

# User's Guide

## Pavement Marking Management System Database

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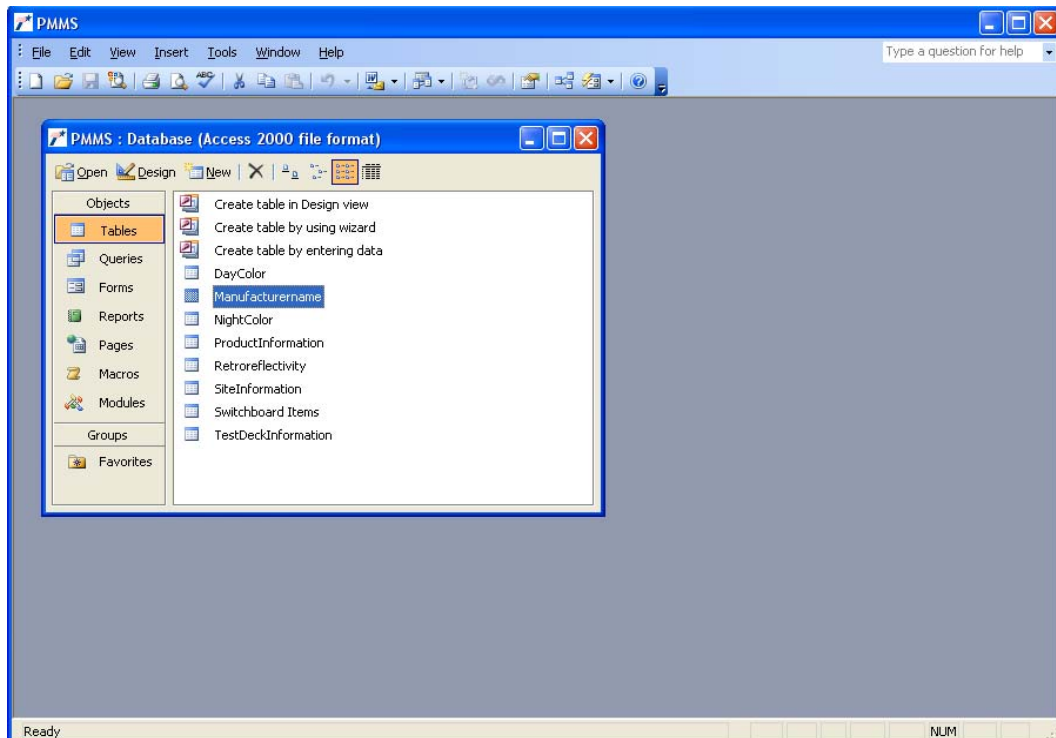
# 1 INTRODUCTION

Pavement markings play a critical role in maintaining a safe and efficient driving environment for road users, especially during nighttime conditions. The Texas Department of Transportation (TxDOT) spends millions of dollars each year for installation and maintenance of pavement markings. In order to ensure that pavement markings remain effective, the highway agencies maintain them regularly by replacing the old markings. Therefore, selecting proper pavement marking materials (PMMs) that can maintain an acceptable level of functional performance over a longer period of time can lead to significant cost savings while maintaining safety. Thus, there is a need to evaluate the current performance specifications used by TxDOT and other users and to develop improved performance specifications reflecting the performance capabilities of existing materials.

The overall objective of the TxDOT research project 0-5548 “Development of Field Performance Tools and Program for Pavement Marking Materials” was to develop a field performance evaluation program and to identify effective field evaluation methods and tools to improve the performance of PMMs. Advantages and disadvantages of different evaluation procedures were studied to design an effective program for evaluating and testing PMMs based on different external conditions, specifications, material selection criteria, and performance measures. As part of this project, field test decks were installed and data were collected. As a component of the project, a tracking database is developed. This document provides instructions and guidance to users of this tracking database.

## 1.1 OVERVIEW OF PMMS DATABASE

Pavement Marking Management System (PMMS) database was developed to incorporate the parameters that are critical to the test deck evaluation, with functions to enter the data and view the existing information pertaining to performance of the markings. PMMS is a program designed to store, manage, and manipulate data for monitoring the performance of pavement markings. This program is based on Microsoft Access® 2003, which is easy to use, and little training is required to operate the application. Access is comprised of different database components called objects, which are tables, queries, forms, reports, macros, and modules appearing on the left side of the database window as shown in [Figure 1](#).



**Figure 1. Database Objects.**

## **1.2 SYSTEM REQUIREMENTS**

### **1.2.1 Central Processing Unit (CPU)**

Office 2003 requires a computer Pentium processor with a clock speed of at least 233 megahertz (MHz). Microsoft recommends a computer with a Pentium III or faster processor.

### **1.2.2 Memory**

Microsoft recommends that your computer have a minimum of 128 MB of RAM. An additional 8 MB of RAM are required for each Office 2003 program that runs at the same time.

### **1.2.3 Available Hard Disk Space**

Office 2003 requires 400 MB of available hard-disk space. Hard disk requirements vary, depending on your configuration. Custom installation choices may require more or less hard disk space.

#### **1.2.4 Client Operating Systems**

Windows 2003

Windows XP

Windows Vista

Windows 7

#### **1.2.5 Supported Software**

Windows Office, Access 2003

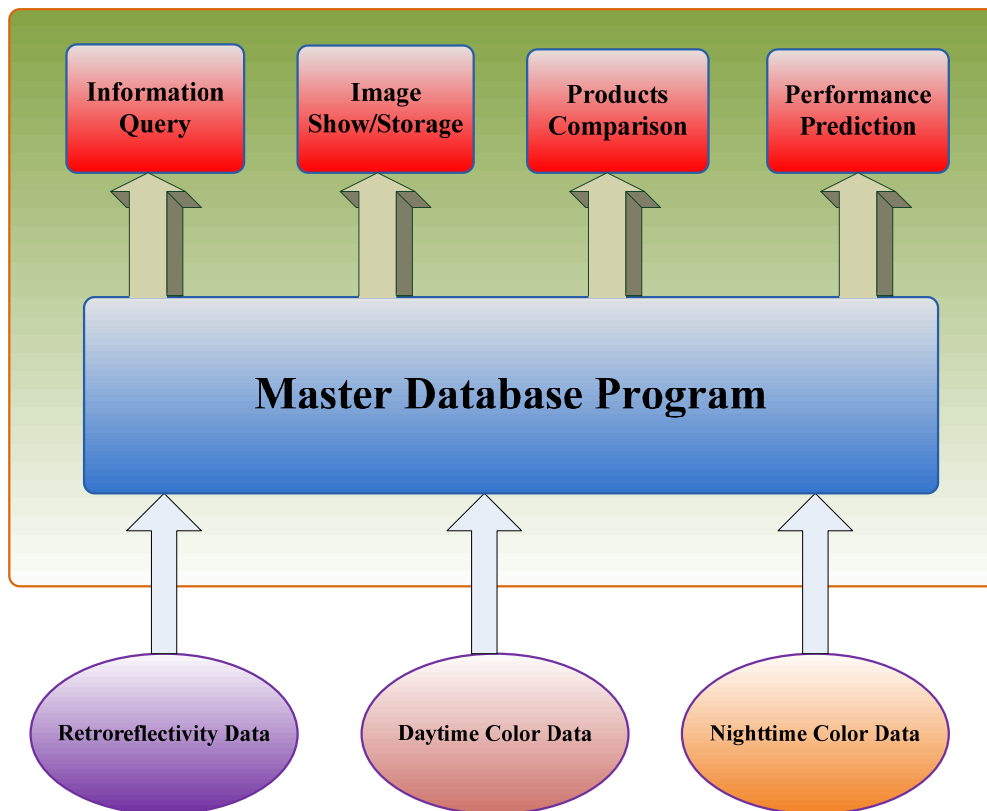
Windows Office, Access 2007

Windows Office, Access 2010



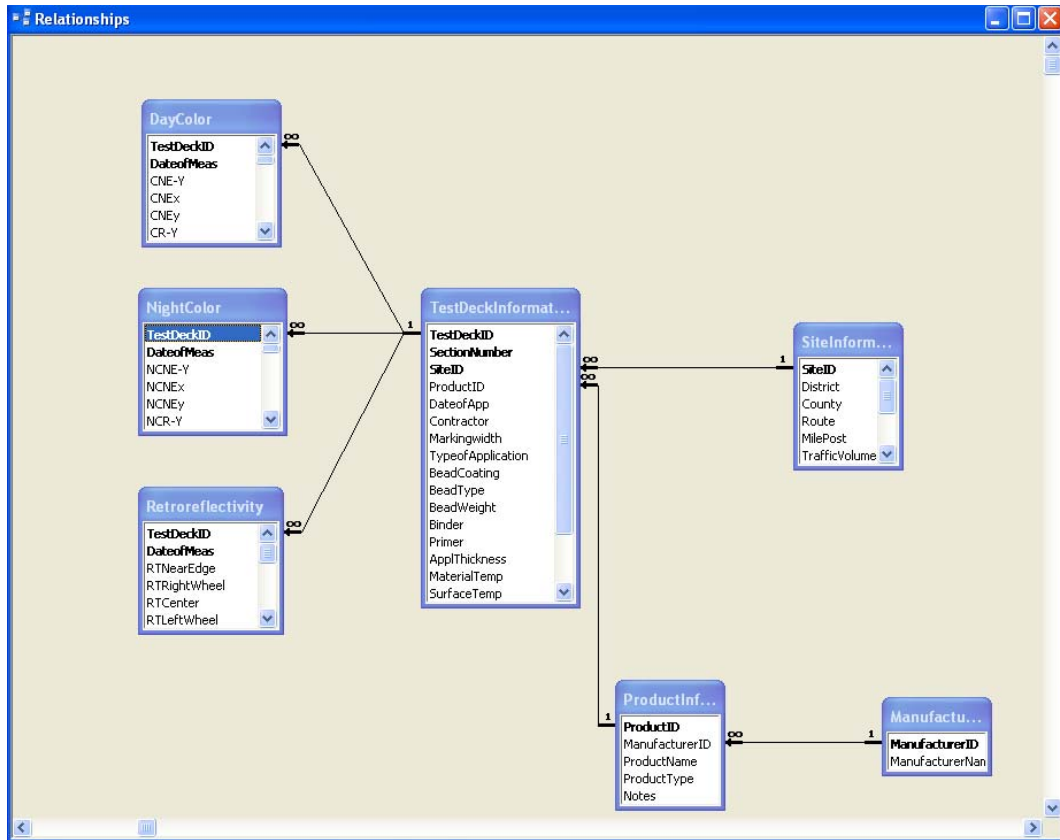
## 2 STRUCTURE OF THE DATABASE

The database includes the information of the pavement marking in three test deck locations, which are Bryan, Beaumont, and Lubbock. Different Products from different manufacturers are included. The structure of the database is shown in Figure 2. Input data to the database include: retroreflectivity, daytime color, and nighttime color. Main database functions include information query, image show/storage, products comparison, and performance prediction.



**Figure 2. Structure of the Database.**

Figure 3 illustrates the design of the database, and the type of relationship between various tables is one-to-many. This design is based on the version developed for performance monitoring on test decks. The Manufacturer Information table has a one-to-many relationship with the Product Information table indicating that one manufacturer has multiple products that are tested. Also, each product could be installed at several test deck locations leading to a one-to-many relationship between the Product Information table and Test Deck Information table. Each site can have several test decks, thereby leading to a one-to-many relationship between the Site Information Table and Test Deck Information table. Finally, each test deck has three sets of readings (retroreflectivity, day color, and night color) that are collected leading to a one-to-many relationship between the tables Test Deck Information and Retroreflectivity, Night Color, and Day Color.



**Figure 3. Relationships Illustrating the Basic Design of the Application.**

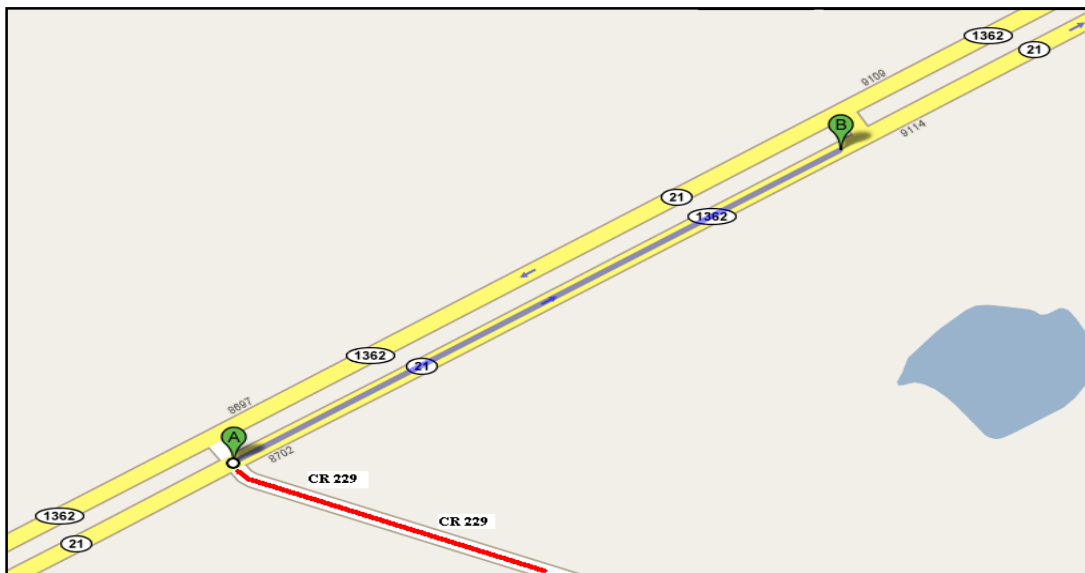
## 3 DATA SOURCE AND FORMATS

### 3.1 PMMS TEST DECKS

Three test decks were installed in Bryan, Beaumont, and Lubbock. Pavement marking products from multiple vendors were installed on those decks. Since the objective of this project is not product evaluation for TxDOT, some of the vendor products might not be formulated according to TxDOT specifications.

#### 3.1.1 Bryan

The test deck is located between Bryan and Caldwell on State Highway 21 with an Average Daily Traffic (ADT) of 11,000 between County Road 229 and the next turnaround lane heading eastbound as shown in [Figure 4](#).

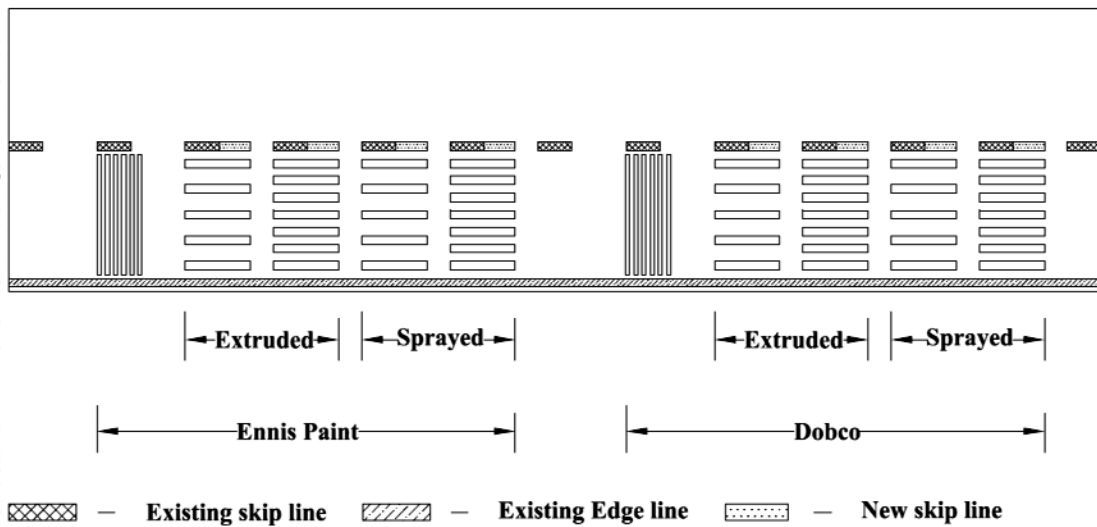


**Figure 4. Test Deck on State Highway 21.**

This location has a new seal coat pavement with newly applied markings. Unlike the usual design, a different deck configuration is designed at this site in order to compare the performance with the newly applied skip lines with the existing skip line(s) and edge line(s). [Figure 5](#) illustrates the test deck configuration at this location, with additional skip lines installed running adjacent to existing skip lines. It has eight sections; the first four sections are striped with Ennis paint thermoplastic and the rest with Dobco thermoplastic. The test deck also consists of a feature used to compare the spray and extruded types of application methods as both application methods are used for each of the products installed. The data collection on retroreflectivity and color at this deck will be conducted on the following types of lines:

- Transverse lines (applied by handcart, extruded).
- Longitudinal lines in the travel lane applied via spraying and extruding.

- Skip lines applied via spraying and extruding.
- Existing edge line(s) and skip line(s).



**Figure 5. Unique Bryan Test Deck Configuration.**

The Bryan test deck was installed on September 9, 2008, with eight sections. A contractor was hired for the installation of all the products. The quality of installation was supervised by a team of researchers and an associate from Ennis paint. [Table 1](#) gives an overview of the products installed, with the information of color, type, and manufacturer.

