The primary objectives of this study were to develop models to forecast future pavement conditions and to determine remaining service life of pavements based on the forecasted conditions. Based on available data in the ODOT pavement database, which contains the condition history of each pavement section, along with its location, year of construction, thickness, materials used, climate, and rehabilitation records, individual regression, family regression, and Markov probabilistic models were developed. For the latter two models, pavements were first grouped into “families” with similar characteristics, based on pavement type, priority, District location, and past performance. Forecasting models were then developed for each such “family”. The developed models were evaluated by comparing the predicted conditions with the actual observed conditions for the five year period between 2001 and 2005. The Markov model was found to have the highest overall prediction accuracy among all the models evaluated, and it can also predict future distresses in addition to the PCR values. As a result of this study, ODOT can forecast future pavement conditions and estimate the remaining service life of pavements. Future rehabilitation needs can also be determined. Such capabilities will significantly benefit planning and management decision-makings at both project and network levels.
Pavement Forecasting Models

Final Report
State Job No. 134148

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and
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Pavement Forecasting Models

Problem

The ability to forecast future pavement condition is highly valuable in supporting various pavement management decisions. ODOT has compiled roadway inventory, pavement condition history, and construction activities data into a comprehensive pavement management database. To fully benefit from this database to support decisions regarding future repair strategies, it is necessary to forecast future conditions and to determine the remaining service life of pavement sections. Such forecasting capability will significantly benefit ODOT in choosing the most cost-effective rehabilitation strategies to maintain and preserve the State’s highway systems.

Objectives

1. To develop models to forecast future pavement conditions using data available to ODOT.
2. To determine remaining service life of pavement sections based on the forecasted condition.
3. To develop decision trees for selecting rehabilitation strategies.
4. To determine an appropriate initial PCR rating for a rehabilitated pavement section.
5. To include local federal aid routes in the pavement management database.

Description

After reviewing the literature, several different pavement condition forecasting models were developed based on available data in the ODOT
pavement database, which contains the condition history of each pavement section, along with its location, year of construction, thickness, materials used, climate, and rehabilitation records.

Individual regression, family regression, and Markov probabilistic models were developed. For the latter two types of models, pavement sections were first grouped into “families” of similar characteristics, based on pavement type, priority, District location, and past performance. Forecasting models were then developed for each such “family”. The developed models were evaluated by comparing the predicted conditions with the actual measured conditions for the five year period of 2001-2005.

Findings

The Markov model has the highest overall prediction accuracy among all the models evaluated, and it has the important advantage of being able to predict future distresses in addition to the PCR values.

The remaining service life of each pavement section is determined based on the conditions predicted by the Markov model and a terminal condition specified by the user. The default terminal condition for Priority system pavements is a PCR value below 65, and for General system pavements, a PCR below 60.

Appropriate initial PCR values after various maintenance and rehabilitation treatments were determined after analyzing distress progressions after the treatment. These initial PCR values provide a more realistic reflection of the actual pavement condition, and encourage selection of treatments that are longer-lasting.

A set of rehabilitation treatment decision trees were developed in cooperation with the Office of Pavement Engineering staff. These decision trees consider pavement type, priority, traffic volume, past treatment and performance, and current distress condition to recommend an appropriate maintenance or rehabilitation treatment for a given pavement. A tool has also been developed to apply the decision trees to the forecasted pavement conditions, thereby allowing the consequences of different multiyear work plans to be evaluated.

In addition to the database for the entire State highway network, a database for local federal-aid routes was developed as an addendum to this study. Although the data currently available for local routes are much less complete than that for State routes, tools have been developed to help local agencies manage their pavement assets.

Conclusions & Recommendations

As a result of this study, ODOT can forecast future pavement conditions and estimate the remaining service life of pavements. Current and future rehabilitation needs can also be determined. Such capabilities will benefit planning and management decision-makings at both project and network levels.

The Markov model is recommended due to its overall accuracy and its ability to predict individual distress in addition to PCR. Further efforts to integrate the outcomes of this study into a decision support tool that will be used routinely by the Central and Districts Offices is recommended.

Implementation Potential

The pavement forecasting model and various tools developed in this study have been included in the current ODOT pavement management database. They may be implemented readily as part of a comprehensive Pavement Management System.
INTRODUCTION

The Ohio Department of Transportation (ODOT) spends several hundred million dollars each year on pavement reconstruction and rehabilitation. Allocating the available budget to various competing projects requires a proper decision making process supported by knowledge regarding the current and future system conditions.

The ability to forecast future pavement condition is very useful in supporting various pavement management decisions. Decision makers can use the predicted future pavement conditions to determine the budget level required for maintenance and rehabilitation, to prioritize pavement repairs, and to develop multiyear rehabilitation work plans.

