is planned on Task 5 during the next quarter.

**Circumstances affecting progress/budget:**

None.

**Gantt Chart:**

Project Progress Chart  
 MRUTC Project 0092-06-13

Updated: June 30, 2007  
 Database Development of an HMA  
 Pavement Performance Analysis System

Task	Description	Qtr 1			Qtr 2			Qtr 3			Qtr 4			Qtr 5			Percent Complete
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov			
1	Literature Review	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	100
2	PMS Review	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	100
3	System Development																50
4	Statistical Modeling																0
5	Final Report																0
Proposed		█															60
Actual		█															