**Table 1. Bryan Test Deck Information.**

Section No.	Product	Color	Type	Manufacturer
1	Thermoplastic (extruded)	White	Thermoplastic	Ennis
2	Thermoplastic (sprayed)	White	Thermoplastic	Ennis
3	Thermoplastic (extruded)	White	Thermoplastic	Ennis
4	Thermoplastic (sprayed)	White	Thermoplastic	Ennis
5	Thermoplastic (extruded)	White	Thermoplastic	Dobco
6	Thermoplastic (sprayed)	White	Thermoplastic	Dobco
7	Thermoplastic (extruded)	White	Thermoplastic	Dobco
8	Thermoplastic (sprayed)	White	Thermoplastic	Dobco



### 3.1.2 Beaumont

The test deck is on a concrete pavement in the city of Beaumont, Texas. The test deck is located on FM 364 between US 90 and I-10 with an ADT of 13,000 as shown in Figure 6 (marked in a red oval). Figure 7 shows a close-up of the stretch specifically on FM 364 between Walden Road and I-10.

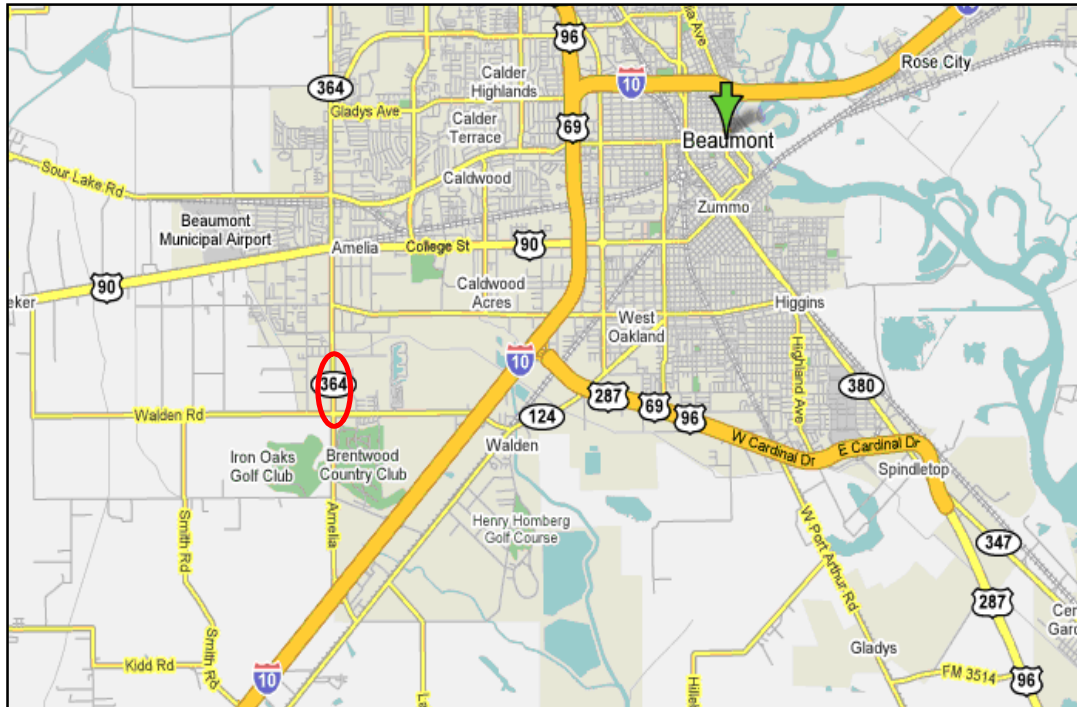


Figure 6. Test Deck Location - Beaumont, Texas.

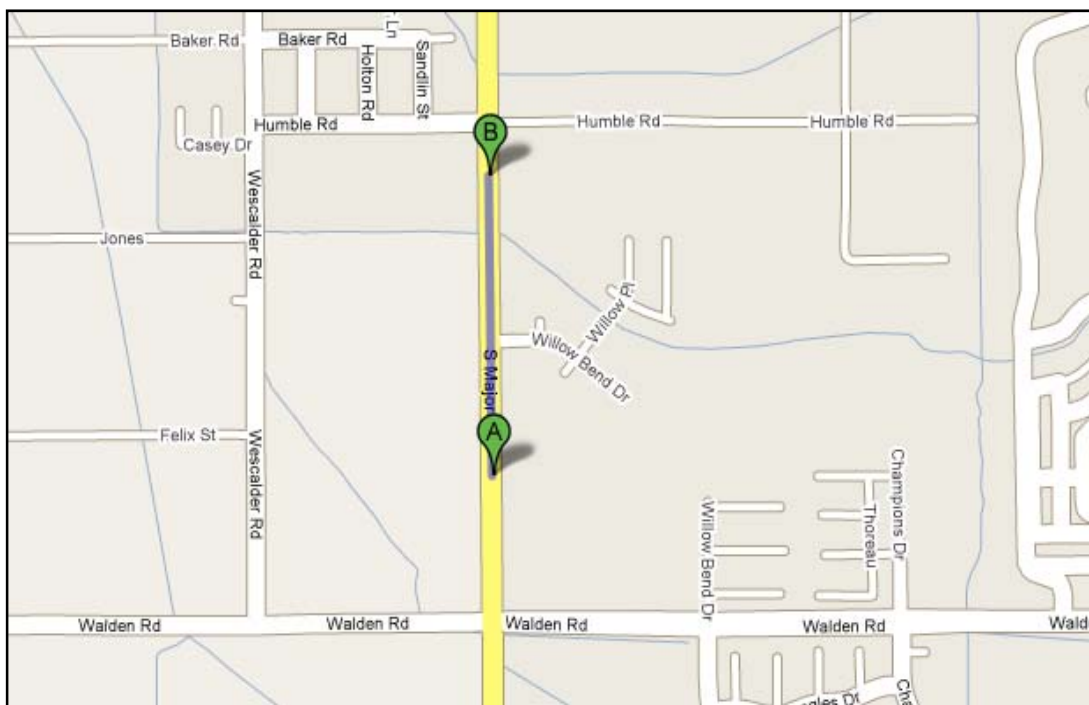


Figure 7. Test Deck Stretch between US 90 and I-10.

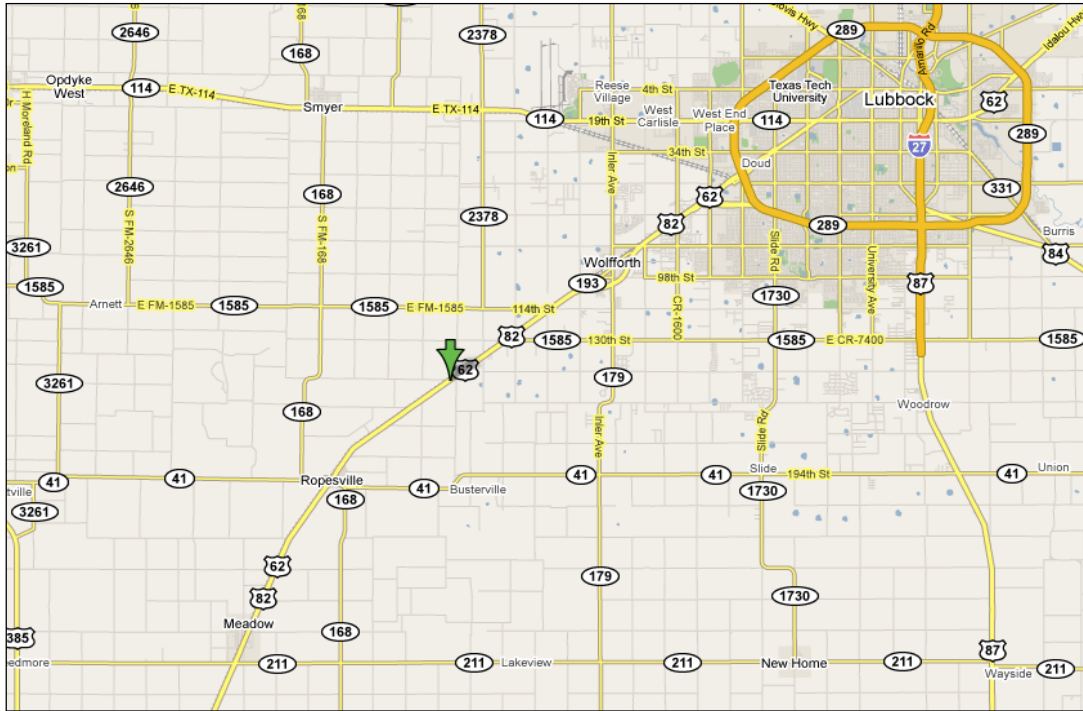
The Beaumont test deck was installed on May 8, 2008, with 10 sections. The installation was carried out by the vendors using their respective products at all the sections. [Table 2](#) gives an overview of the products installed, with the information of name, color, type, and the manufacturer.

**Table 2. Beaumont Test Deck Information.**

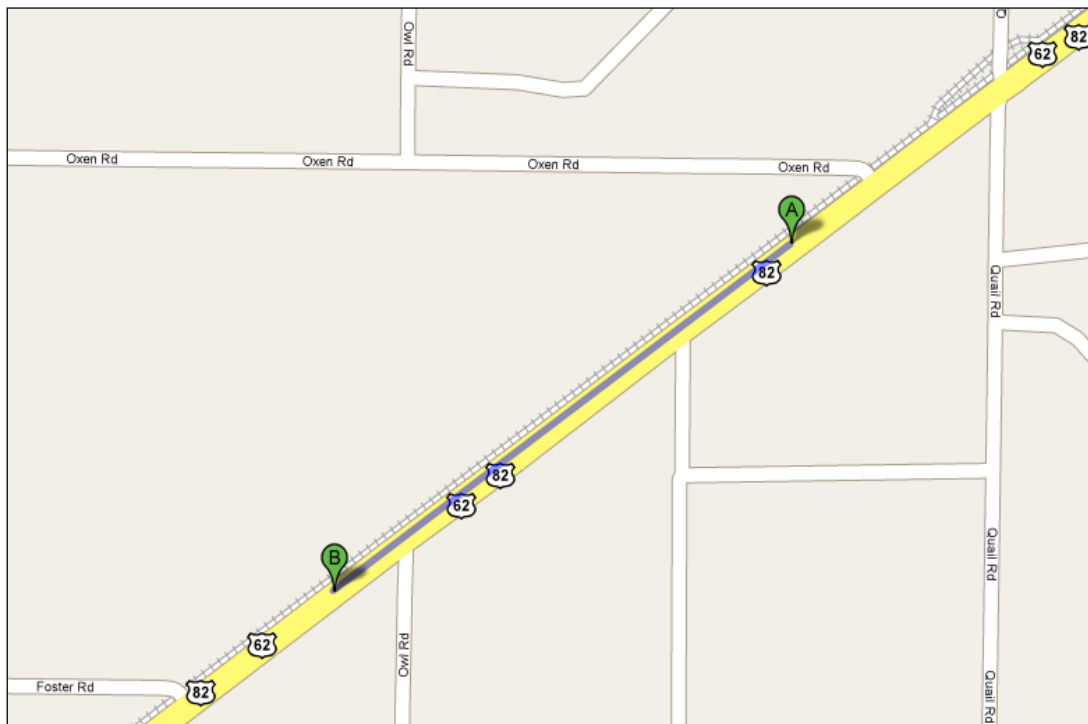
<b>Section No.</b>	<b>Product</b>	<b>Color</b>	<b>Type</b>	<b>Manufacturer</b>
7	Premark Preformed Tape	White	Tape	Flint
8	ATM 300 Tape	White	Tape	ATM
9	Methyl Methacrylate	White	Methyl Methacrylate	Ennis
10	HPS-4 Modified Polyurethane	White	Polyurethane	Ennis
11	HPS-4 Modified Polyurethane	White	Polyurethane	Ennis
12	HPS-5 Polyurea	White	Polyurea	Ennis
13	HPS-5 Polyurea	White	Polyurea	Ennis
14	Methyl Methacrylate	White	Methyl Methacrylate	Ennis
15	Thermoplastic contrast marking	White thermo on black thermo	Thermoplastic	Ennis
16	Thermoplastic	White	Thermoplastic	Ennis

### 3.1.3 Lubbock

The test deck is on asphalt pavement near the city of Lubbock, Texas. It is located on US 62/82 in Hockley County ([Figure 8](#)) with an ADT of 9,000, starting 1000 ft southwest of Oxen Road to the southwest for a distance of 1 mile (southbound outside lane) as shown in [Figure 9](#).



**Figure 8. Test Deck Location - Lubbock, Texas.**



**Figure 9. Test Deck on US 62/82, Hockley County.**

The Lubbock test deck was installed on May 20, 2008, with 15 sections. The sections were installed with Poly-Carb products by vendors except for the first six sections for which a contractor was hired. [Table 3](#) gives an overview of the products installed, with the information of name, color, type, and manufacturer.

**Table 3. Lubbock Test Deck Information.**

<b>Section No.</b>	<b>Product</b>	<b>Color</b>	<b>Type</b>	<b>Manufacturer</b>
1	MARK 55.5	White	Epoxy	Poly-Carb
2	MARK 55.5	Yellow	Epoxy	Poly-Carb
3	MARK 65.5	White	Epoxy	Poly-Carb
4	MARK 65.5	Yellow	Epoxy	Poly-Carb
5	MARK 70.3	White	Epoxy	Poly-Carb
6	MARK 70.3	Yellow	Epoxy	Poly-Carb
7	R&H HD 21 High Build Paint	White	Paint	Ennis
8	R&H HD 21 High Build Paint	White	Paint	Ennis
9	R&H HD 21 High Build Paint	White	Paint	Ennis
10	R&H HD 21 High Build Paint	White	Paint	Ennis
11	Waterbase DURA SHEEN SEMI-Gloss Waterborne Paint	Yellow	Paint	Ennis
12	Waterbase Paint EP series	Yellow	Paint	Ennis
13	Flametape	White	Tape	Ennis
14	Flametape alternate	White	Tape	Ennis
15	Premark Preformed Tape	White	Tape	Flint

### 3.2 REAL-WORLD DATA

In addition to the tracking database for data from the test decks, a real-world database is also developed. This database can track PMM performance of real-world projects. The database is populated with data collected by TxDOT districts with mobile retroreflectometer.

The real world data in the database were collected every six months in Swisher and Hale County of the Lubbock District for two years. There is only one product called Polyurea applied in both white lines and yellow lines. In Hale County, for the white lines, Polyurea is applied for the right edge line(s) and the skip lines in SB I-27; meanwhile, as for the yellow lines, Polyurea is applied for the left edge line(s) in SB I-27. The data in Hale are collected on I-27 from milepost 21 to 58.

Similarly, in Swisher County, white lines are applied for the right edge line(s) and the skip lines in NB and SB I-27, and yellow lines are applied for the left edge line(s) on NB and SB I-27. The data in Swisher are collected for one year from milepost 59 to 90.

### 3.3 DATA FORMATS

Data entry is made easy by adopting Table Datasheet view, which looks like a Microsoft Excel® spreadsheet. The data entering into the tables are arranged in columns technically called ‘fields’ based on different data types. Table 4 shows different data types. The information from the test deck data, site data, retroreflectivity data, product data, and manufacturer data are shown in Tables 5 through 9, respectively.

**Table 4. Data Types.**

<b>Text</b>	(Default) Text or text and number combinations, as well as numbers that do not require calculations, such as zip codes (up to 255 characters).
<b>Memo</b>	Text or text and number combinations that are lengthy (up to 65,535 characters).
<b>Number</b>	Numeric data that can be used in mathematical calculations.
<b>Date/Time</b>	Date and time values.
<b>Currency</b>	Numeric data used in mathematical calculations shown as dollars.
<b>AutoNumber</b>	A unique sequential number (incremented by 1) or random number that is assigned by Microsoft Access when a new record is added to a table.
<b>Yes/No</b>	A field containing one of two values (Yes/No, True/False, On/Off).
<b>OLE Object</b>	An object (such as a graphic, or a Microsoft Excel spreadsheet) that is linked to or embedded in a Microsoft Access table.
<b>Hyperlink</b>	Text or text and number combinations stored and used as a hyperlink address. A hyperlink can have up to four parts: <i>text to display</i> – the text that appears in a field or control <i>address</i> – the path to a file (UNC path) or page (URL) <i>subaddress</i> – a location within the file or page <i>screentip</i> – the text displayed as a tool tip <b>Note:</b> Select <b>Insert...Hyperlink</b> to insert a hyperlink address in a field or control
<b>Lookup Wizard</b>	Creates a field that allows you to choose a value from a list or another table by using a list box or a combo box.