ODOT has compiled roadway inventory, pavement condition history, and construction activities data into a pavement management database. To fully benefit from this database to support decisions regarding future repair strategies, it is necessary to forecast future conditions and determine the remaining service life of pavement sections.

The main purpose of this study was to use the data available in the ODOT pavement database to develop a pavement forecasting model to predict future pavement conditions and to estimate the remaining service life of pavements. The ability to forecast the future condition and to estimate the remaining service life of pavements will significantly benefit ODOT in choosing the most cost-effective maintenance and rehabilitation strategies to preserve the State’s highway systems.

Figure 1 shows the central role of pavement condition forecasting models within a pavement management system.
The current pavement condition rating (PCR) system assigns a rating of 100 to new/under construction sections, if the pavement is being rehabilitated when the rater visits. However, depending on the actual rehabilitation treatment performed, some of the existing distresses may not be completely eliminated and could resurface rather quickly after treatment. As a result, some rehabilitated pavement sections deteriorate much faster than others, depending on the repair treatment applied and the distress condition prior to the repair. If many such ‘band-aid’ repairs were performed, the average PCR values in a single year can be misleading. Therefore, the second purpose of this study was to determine the most reasonable initial rating for the repaired section taking into account the distress condition of the pavement being repaired and the specific repair treatment applied.

Given the specific condition and traffic loading of a pavement, the most suitable maintenance or rehabilitation treatment action can often be determined with the help of a decision tree. Another purpose of this study was to develop and implement pavement maintenance and rehabilitation decision trees for different pavement types and priorities, in cooperation with
the Office of Pavement Engineering. By applying the decision trees to the forecasted pavement conditions, treatment needs in future years can be determined. ODOT decision makers can then formulate multi-year work plans based on budgetary and other constraints.

**Background**

Various models have been proposed to predict future pavement conditions. Given the numerous known and unknown parameters that can influence the performance of a pavement, a statistical approach based on past performance history is most widely accepted by highway agencies. Some statistical models are developed based on data collected from a single test road. For example, the AASHTO Design Equations originated from the results of the AASHO road test. Other statistical models are based on data collected from test roads located at diverse geographical locations. The LTPP test project is a rather extreme example, with pavement sections monitored throughout the entire United States. However, due to the enormous cost to construct and monitor pavements, the number of LTPP sites in Ohio is rather limited. Therefore, a more practical and sensible approach is to develop prediction models based on data collected from in-service pavements in a state or region. The ODOT pavement management database, which contains detailed in-service pavement conditions, traffic, and construction records since 1985 for all highways in the State of Ohio, provides an excellent basis to develop pavement condition forecasting models for Ohio. This database includes the most essential information needed to forecast pavement performance. These include functional class, pavement type and location, construction date (pavement age) and the specific maintenance and rehabilitation treatment performed, pavement structural buildup and materials used, pavement condition rating (PCR) and individual distress rating history, and traffic loading.

The first step in developing a pavement condition forecasting model is to determine the parameter or parameters to be predicted and the factors that affect the predicted parameter. ODOT has been using PCR as the primary indicator of pavement condition and for decision-making. Therefore, predicting a pavement section’s PCR is obviously important. Previous studies have found that a pavement’s PCR value is mostly dependent on age, with different pavement types having different rates of deterioration. Despite their simplicity, however,
such models are rather inaccurate in their prediction. That is, they often have relatively large 
prediction errors and low coefficients of determination (R-square). In fact, pavements of the 
same type can have significantly different deterioration trends due to differences in structures 
(layer thicknesses and materials), subgrade soil support, climate, pre-existing defects, traffic 
loadings, maintenance practices, etc. Figure 2 show the deterioration trends of overlays 
constructed between 1995 and 2006 on Districts 2 and 11 General system flexible pavements. 
It is apparent that pavements with the same age can have significantly different PCR values.

A pavement’s PCR value is determined from the observed surface distresses: cracking, rutting, 
raveling, etc. The ODOT pavement database contains both the PCR history and the 
corresponding individual distresses. Different distresses may progress quite differently with 
time, and different repair treatments may be required depending on the type of distresses 
present. Therefore, it is desirable to utilize the individual distress data available in the ODOT 
pavement database to provide prediction of the future distress conditions. The PCR value of a 
pavement section can then be obtained by combining the predicted individual distresses.