**Table 5. Test Deck Data Information.**

<b>Field Name</b>	<b>Data Type</b>	<b>Description</b>
TestDeckID	AutoNumber	ID to track test deck data
SectionNumber	Number	Section Number
SiteID	Number	ID to track test site
ProductID	Number	ID to track products
DateofApp	Date/Time	Date and time of application
Contractor	Text	Contractors name
MarkingWidth	Text	Width of the pavement marking applied
TypeofApplication	Text	Methods of the application
BeadCoating	Text	Coating of the bead
BeadType	Text	Type of beads
BeadWeight	Text	Weight of the bead
Binder	Text	Type of binder
Primer	Text	Type of primer
ApplThickness	Text	Thickness of pavement marking
MaterialTemp	Text	Temperature of the material applied
SurfaceTemp	Text	Temperature of the road surface
WeatherCondition	Text	Weather condition while applying
Retroreflectivity	Number	Retroreflectivity ID
Day Color	Number	Day Color ID
Night Color	Number	Night Color ID

**Table 6. Site Data Information.**

<b>Field Name</b>	<b>Data Type</b>	<b>Description</b>
SiteID	AutoNumber	ID to track site information
District	Text	Name of the district
County	Text	Name of the county
Route	Text	Route number
MilePost	Text	Mile post
TrafficVolume	Text	Traffic volume
TruckPercentage	Text	Truck percentage
SurfaceType	Text	Pavement surface type
SpeedLimit	Number	Speed limit
PavementAge/Condition	Text	Pavement age and condition
Notes	Memo	Gives site data information

**Table 7. Retroreflectivity Data Information.**

<b>Field Name</b>	<b>Data Type</b>	<b>Description</b>
TestDeckID	AutoNumber	ID to track test deck data
DateofMeas	Date/Time	Date and time of measures
InspectionInterval	Number	Collection interval
RTNearEdge	Number	Retroreflectivity value of a point near edge line(s) on transverse line
RTRightWheel	Number	Retroreflectivity value of a point near right wheel on transverse line
RTCeneter	Number	Retroreflectivity value of a point at center on transverse line
RTLeftWheel	Number	Retroreflectivity value of a point near left wheel on transverse line
RTNearSkip	Number	Retroreflectivity value of a point near skip line on transverse line
RFiveLong1	Number	Retroreflectivity value of measure point 1 of five longitudinal lines
RFiveLong2	Number	Retroreflectivity value of measure point 2 of five longitudinal lines
RFiveLong3	Number	Retroreflectivity value of measure point 3 of five longitudinal lines
RFiveLong4	Number	Retroreflectivity value of measure point 4 of five longitudinal lines
RFiveLong5	Number	Retroreflectivity value of measure point 5 of five longitudinal lines
RSevenLong1	Number	Retroreflectivity value of measure point 1 of seven longitudinal lines
RSevenLong2	Number	Retroreflectivity value of measure point 2 of seven longitudinal lines
RSevenLong3	Number	Retroreflectivity value of measure point 3 of seven longitudinal lines
RSevenLong4	Number	Retroreflectivity value of measure point 4 of seven longitudinal lines
RSevenLong5	Number	Retroreflectivity value of measure point 5 of seven longitudinal lines
RSevenLong6	Number	Retroreflectivity value of measure point 6 of seven longitudinal lines
RSevenLong7	Number	Retroreflectivity value of measure point 7 of seven longitudinal lines
RFiveLongEdge	Number	Retroreflectivity value of edge line(s) near five longitudinal lines
RFiveLongSkip1	Number	Retroreflectivity value of skip line 1 near five longitudinal lines
RFiveLongSkip2	Number	Retroreflectivity value of skip line 2 near five longitudinal lines
RSevenLongEdge	Number	Retroreflectivity value of edge line(s) near seven longitudinal lines
RSevenLongSkip1	Number	Retroreflectivity value of skip line 1 near seven longitudinal lines
RSevenLongSkip2	Number	Retroreflectivity value of skip line 2 near seven longitudinal lines
ImageNameTR	Text	The name of real world image of transverse lines
ImageTR	OLE Object	The binary file of real world image of transverse lines
ImageName5L	Text	The name of real world image of five longitudinal lines
Image5L	OLE Object	The binary file of real world image of five longitudinal lines
ImageName7L	Text	The name of real world image of seven longitudinal lines
Image7L	OLE Object	The binary file of real world image of seven longitudinal lines

**Table 8. Product Data Information.**

<b>Field Name</b>	<b>Data Type</b>	<b>Description</b>
ProductID	AutoNumber	ID to Track product information
ManufacturerID	Number	ID to Track manufacturer information
ProductName	Text	Name of the Product
ProductType	Text	Type of Product
Notes	Memo	Gives product data information

**Table 9. Manufacturer Data Information.**

<b>Field Name</b>	<b>Data Type</b>	<b>Description</b>
ManufacturerID	AutoNumber	ID to Track manufacturer information
ManufacturerName	Text	Product Manufacturer's Name



## 4 IMPLEMENTATION AND USE OF DATABASE

This section describes how to input data with required format into the database. Files required by the Access database are also discussed. The steps to use all features of the database are documented.

### 4.1 DATABASE FILES

#### 4.1.1 Image File – To Store Pictures

Photos are taken on lines at test decks at the time of each data collection trip. These pictures are stored in the database and can be queried by location, product, time, etc.

The image files are named according to the following principles:

- The order of the file names follows the sequence of site, month, year, section no., and deck type.
- The site names are abbreviated as follows:
  - be** – Beaumont.
  - br** – Bryan.
  - lu** – Lubbock.
- The deck types are abbreviated as follows:
  - l5** – 5 longitude lines.
  - l7** – 7 longitude lines.
  - tr** – transverse lines.

Example: **be011012l5** – the picture of the 5 longitude lines at section 12 in Beaumont taken in January 2010.

#### 4.1.2 Mousehook.dll

Mousehook.dll is a library associated with Stephen Lebans hack for locking the mouse wheel in Access so that it does not scroll through records. This file is included in the delivered data.

#### 4.1.3 Favicon.ico

The Favicon.ico file is used for the background of Splash Screen. This file is included in the delivered data.

#### 4.1.4 PMMS\_photo v1.4.mdb

PMMS\_photo v1.4.mdb file, the master database program, used to store and manage the test deck data, is the Access database file. When double-clicked, the database will be launched.

#### 4.1.5 RealworldV1.1.mdb

RealworldV1.1.mdb file, the other master database program, used to store and manage the real-world data collected from I-27, is the Access database file. When double-clicked, the database will be launched.

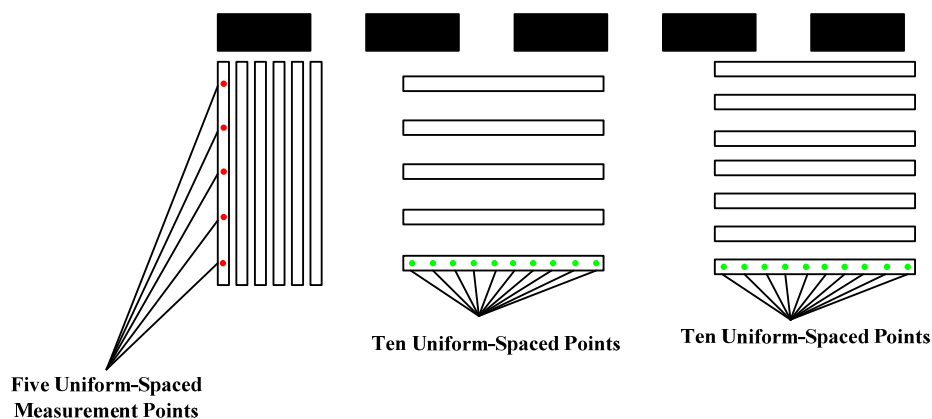
### 4.2 DATA STORAGE AND INPUT

#### 4.2.1 Data Measurements and Processing

Retroreflectivity data, night color data, and day color data are measured in the field. These data items, along with product information, vendor, site information, installation date, etc. are stored in tables for further processing, as explained below. The example collected retroreflectivity data for a section can be examined in the [appendix](#).

##### *Retroreflectivity Data*

Retroreflectivity data are measured using LTL-X (from DELTA), a handheld retroreflectometer based on 30 meter geometry. The retroreflectivity data, in the unit of  $\text{mcd/m}^2/\text{lux}$ , are measured in the field. For the 6 transverse lines, as shown in [Figure 10](#), there are 5 uniform-spaced measurement points on each line, which are near edge line(s) point, right wheel point, center point, left wheel point, and near skip line point. For the 5 longitudinal lines and 7 longitudinal lines, only one value is used for each line, which is the average value of 10 uniform-spaced points on each line. The readings are first recorded in a paper sheet and then enter into an Excel sheet and averaged if needed. A summary Excel file is then created for data input as described in [4.2.2](#).



## Figure 10. Definition of the Measurement Points.

### *Nighttime Color Data*

Nighttime color measurements are taken using LTL-Y. After entering the original data into Excel files, the average data can be easily obtained. Using Excel, the RGB data can be converted into RLXY data, which are then typed into a summary file.

### *Daytime Color Data*

Daytime color measurements are taken using the BYK color-guide. The process of obtaining the data is almost the same as the nighttime color data except for the converting process as the data coming from the BYK color-guide is already RLXY type data. In this case, the converting step can be bypassed, and the data can be directly typed into a summary file.

## 4.2.2 Data Input

The next step after data extraction is to transfer the data into our database system. The steps for data input are illustrated below.

The table “SiteInformation,” which has one-to-many relationship with other information and tables, is the primary way to input and update the data. After double-clicking the table SiteInformation, the information such as Site ID, District, County, Route, Mile Post, Traffic Volume, Truck Percentage, Surface Type, Speed Limit, Pavement Age/Condition, and Notes can be easily seen as shown in [Figure 11](#). There is a cross icon in front of each row used to expand the table “TestDeckInformation,” which includes entire information related to the test deck for each district before the item Site ID as shown in [Figure 12](#). The user can choose the cross icon corresponding to the district of which the user wants to input the data. Each district has three sets of readings (retroreflectivity, day color, and night color). In the same way, the user can click the cross icon before the item Test Deck ID to expand to one of the data tables (retroreflectivity, day color, and night color) and then input the data as shown in [Figure 13](#). Before clicking the cross icon in the table TestDeckInformation, the user can switch the data table by opening the subdatasheet and choosing the data table in which the user wants to input the corresponding data in Microsoft Access as shown in [Figure 14](#). It is an easy way to input the data by copying and pasting new data from the summary Excel file. For the real-world database, the way to input data is the same as the test deck database by opening the table SiteInformation and choosing the cross icon to further expand data tables for the input.

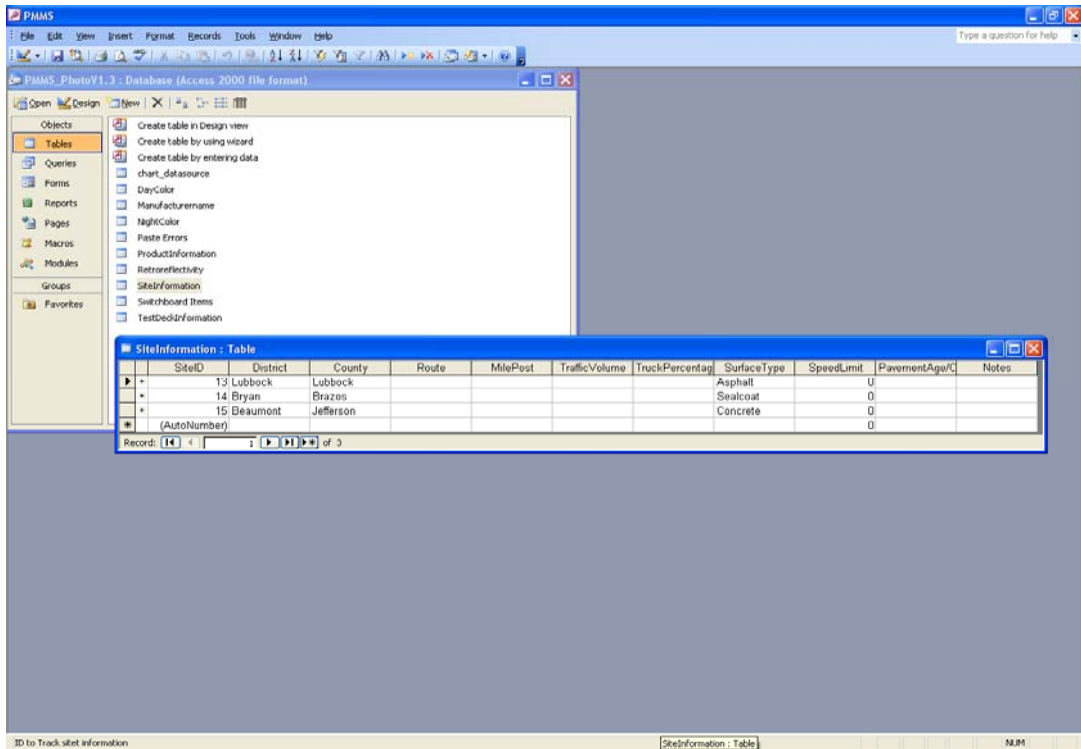


Figure 11. Table for the Input Data.

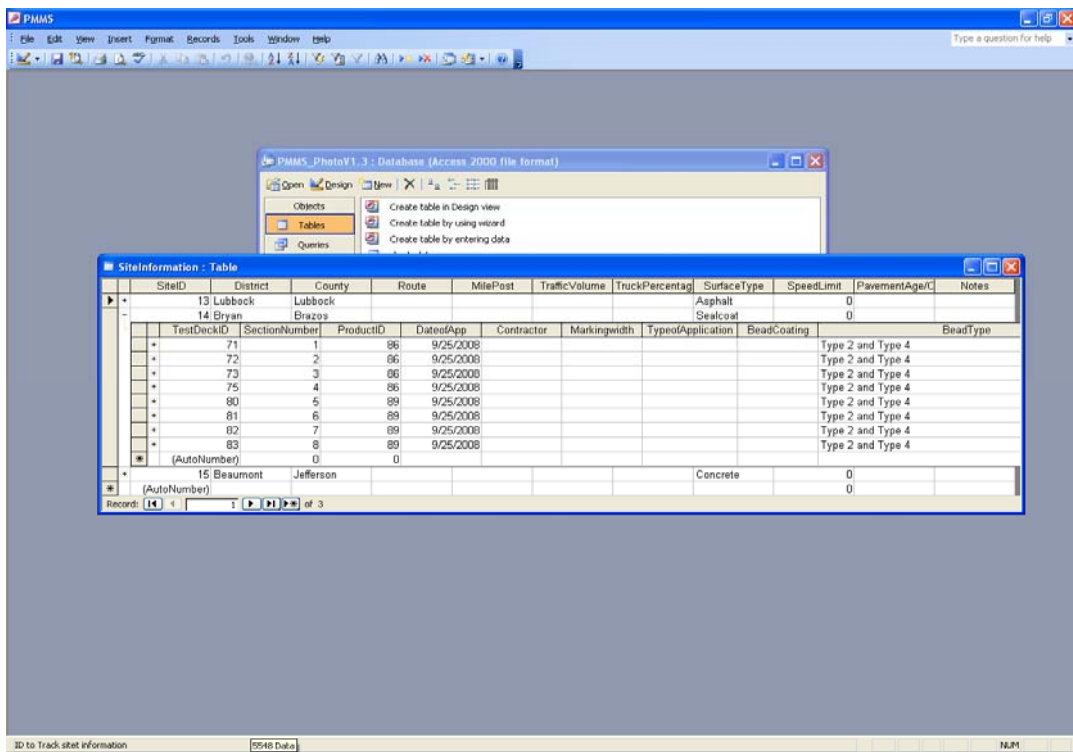


Figure 12. Expanded Table for the Input Data.

SiteInformation : Table

SiteID	District	County	Route	MilePost	TrafficVolume	TruckPercentage	SurfaceType	SpeedLimit	PavementAge/C	Notes	
13	Lubbock	Lubbock					Asphalt		0		
14	Bryan	Brazos					Sealcoat		0		
TestDeckID	SectionNumber	ProductID	DateofApp	Contractor	Markingwidth	TypesApplication	BeadCoating	BeadType			
71	1	06	9/25/2008					Type 2 and Type 4			
72	2	06	9/25/2008					Type 2 and Type 4			
DateofMeas	InspectionInterval	RTNearEdge	RTRightWheel	RTCenter	RTLeftWheel	RTNearSkip	RFireLong1	RFireLong2	RFireLong3	RFireLong4	RFireLong5
9/25/2008	1						180	472	462	451	485
1/7/2009	3						207	517	441	484	448
4/8/2009	6						208	533	402	475	422
7/2/2009	9						242	561	404	501	401
10/22/2009	12						267	596	352	491	373
1/22/2010	15						296	528	309	436	288
73	3	06	9/25/2008					Type 2 and Type 4			
75	4	06	9/25/2008					Type 2 and Type 4			
80	5	09	9/25/2008					Type 2 and Type 4			
81	6	09	9/25/2008					Type 2 and Type 4			
82	7	09	9/25/2008					Type 2 and Type 4			
83	8	09	9/25/2008					Type 2 and Type 4			
(AutoNumber)	0	0									
15	Beaumont	Jefferson					Concrete		0		
(AutoNumber)									0		

Record: 14 of 4

Figure 13. Expanded Further Table for the Input Data.

SiteInformation : Table

SiteID	District	County	Route	MilePost	TrafficVolume	TruckPercentage	SurfaceType	SpeedLimit	PavementAge/C	Notes
13	Lubbock	Lubbock							0	
14	Bryan	Brazos							0	
TestDeckID	SectionNumber	ProductID	DateofApp	Contractor	Markingwidth	TypesApplication	BeadCoating	BeadType		
71	1	06	9/25/2008					Type 2 and Type 4		
72	2	06	9/25/2008					Type 2 and Type 4		
73	3	06	9/25/2008					Type 2 and Type 4		
75	4	06	9/25/2008					Type 2 and Type 4		
80	5	09	9/25/2008					Type 2 and Type 4		
81	6	09	9/25/2008					Type 2 and Type 4		
82	7	09	9/25/2008					Type 2 and Type 4		
83	8	09	9/25/2008					Type 2 and Type 4		
(AutoNumber)	0	0								
15	Beaumont	Jefferson							0	
(AutoNumber)									0	

Record: 14 of 0

Insert Subdatasheet

Tables | Queries | Both

- chart\_datasource
- DayColor
- Manufacturername
- NightColor
- Paste Errors
- ProductInformation
- RecordsActivity
- SiteInformation
- Subdatasheet Items
- TestDeckInformation

Link Child Fields: TestDeckID

Link Master Fields: TestDeckID

Figure 14. Subdatasheet for Switching Data Table.

### 4.3 SPLASH SCREEN AND SWITCHBOARD

Splash Screen is a type of form that welcomes the users to the application and provides general information (Figure 15). A macro is enabled by clicking the close button leading to switchboard. Switchboard is another form that functions as a main menu for the users to start search, to acquire the prediction information, or to view charts for performance comparison (Figure 16).

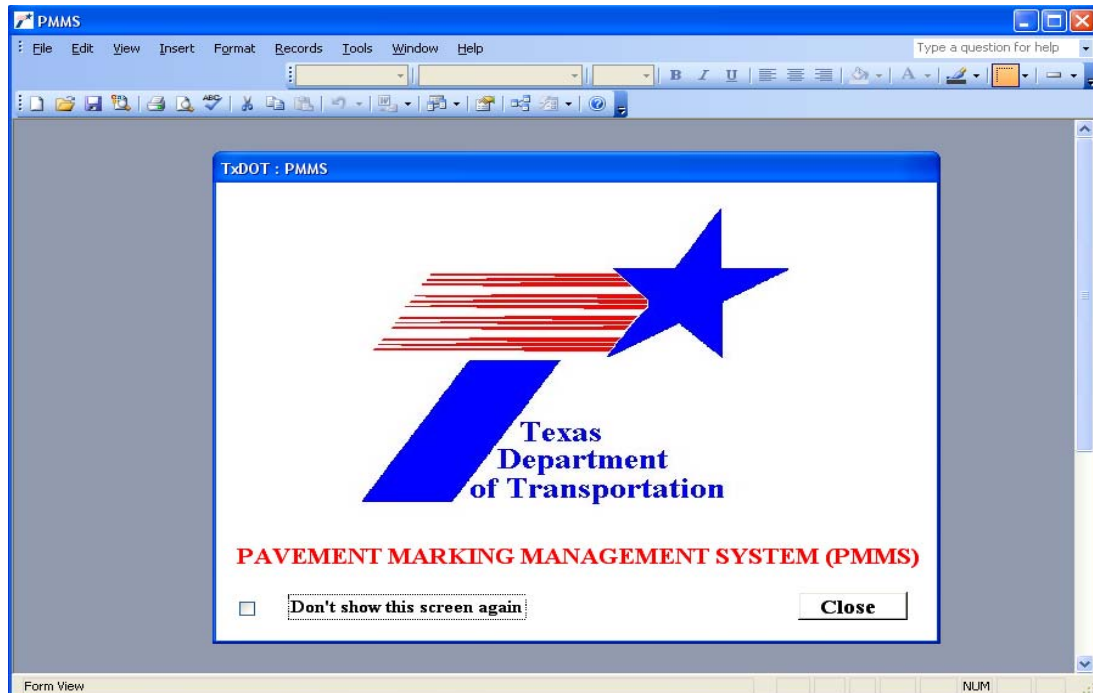


Figure 15. Splash Screen.

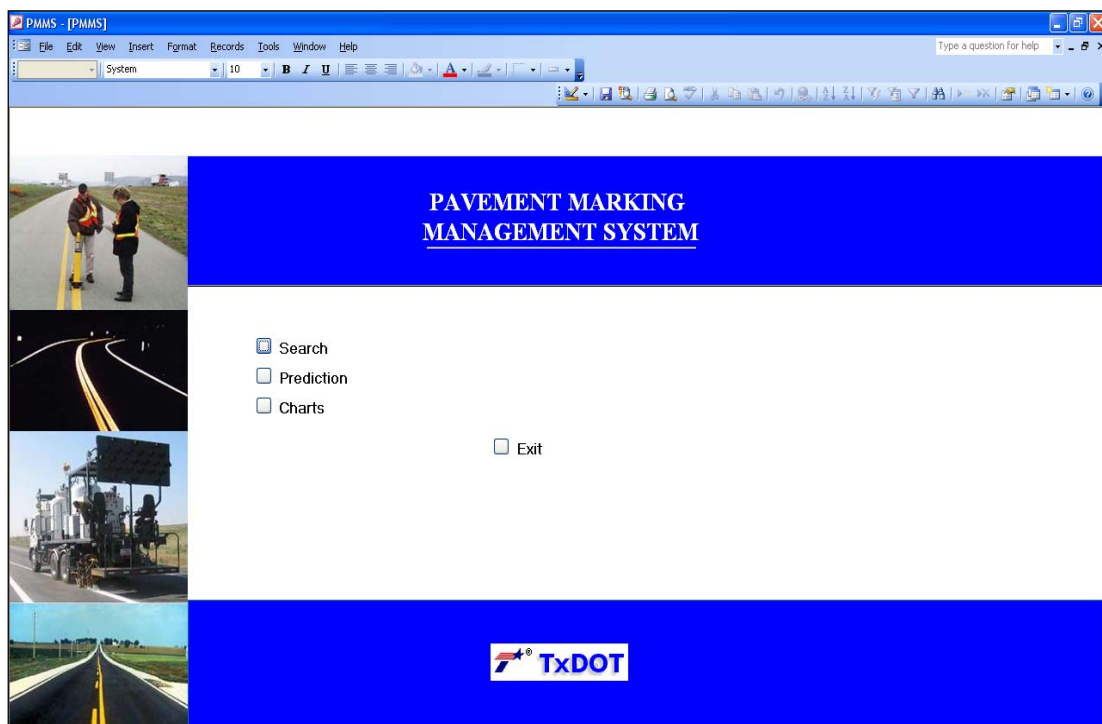
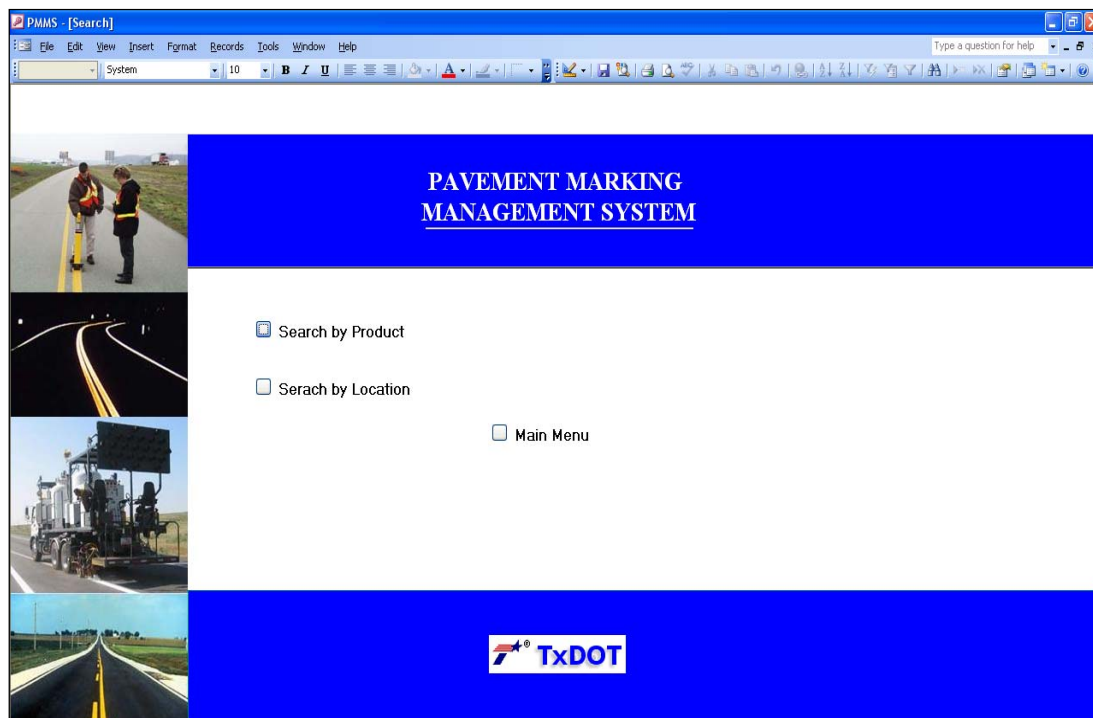


Figure 16. Switchboard.

## 4.4 SEARCH

This search selection on the main menu has two options, which are ‘Search by Product’ and ‘Search by Location’ as illustrated in [Figure 17](#). The user can choose between these options to examine the performance of a single product at multiple locations (by clicking Search by Product button) or multiple products at a single location (by clicking Search by Location button).



**Figure 17. Search Menu with Search by Product and Location Options.**

### 4.4.1 Search by Product

Users can check the performance of a single product at multiple locations in the search by the search product option. [Figure 18](#) and [Figure 19](#) show the screens of this search option. In [Figure 18](#), a set of drop-down combo boxes provides multiple options for users to view the data related to that particular product. These three boxes are a set of cascading combo boxes designed in a way that when a manufacturer is selected, the next combo box (which is Product) retrieves all the products installed from this selected manufacturer. Then the Date of Application combo box gets refreshed and displays only those dates on which that particular product is installed after selecting the above two combo boxes. Finally, on clicking the Search button located in the center of the product search window, test deck, site, measurement, and photo information of that product are displayed on a pop-up form as shown in [Figure 19](#). By clicking the Next or Previous button users can examine real photos of that particular product in different collecting times. To go back to the previous search window, simply close this interface by pressing the close symbol at the right upper corner in this screen.

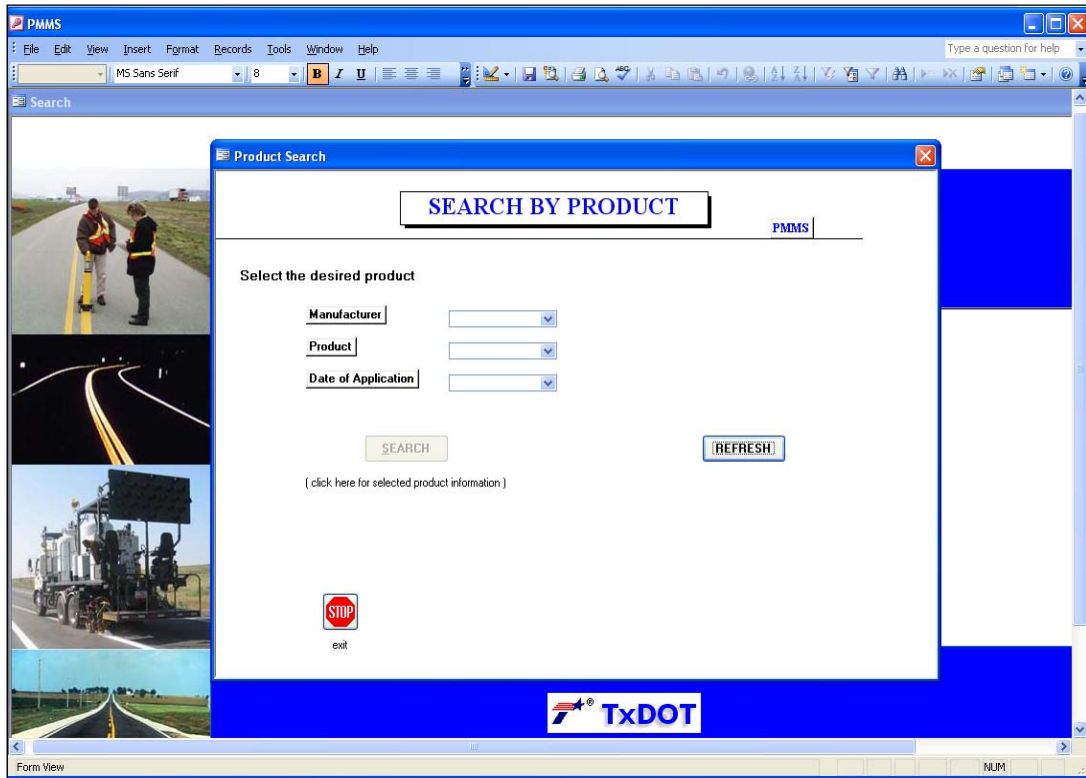


Figure 18. Search Form with Search by Product Drop-Down Combo Boxes.

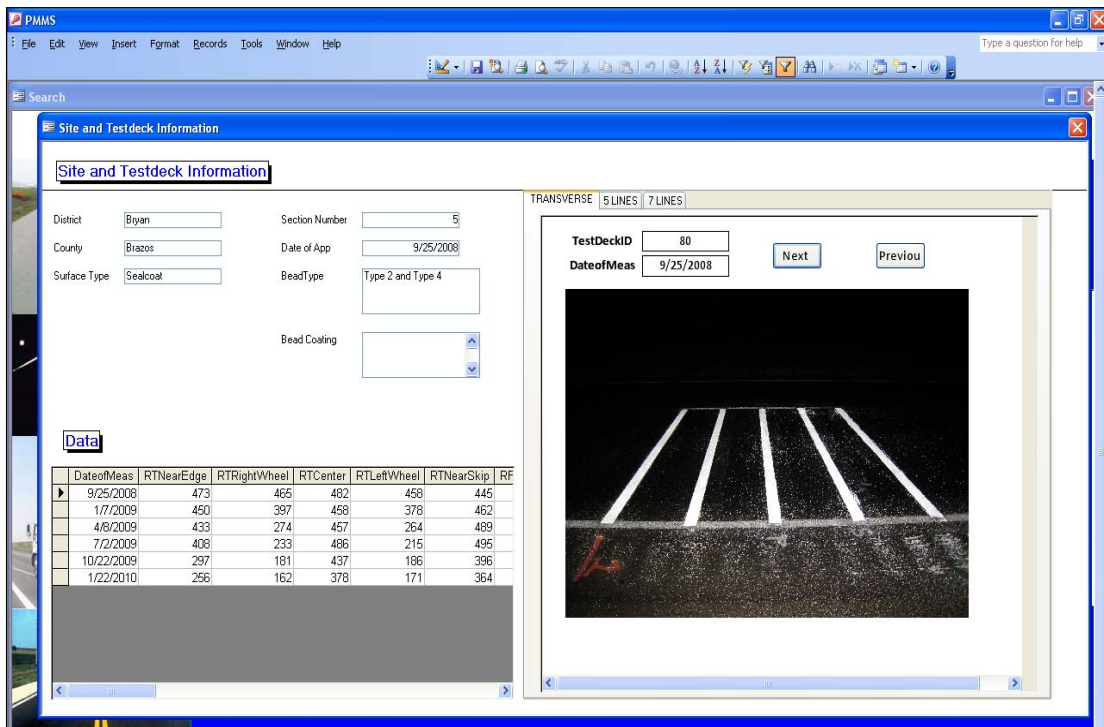


Figure 19. Final Pop-Up Form for a Selected Product.



#### 4.4.2 Search by Location

A similar form is designed for a search by location option, which returns a list of all the products installed at a certain location. A drop-down combo box provides options to select the desired district as shown in Figure 20. When the location is selected, the search button is enabled and after clicking the Search button, manufacturer, product, surface type and date of application information of that product are displayed on a pop-up form as shown in Figure 21.

**Figure 20. Search Form with Search by Location Drop-Down Combo Box.**

DateofMes	RTNearEdge	RTRightWhe	RTCen	RTLeftWhe	RTNearSk	RFiveLongEdg	RFiveLong
2008-9-25	471	465	461	454	480	516	1
2009-1-7	423	424	454	398	451	607	2
2009-4-8	403	320	450	320	454	616	2
2009-7-2	372	270	495	249	461	648	2
2009-10-22	294	219	467	223	460	645	2
2010-1-22	275	187	428	187	413	590	2

**Figure 21. Final Pop-Up Form for a Selected Location.**

## 4.5 PREDICTION

The prediction option provides the predicted information for each measurement point at a certain location. The prediction is made with a time series approach and is based on historical reading without considering the specifics of the product itself or the surface type the product is installed on. Information related to prediction method is documented in the project final report.

After clicking the prediction button, a form named Prediction will pop up to let users choose a single product at a certain section as shown in Figure 22. Four combo boxes of District, Manufacturer, Product, and Section Number help users to constrain the searching options to find their desired product information quickly. By clicking the Prediction button below the combo boxes, the initial prediction information form will pop-up as shown in Figure 23. Information about the selected product will appear on the left top area of the prediction information form and specific data about this product at the corresponding section will be displayed on the right top area. In order to get the prediction information, the user needs to select the prediction time length, which consists of 3 months, 6 months, and 9 months in the middle area of the form. Once users select the prediction time length, the other two options will be blocked. If users want to change to another time length, they need to click the selected time length again, and then all options will be enabled again. After selecting the prediction time length, the user can click different toggle buttons in the sketch map at the bottom of the screen to examine the prediction performance in the selected section to see the prediction value and curve as shown in Figure 24.

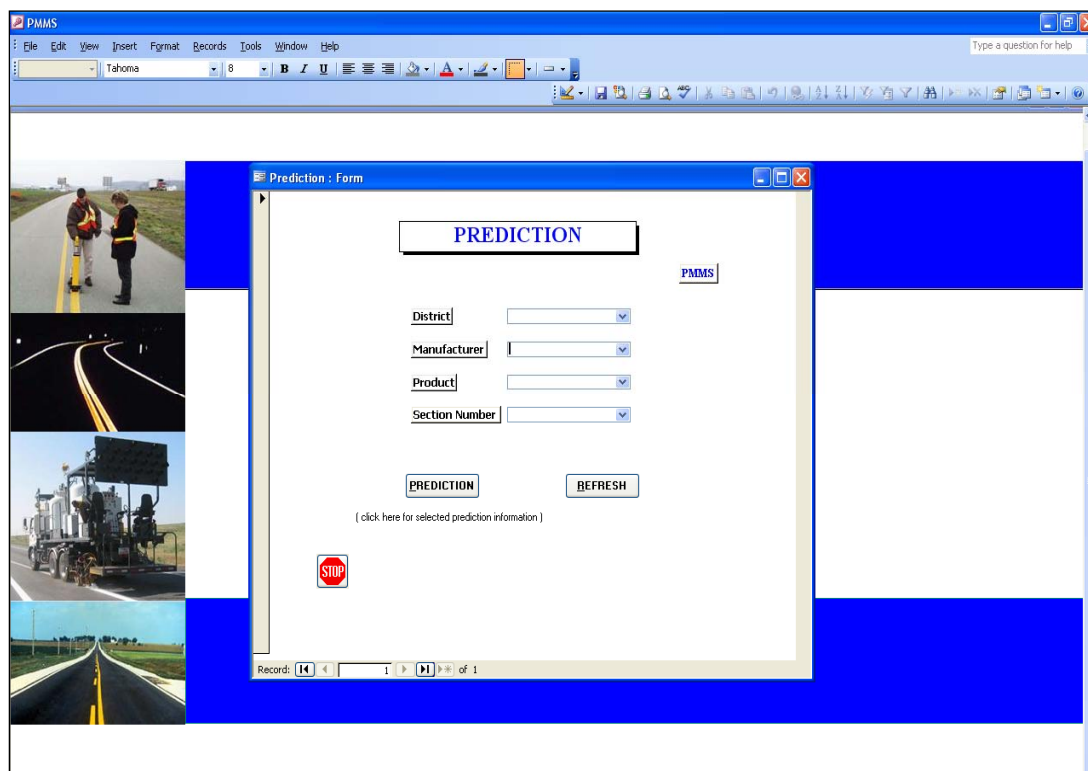


Figure 22. Prediction Form with Search by Product Drop-Down Combo Boxes.

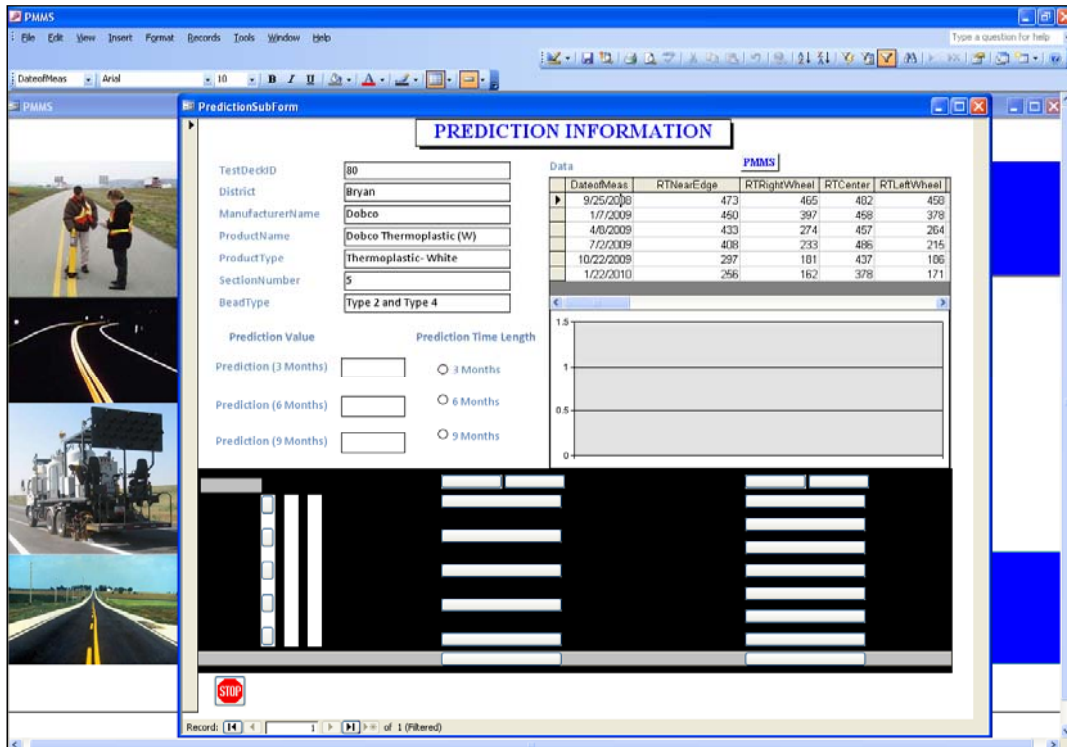


Figure 23. Initial Prediction Information Form.

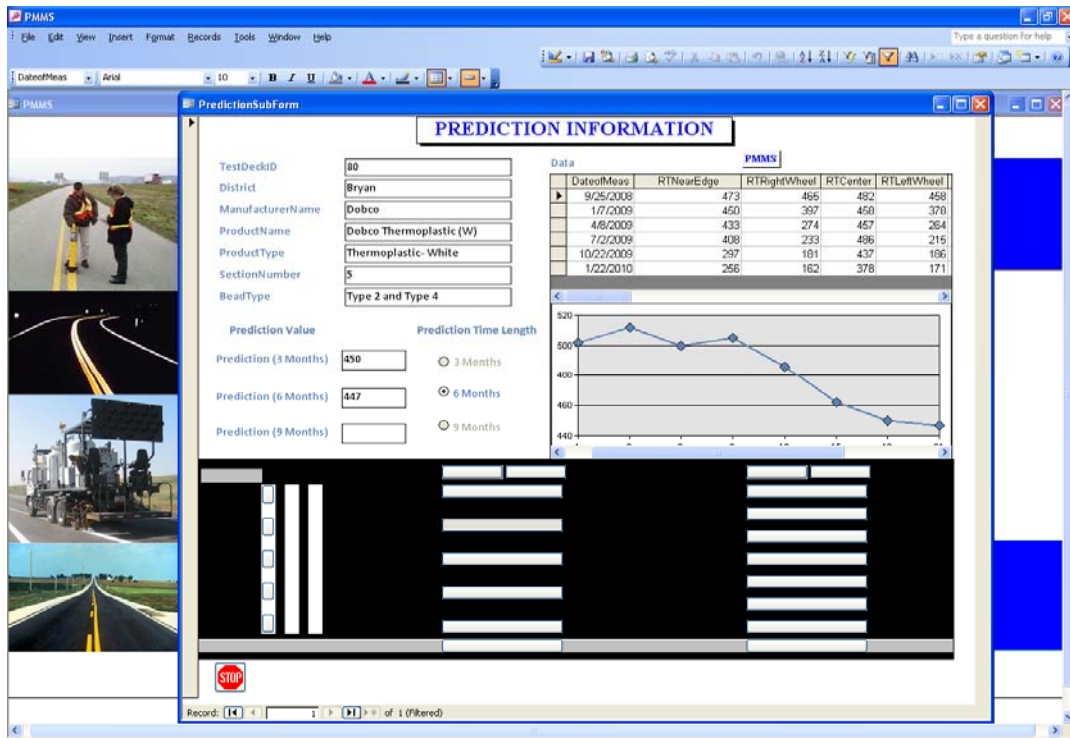


Figure 24. Prediction Information Form.

## 4.6 CHARTS

The charts option in the main menu allows users to view the performance of the products graphically, and users can choose either Interactive Chart or Interactive Form to monitor the performance of the products.

### 4.6.1 Interactive Chart

The option Interactive Chart can be used to monitor the performance of a single product or a section over a period of time or to compare different products installed by selecting a particular location using the drop-down box as shown in Figure 25. When the desired location is selected, the three buttons located below the drop-down box will be enabled and allow users to choose different marking types. In which transverse represents the transverse lines, five represents longitudinal five lines and seven represents the longitudinal seven lines. Users can restart their selection by clicking on the refresh button to clear all the selected records. After the selection of location and marking type, another window with the chart information will pop up as shown in Figure 26. To enhance the flexibility, the Charts form can be modified as desired by the user by clicking the drop-down arrows by the field names as shown in Figure 26. The selection in the fields named Manufacturer Name, Product Name, Product Type, Section Number, and Date of Measurement on the chart can be changed using these drop-down arrows to view only particular information. The buttons on top of the chart represent individual lines shown in the chart. Users can left click on the button and drag it out of the window to delete the selected line. To add the lines to the chart, the users need to right click in the chart field and select the field list option. Choose the new lines that need to be added and the data area option; the new lines can be added by clicking the add button as shown in Figure 27.

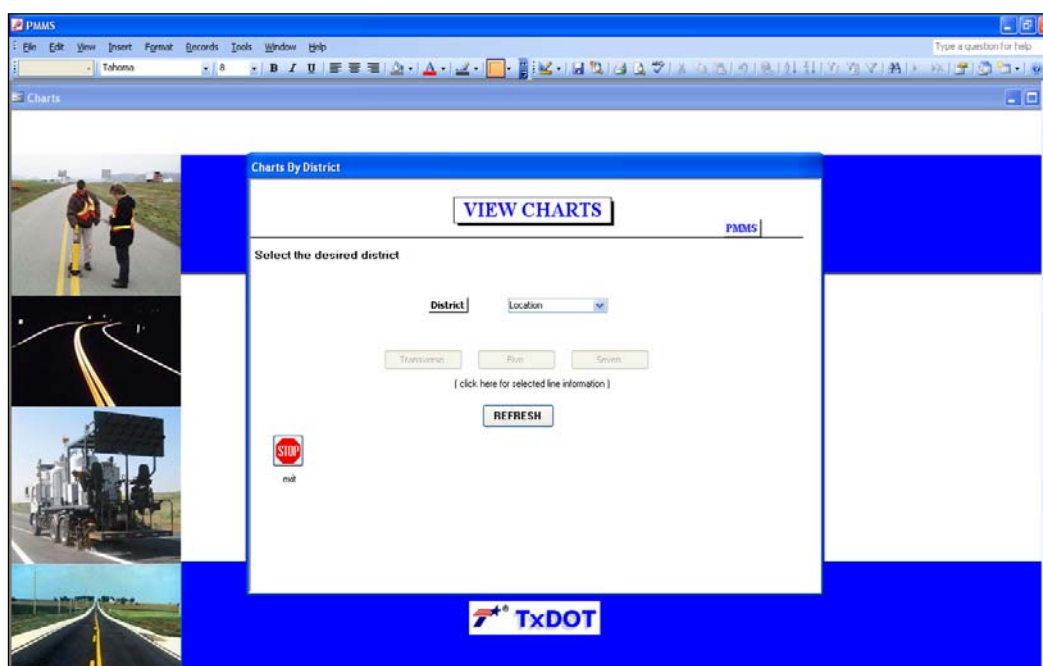


Figure 25. Interactive Chart with Location Selection.

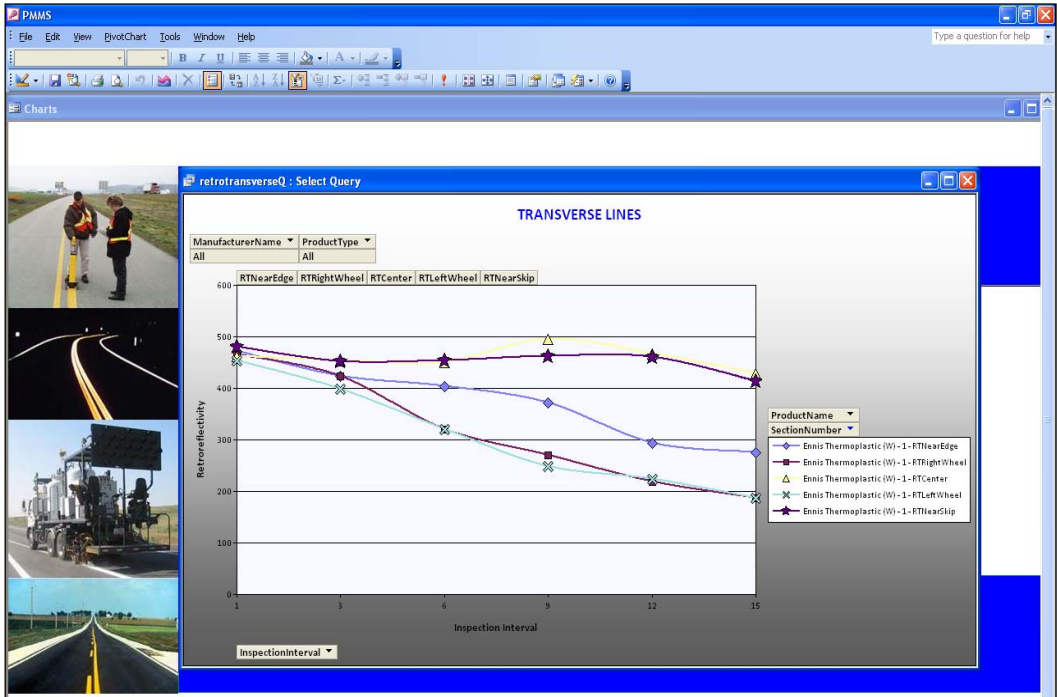


Figure 26. Final Pop-Up Form to View Graphical Performance.

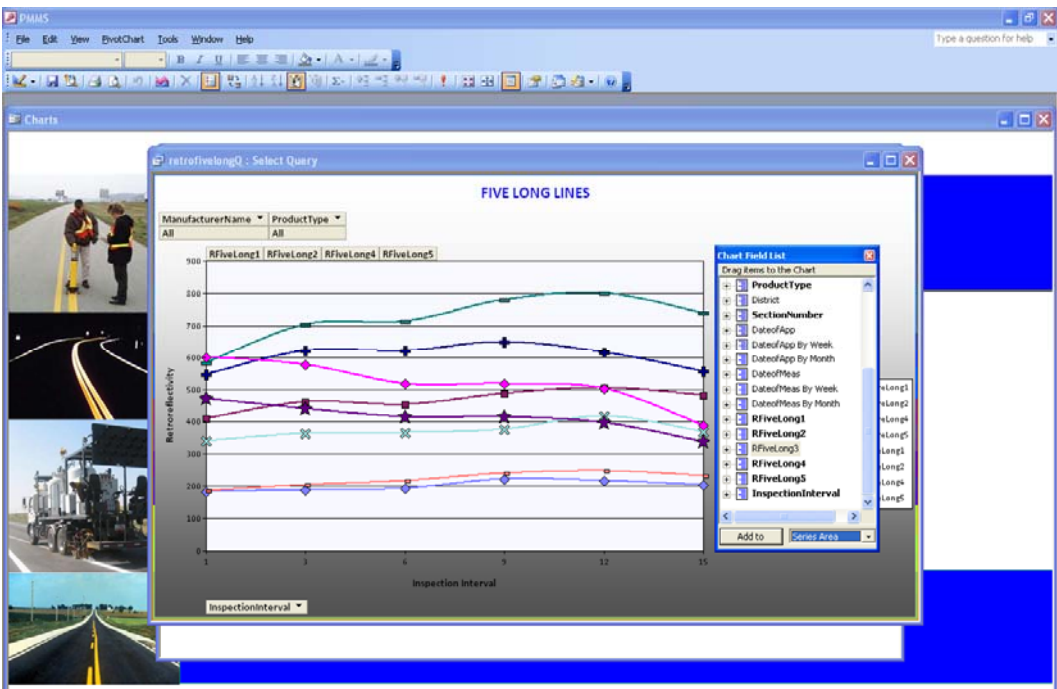


Figure 27. Adding Lines to the Chart.

#### 4.6.2 Interactive Form

The option Interactive Form can be used to compare the performance of different products on a measurement point by selecting a particular product type and location using the drop-down boxes as shown in Figure 28. After selecting District, Manufacturer, Product, and Section Number the toggle buttons become enabled in the sketch map. Users can select the measurement point to examine the performance of

different products in different locations by clicking the corresponding toggle button (as shown in Figure 29).

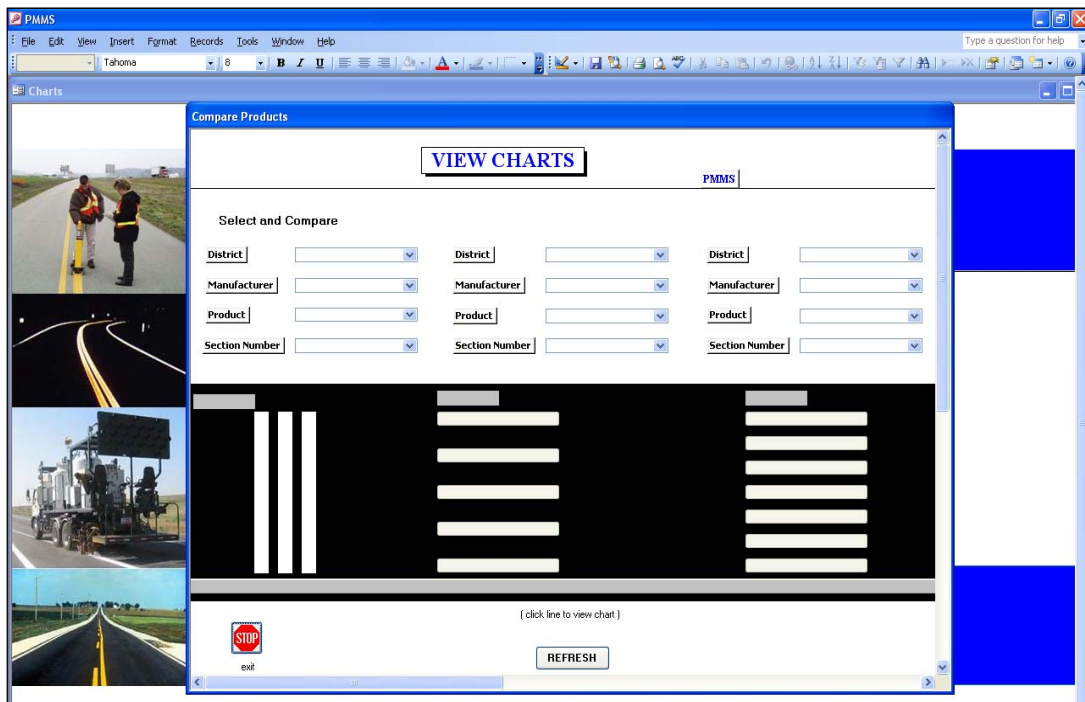


Figure 28. Interactive Form with Drop-Down Fields.

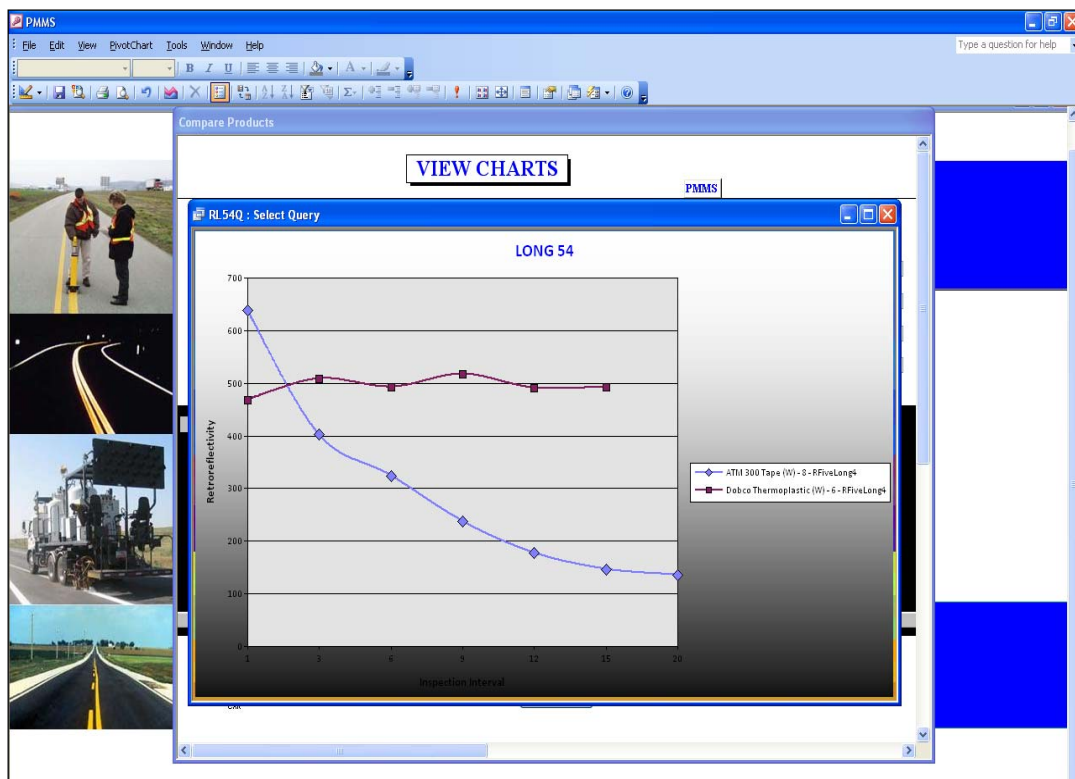


Figure 29. Final Pop-Up Form to View Different Graphical Performance at a Measurement Point for Different Products.

## 4.7 IMAGE INPUT

To edit and manage photos, there is a form named 'Imageinput' under the catalog, helping users to manage these photos (Figure 30). After choosing the District, the SectionNo, and the sub-test deck type, the new image can be loaded into the database.

After double-clicking the "Imageinput form," a pop-up window will be displayed as shown in Figure 30. Users can select a particular section in a test location by using these two combo boxes of the pop-up window. A further window with the information of the TestDeckID, date, file name, and photo of the selected location will then pop up by clicking the Search button as shown in Figure 31. The Next and Previous buttons allow users to view different photos of different times in this particular section (Figure 32). Users can also change and add new photos by clicking the Add Image button and selecting the photos users want.

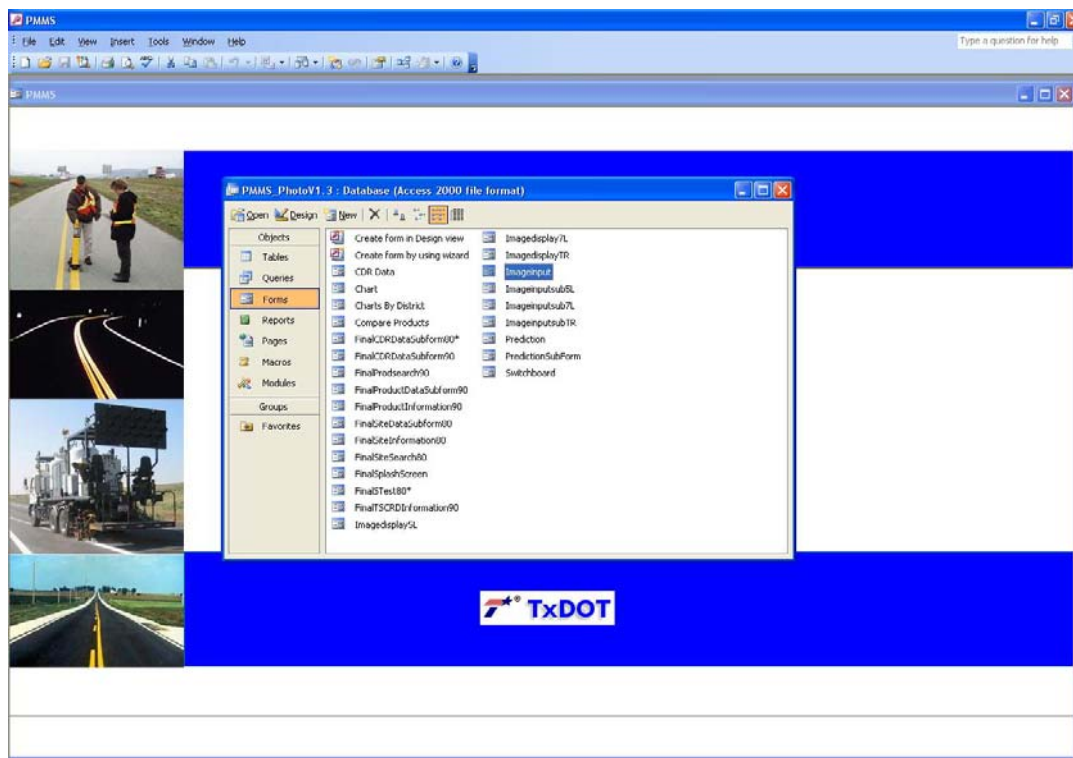
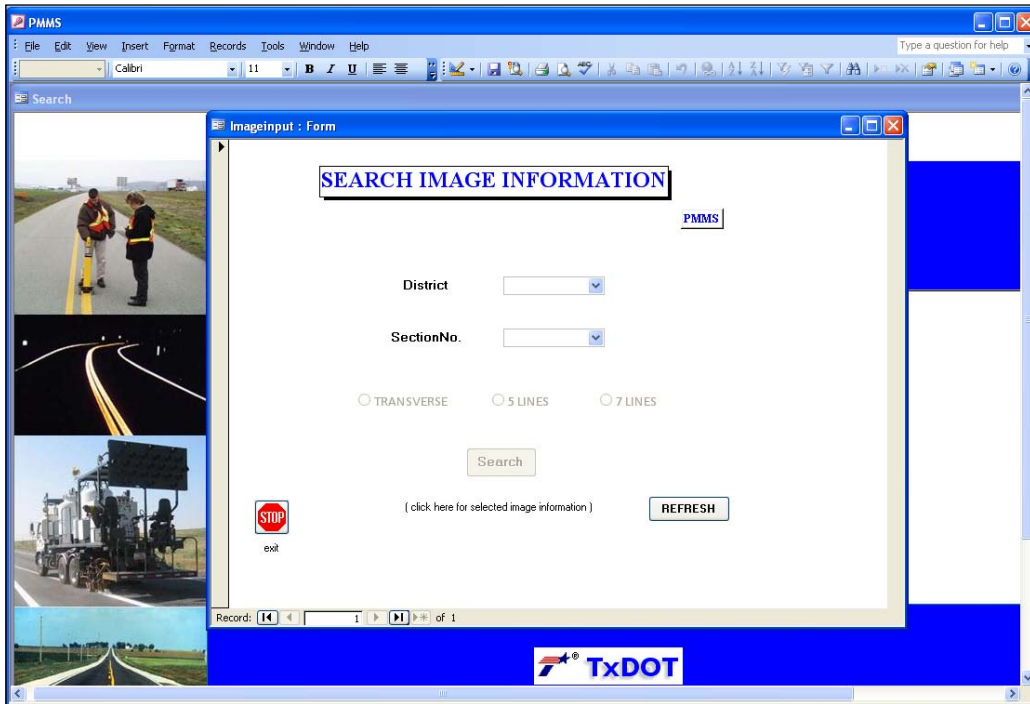
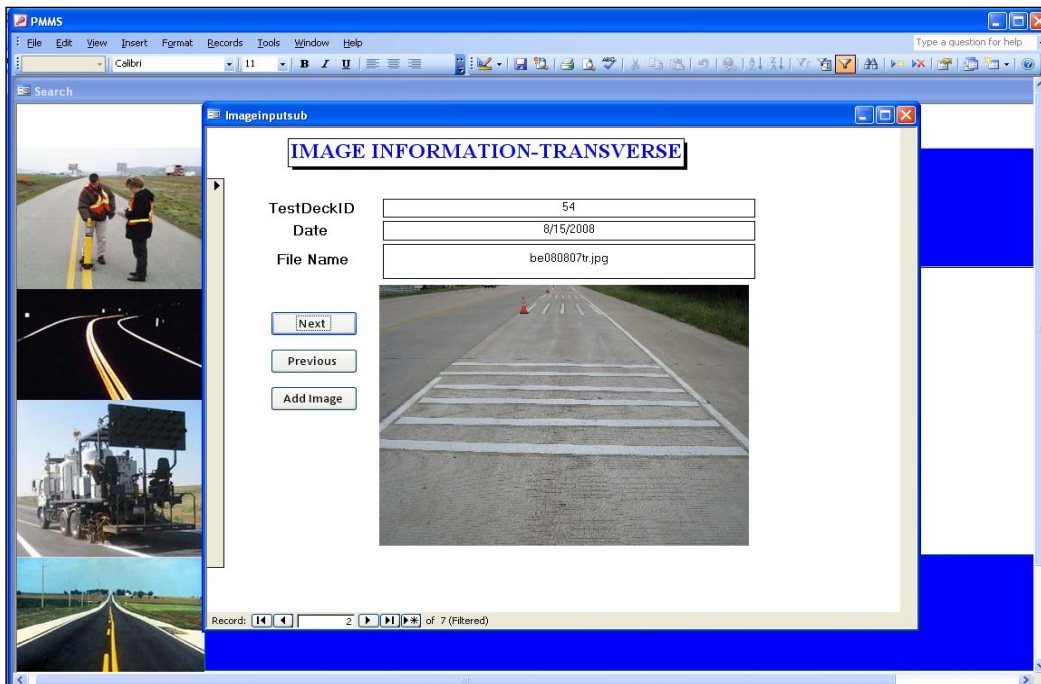


Figure 30. 'Imageinput' Form in the Catalog.



**Figure 31. Search Form with Search by a Section of a Particular Location for Inputting Images.**



**Figure 32. Pop-Up Form Displaying the Image of a Section of a Particular Location.**

#### 4.8 USER INTERFACE AND SECURITY

The system includes a user-friendly switchboard that acts as a graphical user interface to access all the functions, as shown in Figure 16. The switchboard also acts as a one-point service area for different user groups for multiple applications, as the

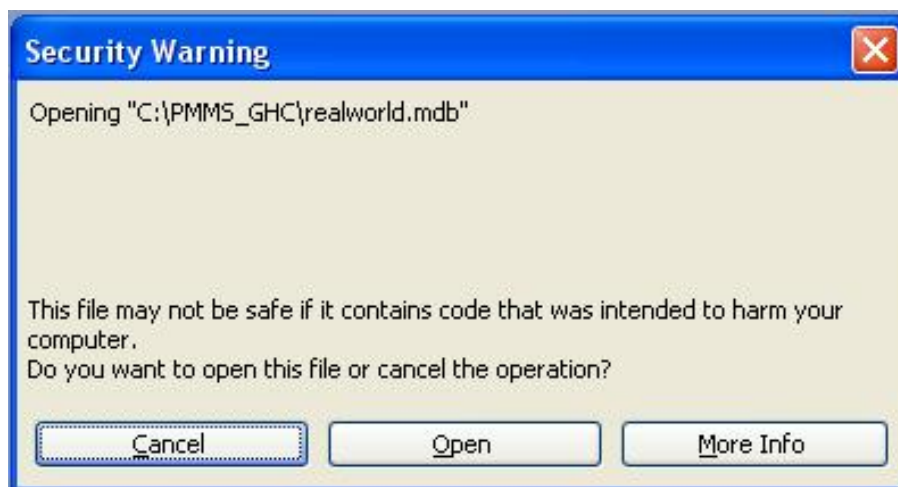


system is enabled with user-level security. This means that the same system can be used as a view/search-only application or view/search/edit-only application depending on the requirement. User-level security assigns user names and passwords to restrict the data access preventing accidental data loss and maintaining data integrity at the same time.

**Note:** Upon first launching the database, users might see a pop-up warning message asking whether it is necessary to block unsafe expressions intended to harm their computer. Depending on the version of the operation system and Microsoft Access, a window may be shown as in Figure 33. Click “No” to unblock these expressions in order to launch the database normally. Click “Open” in the following pop-up window shown in Figure 34.



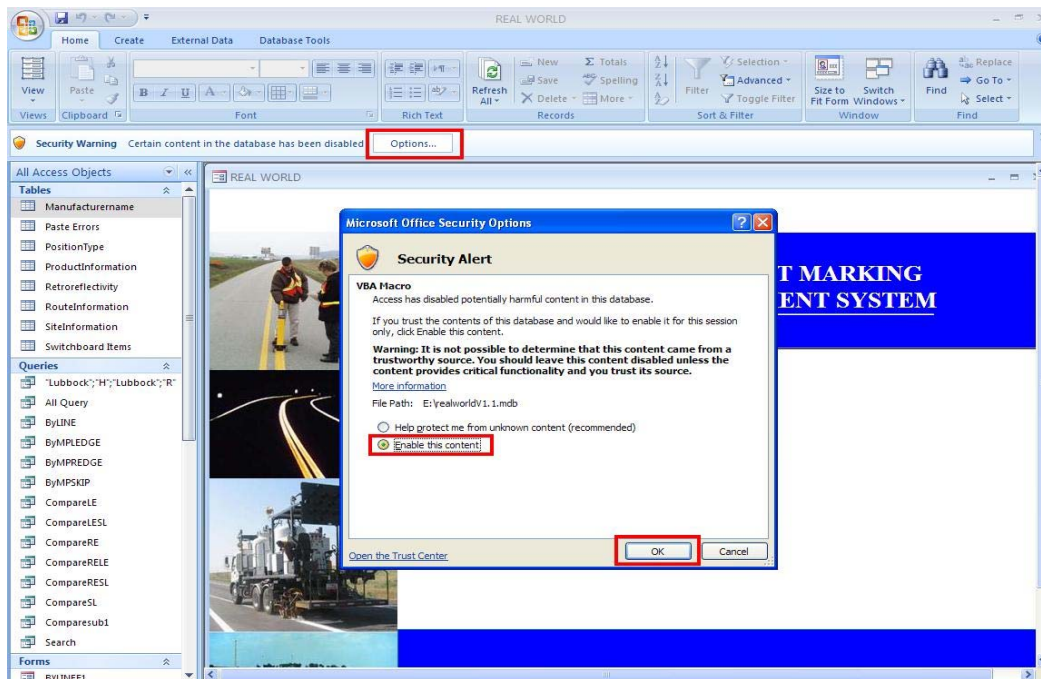
**Figure 33. Security Warning Window for Macros in Microsoft Access 2003.**



**Figure 34. Security Warning Window for Launching Microsoft Access 2003.**

This is the issue of the security/macro setting of Microsoft Access on an individual computer. If the default security setting in the user’s computer is low, then the database will work fine without warning messages for the security issue. If the default security level is not “low” a warning bar should appear, and users need to check the corresponding “enabling the content” option (or click No to unblock “unsafe” function for older versions of Access service pack) to make sure that the database works fine. Some computers may have a default security level other than low but also have a default of not displaying the warning message; in this case the program may

not run. Different service pack versions of Microsoft Access may also affect the way the security level is handled, and the way messages are displayed. For instance, in Microsoft Access 2007, users probably need to click Option and enable macros as shown in Figure 35.



**Figure 35. Security Warning Window for Launching Microsoft Access 2007.**

According to corresponding tests, following (once) the instructions below can eliminate this security-related issue:

- For Microsoft Access 2003, users need to choose options Tools-Macro-Security and then click Low. The security message will not pop up and everything should run fine.
- For Microsoft Access 2007, users need to choose options Microsoft Office Button-Access Option-Trust Center, and then there are two ways:
  1. Select Trusted Locations – check Allow Trusted Locations on my network – click Add new location – browse the location where you want to put the database – click Ok.
  2. Select Macro Settings – check the last one Enable all macros – click Ok. After doing that, when reopening the database, the security message should not pop up.

In all, selecting the option to allow unsafe program/functions solves the problem but sometimes the warning message may not display because of the current settings. This needs to be done every time the database is opened.

## 4.9 REAL-WORLD DATABASE

The real-world database is used to track PMM performance of real-world projects. The database is populated with data collected from I-27 in Hale and Swisher Counties from the Lubbock District with mobile retroreflectometers. Opening the real-world database, a switchboard (similar to the test deck database) will pop up and function as a main menu for the users to start search by products, to compare performance between different products, or to view performance charts (Figure 36).

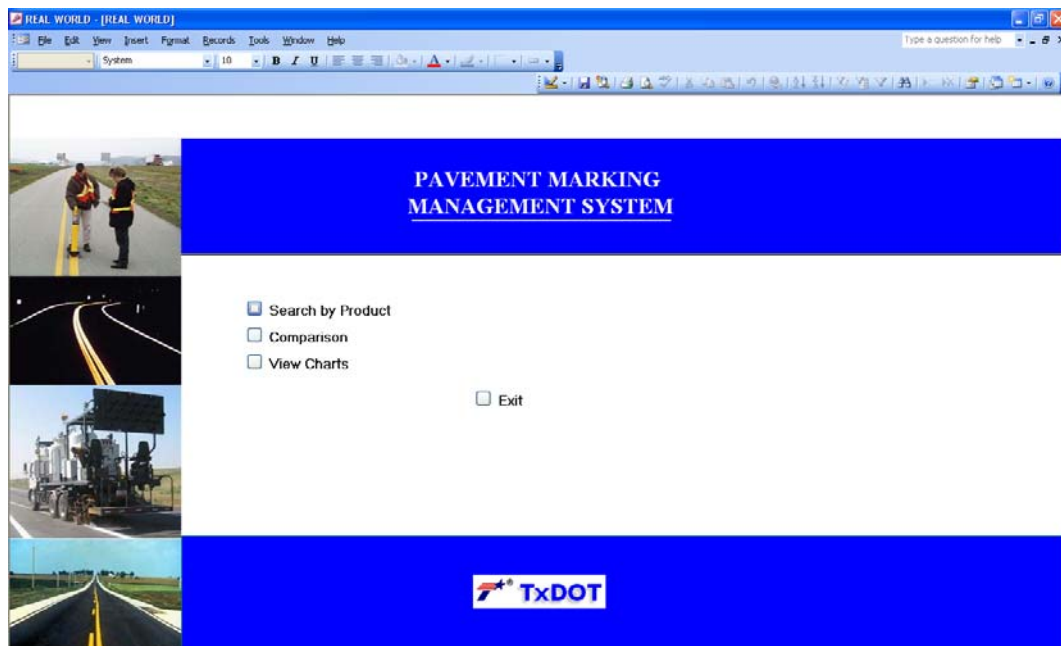


Figure 36. Switchboard in Real-World Database.

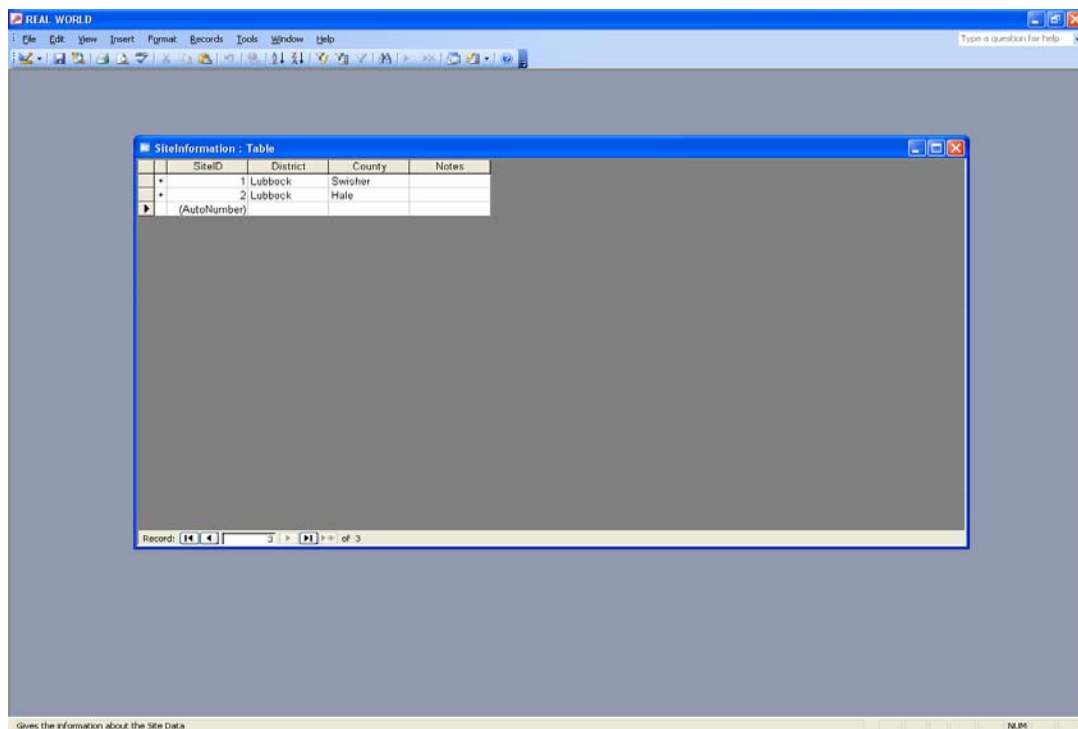
### 4.9.1 Data Input

Tables are fundamental objects used for data entry that are similar to Microsoft Excel spreadsheets. The basic purpose of this is to ensure minimum training and entry of data in appropriate fields. The real-world database has five tables that take information pertaining to manufacturer, product, retroreflectivity measurement, route, and site information.

As in the test deck database, the table SiteInformation is the primary way to input and update the data with a one-to-many relationship with other tables. After double-clicking the table SiteInformation in the catalog, the information (Site ID, District, and County) can be examined as shown in Figure 37. By clicking the cross icon at the head of each row, the table SiteInformation is expanded to the table RouteInformation, which contains information such as RouteID, ProductID, Route, Date of Application, Month of Measurement, etc. for a particular selected site (Figure 38). RouteID is based on different pairs of routes and products. Furthermore, by choosing the cross icon corresponding to each RouteID, the user can expand to the table Retroreflectivity that contains retroreflectivity data for a particular product in a

site in the real-world that were measured using mile posts against the test deck data, which were collected according to test deck and section location, as shown in [Figure 39](#). Finally, according to the Excel file containing original retroreflectivity data measured by mobile retroreflectometers, the user can copy/paste such data into the table Retroreflectivity the real-world database. Note that in the Excel file, Polyrea (White Solid) corresponds to RightEdge of the table Retroreflectivity, Polyrea (White Broken) corresponds to SkipLine, and Polyrea (Yellow Solid) corresponds to LeftEdge ([Figure 39](#)).

On the other hand, datasets from the mobile retroreflectivity unit (MRU) could be directly imported to the real-world database if it is formatted according to different fields of the retroreflectivity table. This can be done in Access through the option File>Get External Data>Import. But this option could be time consuming depending on the type of MRU that needs some expertise.



**Figure 37. Table for the Input Data in the Real-World Database.**

**SiteInformation : Table**

SiteID	District	County	Notes
1 Lubbock Swisher			
RouteID	ProductID	Route	DateofApp
1	1	1 H-27 NB	0
2	1	1 H-27 NB	6
3	1	1 H-27 NB	12
4	1	1 H-27 SB	0
5	1	1 H-27 SB	6
6	1	1 H-27 SB	12
12	2	2 H-27 NB	6
13	2	2 H-27 NB	12
14	2	2 H-27 SB	0
15	2	2 H-27 SB	6
16	2	2 H-27 SB	12
22	2	2 H-27 NB	0
(AutoNumber)	0		0
2 Lubbock Hale			
RouteID	ProductID	Route	DateofApp
7	1	1 H-27 SB	0
8	1	1 H-27 SB	6
9	1	1 H-27 SB	12
10	1	1 H-27 SB	18
11	1	1 H-27 SB	24
17	2	2 H-27 SB	0
18	2	2 H-27 SB	6
19	2	2 H-27 SB	12
20	2	2 H-27 SB	18
21	2	2 H-27 SB	24
(AutoNumber)	0		0

Records: 4 of 10

Figure 38. Expanded Table for the Input Data in Real-World Database.

**SiteInformation : Table**

SiteID	District	County	Notes
1 Lubbock Swisher			
RouteID	ProductID	Route	DateofApp
1	1	1 H-27 NB	0
2	1	1 H-27 NB	6
3	1	1 H-27 NB	12
4	1	1 H-27 SB	0
5	1	1 H-27 SB	6
MilepostID	MilePost	RightEdge	LeftEdge
134	59	394	538
135	60	447	501
136	61	429	577
137	62	514	560
138	63	388	536
139	64	279	498
140	65	346	459
141	66	445	435
142	67	309	500
143	68	460	520
144	69	488	487
145	70	455	400
146	71	449	512
147	72	339	528
148	73	348	563
149	74	491	536
150	75	430	633
151	76	416	588
152	77	357	519
153	78	431	547
154	79	421	506
155	80	306	543
156	81	295	631
157	82	540	516
158	83	328	598
159	84	352	622
160	85	364	581
161	86	366	603
162	87	392	618
163	88	443	563
164	89	394	535
165	90	430	579
(AutoNumber)			

Records: 5 of 12

Figure 39. Further Expanded Table for the Input Data in the Real-World Database.

## 4.9.2 Search by Product

Users can check the performance of the product by using the combo box options. This search option was shown in Figures 40 and 41. In Figure 40, a set of drop-down combo boxes provides multiple options for users to view the data related to that particular product. These are a set of cascading combo boxes designed in a way that when a manufacturer is selected (only one option called Polyurea), the next combo box retrieves all the products installed from this selected manufacturer with different colors. In addition, users could change their selection via clicking the refresh button or directly reselecting combo-box options. Finally, on clicking the Search button, a pop-up window will be activated as shown in Figure 41 and display information such as site, collection time, and measurement record. Users can drag the scroll bar located in the right hand of the pop-up window to view all the records.

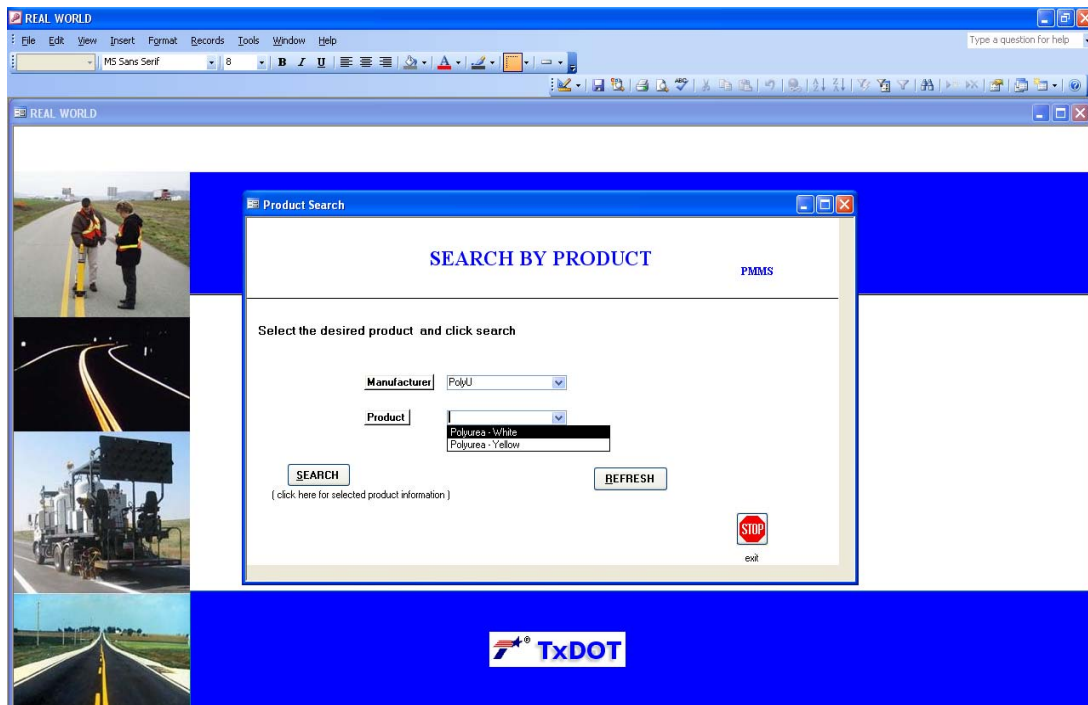
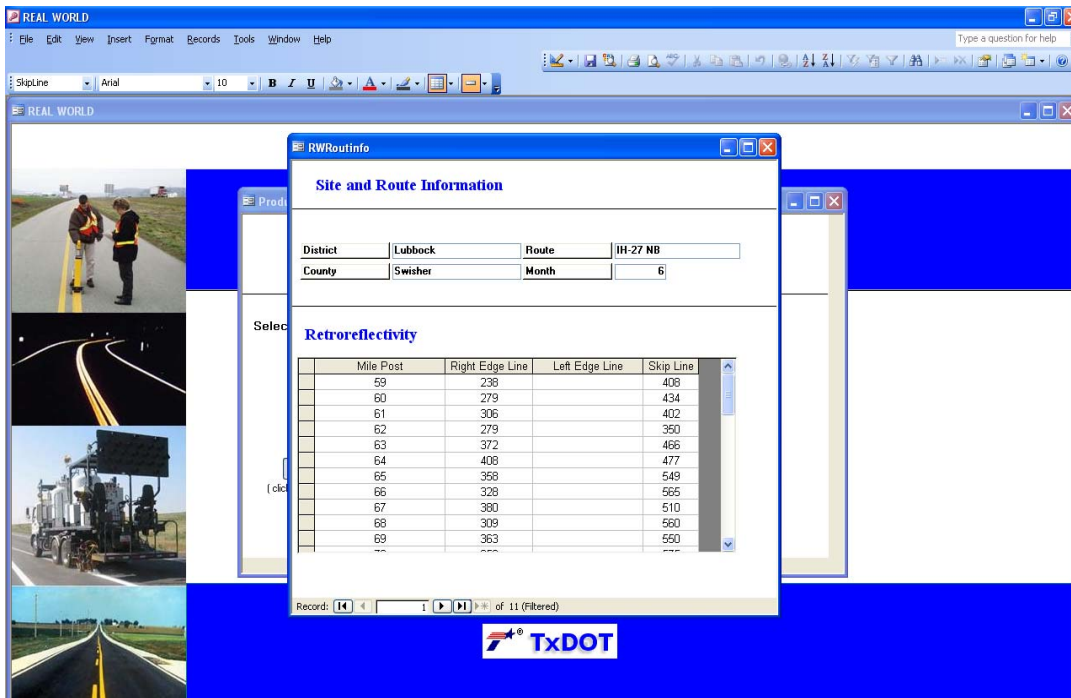


Figure 40. Search Form with Search by Product in Real-World Database.



**Figure 41. Pop-Up Window for a Selected Product.**

### 4.9.3 Comparison

The option Comparison can be used to compare the performance of different products on different measurement locations by selecting a particular site, a product type, the collection time, a measurement route, and location using the drop-down boxes as shown in Figure 42. After selecting District, Manufacturer, Product, and Month/Route, the toggle buttons become enabled in the sketch map, which can be used to select the exact location, e.g., the right edge of the road, the left edge of the road, or the skip line. In the same way, users can select other products by using the next drop-down boxes. The refresh button can be used to clean all selected options when users change their mind. After all options have been selected, users can examine the performance of different products in different locations by clicking the Compare button (as shown in Figure 43). At most, three items can be compared at the same time.

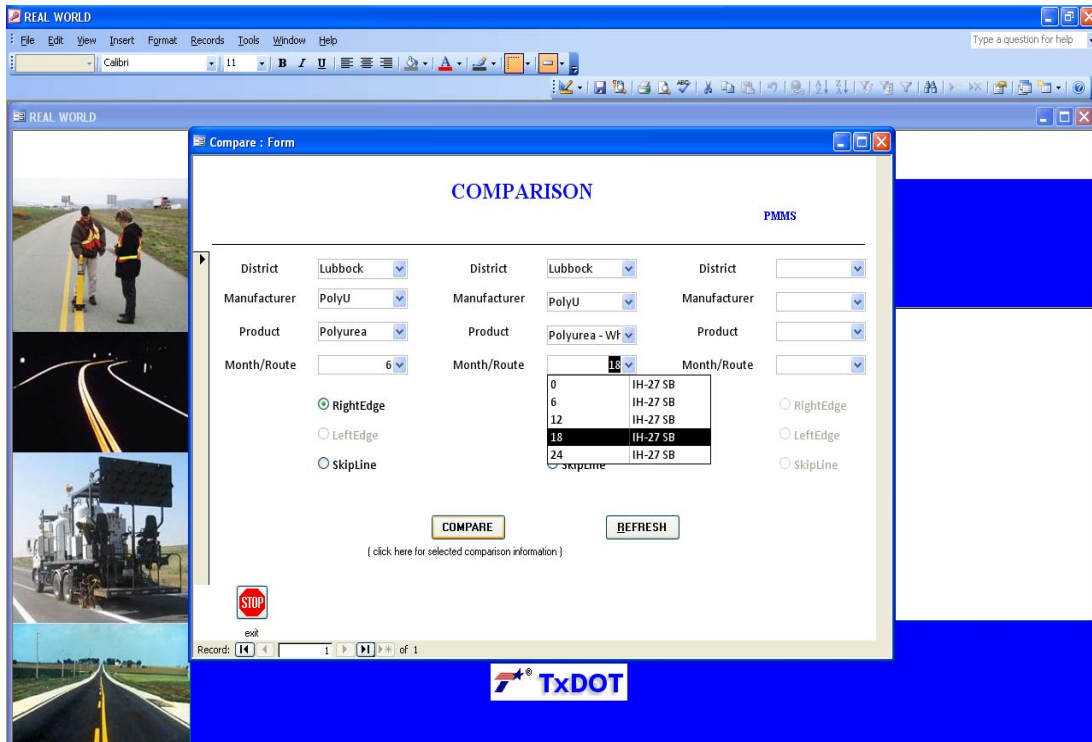


Figure 42. Comparison Form of Real-World Database.

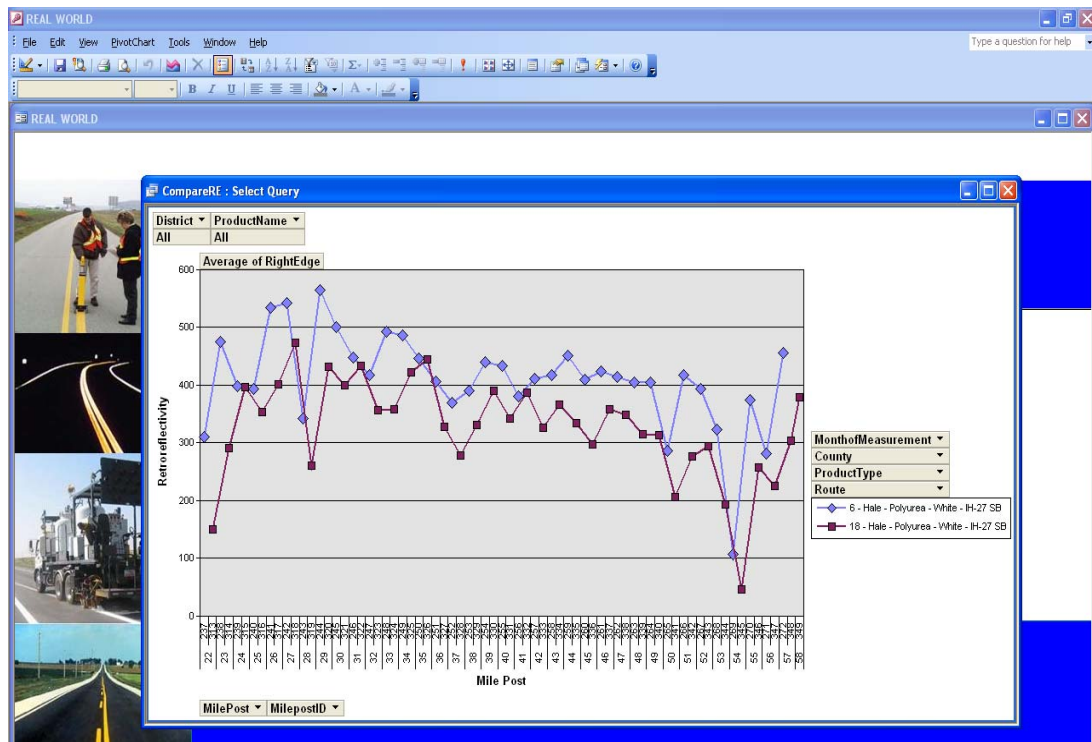


Figure 43. Pop-Up Form of Products Comparison in Real-World Database.



#### 4.9.4 View Charts

The option View Charts can be used to monitor the performance of all products over a period of time at a particular mile post or to compare different products or the performance of a product at different times by using the tabs on the top left of the window as shown in Figure 44. There are four tabs that can be selected to examine the performance of the real-world pavement marking at different locations. The tab by type allows users to examine the performance of all products at different locations over time. To enhance the flexibility, displayed charts can be modified as desired by clicking the drop-down arrows as shown in Figure 45. The selection in the fields named District, County, Route, Manufacturer Name, Product Name, Product Type, Month of Measurement, and Mile Post on the chart can be changed using these drop-down arrows to view specific information. The tab right edge line(s) means that users can only examine the performance of pavement markings located at right edge line(s). Similarly, the tabs left edge line(s) and skip line only allow users to inspect the performance of left edge line(s) and skip line, respectively.

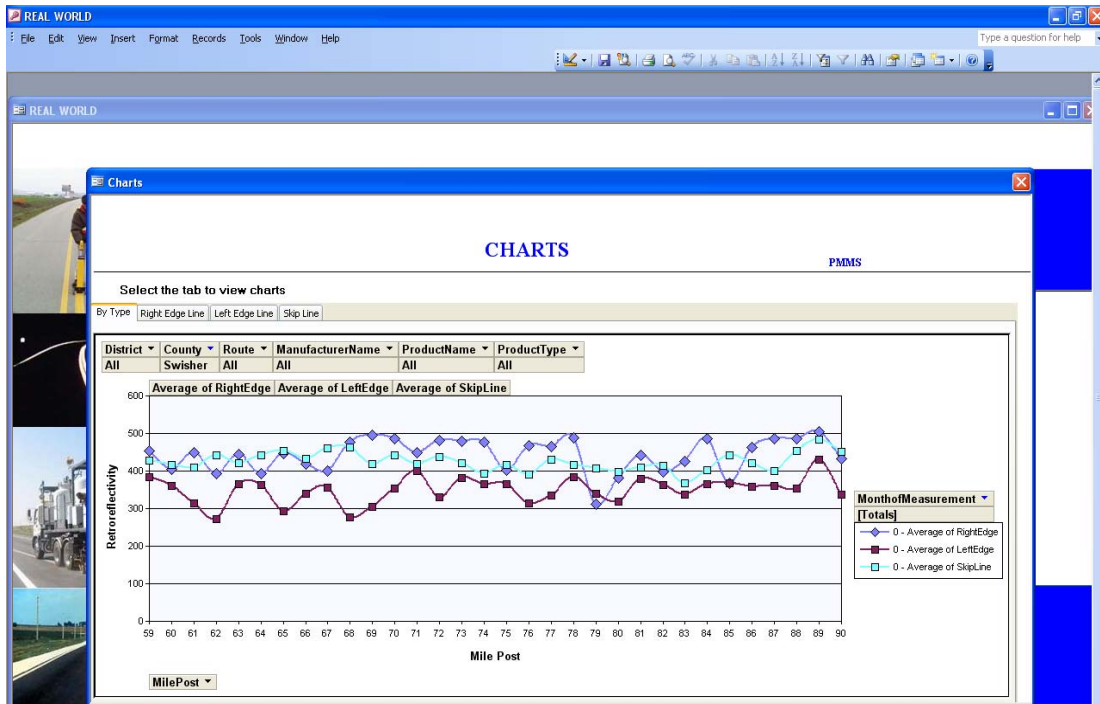
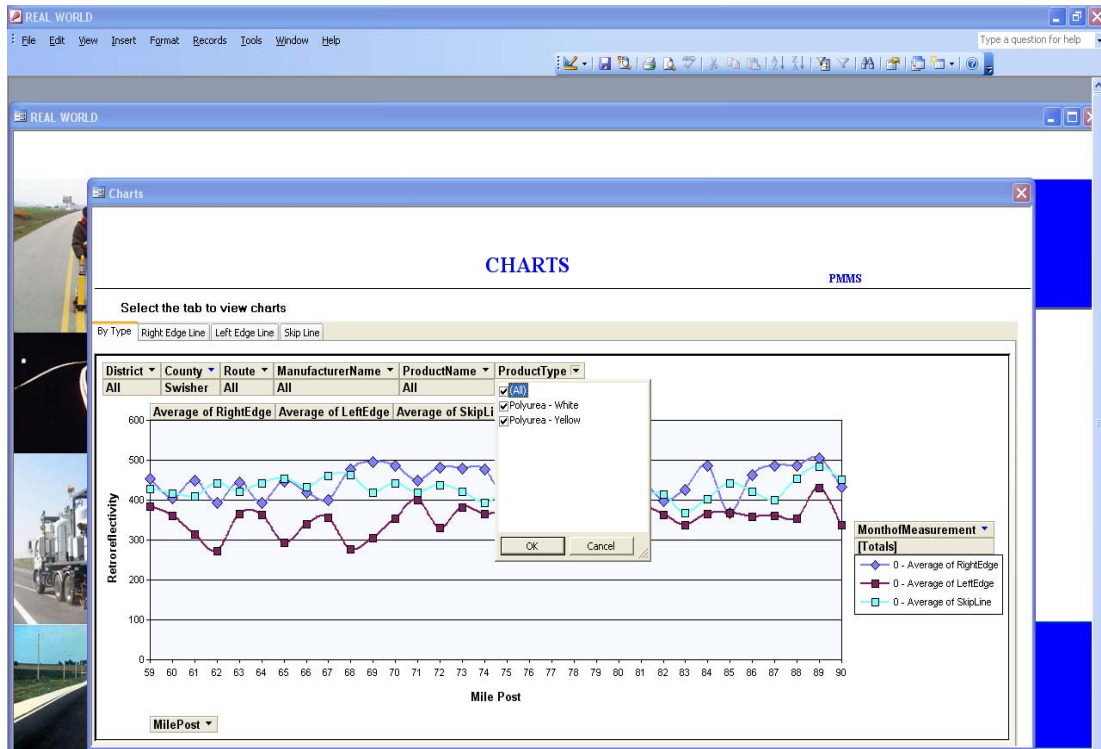


Figure 44. Main Window of View Charts.



**Figure 45. Changing Display with the Drop-Down Arrows.**

## **5 DATABASE UPDATE AND FUTURE RELEASE**

Future release of the system would include capabilities of facilitating comparisons such as the performance of a product between high traffic and low traffic, or between roadways with different truck percentages. PMMS also facilitates intelligent data sharing between different platforms for future developments. In an event the project is extended and further evaluation is done beyond the initial project termination date, new data of long-term performance of PMMs will be added to the database.



# APPENDIX

*Sample Retroreflectivity Data from the Test Deck for One Section*

Retroreflectivity Measurement Date	Note: Measured with an LTL-X			Note: 1 is nearest edgeline and the last (5 or 7) is nearest the skipline																			
	Transverse Measurement location			5-line Longitudinal Location			7-line Longitudinal Location																
	Near Edge	Right Wheel	Center Left Wheel	Edge	1	2	3	4	5	Skip-1	Skip-2	Edge	1	2	3	4	5	6	7	Skip-1	Skip-2		
9.25.08 Initial	471	465	461	454	480	185	581	633	545	598	719	370	646	167	562	628	594	516	593	633	632	389	810
01.07.09	423	424	454	398	451	204	701	629	620	577	742	321	587	180	677	635	658	607	581	629	688	340	797
04.08.09	403	320	450	320	454	217	711	562	620	518	752	323	493	207	690	585	615	616	515	558	706	348	738
07.02.09	372	270	495	249	461	240	779	575	648	518	740	306	508	234	721	580	625	648	527	617	695	343	791
10.22.09	294	219	467	223	460	248	800	496	614	502	817	283	539	242	756	494	582	645	505	566	771	328	748
01.22.10	275	187	429	187	413	231	739	299	555	387	732	244	402	222	727	386	486	590	397	516	712	297	698
04.22.10	235	160	369	168	390	224	711	267	515	283	692	258	354	228	675	247	446	547	319	429	671	248	613
08.10.10	207	142	346	147	347	241	747	190	493	210	657	223	310	242	761	195	384	524	291	392	620	288	567

*Sample Retroreflectivity Data Collected in the Real-World*

Retroreflectivity Readings for Southbound I-27 in Hale County					
Polyurea - White Solid					
Mile Post	Months				
	Initial	6 Months	12 Months	18 Months	24 Months
21	485	NaN	NaN	NaN	274
22	362	311	328	150	97
23	533	475	322	291	280
24	393	399	355	396	317
25	484	393	296	354	344
26	416	535	365	401	323
27	416	543	472	473	445
28	476	342	257	260	278
29	445	564	492	432	365
30	439	500	381	400	349
31	384	448	391	434	367
32	340	418	373	357	296
33	449	493	353	358	357
34	483	486	421	423	392
35	435	447	382	445	382
36	439	407	351	328	310
37	437	369	274	278	211
38	434	390	222	331	313
39	436	440	384	390	305
40	430	434	329	342	298
41	406	380	287	388	301
42	453	411	322	327	274
43	424	418	363	366	342
44	418	451	362	335	310
45	447	410	283	297	243
46	359	424	380	358	328
47	470	415	353	349	306
48	371	405	239	315	239
49	438	404	401	314	398
50	486	287	237	207	139
51	389	418	214	277	195
52	359	393	323	294	278
53	491	323	211	193	140
54	504	107	418	47	44
55	465	374	264	257	221
56	499	282	251	226	247
57	474	456	336	304	339
58	432	NaN	317	379	377
<b>Average</b>	<b>437</b>	<b>417</b>	<b>333</b>	<b>326</b>	<b>290</b>

Retroreflectivity Readings for Southbound I-27 in Hale County					
Polyurea - White Broken					
Mile Post	Months				
	Initial	6 Months	12 Months	18 Months	24 Months
21	475	NaN	NaN	NaN	300
22	480	278	387	190	178
23	527	462	399	405	358
24	454	451	371	409	433
25	469	397	436	379	413
26	433	299	424	394	439
27	475	434	407	385	397
28	482	444	425	424	275
29	492	444	369	230	235
30	449	457	381	408	370
31	408	449	409	407	413
32	367	415	436	396	421
33	465	394	427	366	345
34	421	472	444	427	360
35	440	456	385	393	440
36	452	268	369	308	326
37	478	385	359	322	371
38	442	233	332	289	346
39	386	390	382	343	303
40	396	385	362	349	331
41	444	384	369	304	378
42	356	420	422	360	345
43	346	447	425	350	379
44	352	427	438	440	375
45	447	432	437	431	376
46	430	511	470	484	489
47	445	388	478	454	441
48	399	426	493	367	364
49	395	471	528	458	401
50	463	451	497	415	417
51	418	450	412	461	444
52	448	438	418	460	390
53	447	237	395	185	370
54	482	148	418	110	323
55	463	464	609	567	485
56	451	430	518	527	562
57	441	539	521	472	451
58	435	NaN	568	552	548
<b>Average</b>	<b>438</b>	<b>412</b>	<b>430</b>	<b>384</b>	<b>386</b>

Retroreflectivity Readings for Southbound I-27 in Hale County					
Polyurea - Yellow Solid					
Mile Post	Months				
	Initial	6 Months	12 Months	18 Months	24 Months
21	260	NaN	NaN	NaN	183
22	470	277	310	137	149
23	488	503	396	423	375
24	474	465	414	391	438
25	434	466	448	432	462
26	411	422	422	377	410
27	352	384	374	371	370
28	383	390	379	363	301
29	403	402	384	369	358
30	413	393	435	389	384
31	350	400	414	422	398
32	355	457	400	437	420
33	356	422	484	411	328
34	383	356	394	356	371
35	357	381	368	355	333
36	444	406	376	296	345
37	357	428	411	295	290
38	395	366	271	198	288
39	390	449	389	383	328
40	397	433	439	377	328
41	429	460	470	355	366
42	373	461	466	411	383
43	391	488	479	415	403
44	394	497	433	405	380
45	399	384	373	357	329
46	384	467	415	372	398
47	362	407	342	361	337
48	362	408	442	368	342
49	362	388	446	398	370
50	385	346	369	284	288
51	378	360	445	358	339
52	382	330	399	371	277
53	379	246	329	89	171
54	374	385	414	210	253
55	419	434	381	329	322
56	425	359	422	304	272
57	340	434	423	315	277
58	365	NaN	301	255	239
<b>Average</b>	<b>389</b>	<b>407</b>	<b>402</b>	<b>344</b>	<b>336</b>