The ODOT PCR procedure rates each individual distress based on its severity and extent. 
Severity levels are categorized as low, medium or high (represented using L, M and H). 
Extent levels are categorized as occasional, frequent and extensive (represented using O, F 
and E). Hence, the resulting distress rating categories are LO, LF, LE, MO, MF, ME, HO, 
HF, and HE. For example, a distress rating of HF indicates that the severity of the distress is 
high and frequently occurring. Further, a category of NULL is used to indicate the absence of 
a particular distress. Therefore, for each distress, a total of ten levels ranging from NULL, 
LO, LF, LE, …, to HE, corresponding to ten discrete deduct values are possible. However, 
these discrete deducts values are ‘stepped.’ For example, a pavement section may receive a 
transverse cracking rating of MF (medium severity and frequent extent) five years in a row, 
followed by a rating of HE (high severity and extensive extent). The numerical deduct values 
would indicate the distress condition remained the same during those five years, but became 
significantly worse at the following year. The actual deterioration of the pavement is more 
likely to progress gradually, rather than following a ‘stepped’ function with time. A method 
to ‘extract’ and ‘smooth’ the individual distress data to reflect the actual deterioration is 
necessary to predict future distresses. The “smoothing” of distress data also lays the
foundation to calibrate available mechanistic models, such as for rutting and cracking distresses.

Figure 2. Pavement Condition Deterioration Trend for General System Flexible Pavement Treated with Activity Code 50 in Districts 2 and 11
Objective of the Research

The objectives of the study were:

1. To develop models to forecast future pavement conditions using data available to ODOT;
2. To determine remaining service life of pavement sections based on forecasted condition;
3. To develop decision trees for selecting rehabilitation strategies based on estimated remaining life of pavement sections; and
4. To determine an appropriate initial PCR rating for a rehabilitated pavement section.

The first addendum to the original contract added the following objectives:

5. To incorporate the new distress types, for example, thermal cracking, into the pavement forecasting models based on 2004, 2005, and 2006 PCR data.
6. To implement the Pavement Quality Index into the pavement management information system.
7. To revise the recommended rehabilitation treatment report function in the Pavement Management Information System to include estimated project cost based on user supplied unit cost.

The objectives of the second addendum were:

8. To incorporate the existing pavement condition data for local federal aid routes into the ODOT pavement management database.
9. To modify the existing analysis and reporting tools to support pavement management decisions for local federal routes.
GENERAL DESCRIPTION OF RESEARCH

This research project consists of the following tasks.

- Task 1 was to review literature and survey existing models
- Task 2 was to develop and select a forecasting model for predicting future pavement conditions
- Task 3 was to determine remaining pavement service life based on specified terminal conditions
- Task 4 was to determine appropriate initial PCR for rehabilitated pavements
- Task 5 was to develop decision trees for selecting rehabilitation strategies
- Task 6 was to update the existing PMIS to accommodate the updated PCR procedure implemented in 2004
- Task 7 was to incorporate local federal aid routes into the pavement database and develop corresponding management tools
- Task 8 was to prepare a draft final report for this study

The above tasks are further described in the following paragraphs.

Task 1 Literature Review and Survey of Existing Models

The pavement deterioration process is influenced by many interacting parameters including, but not limited to, pavement design, layer thicknesses, materials used, construction quality, underlying soil characteristics, climate, traffic loading, and maintenance activities. Some of the parameters are not quantifiable or yet fully understood, while most of the parameters are subject to different levels of variations. Therefore, in order to predict future pavement condition, statistical models based on observed past performance of pavements are the most accepted approach.

Most of the existing statistical forecasting models can be categorized into two types: regression models and Markov transitional probability models. Both models rely on available
past performance data to predict likely future conditions. To reduce the variability typically associate with pavement performance data, both models first group pavements into similar “families,” based on pavement type (concrete, asphalt or composite), functional class, and/or District jurisdiction. The regression models then use a selected set of independent variables, such as the age of the pavement, cumulative traffic loading, climatic conditions, etc., to predict the dependent variable – future pavement condition. Linear or nonlinear regression models (i.e., sigmoid or reversed S-shaped curves) have been developed by various researchers/highway agencies.

The current ODOT Pavement Design & Rehabilitation Manual contains a set of linear regression equations (Section 101-1) as the pavement deterioration models for new or rehabilitated rigid, flexible, and composite pavements. These equations are shown in Table 1. Factors not considered in these equations include: (1) functional class (i.e., priority versus general/urban systems) as the traffic levels, design thicknesses, and construction specifications are quite different among different functional classes, resulting in different rates of deterioration, (2) district jurisdiction, which contributes to variations in climate, materials used, traffic composition, and maintenance and rehabilitation practices. As a result, these simple linear regression models may not provide very accurate predictions.

Figure 3 shows a comparison of the actual versus the predicted PCR during the time period of 2000-2006 for overlays without repair (treatment activity 50) on District 11 General system flexible pavements. The regression equation used for prediction is the non-structural overlays with minimum repair on flexible pavements. As can be seen in Figure 3, the predicted and actual PCR values do not match very well, as pavement age is the only independent parameter for prediction. As shown earlier, pavements with the same age can have very different conditions, and hence, PCR values.

Saraf and Majidzadeh (1992) developed 40 different equations to forecast pavement distress and PCR for Ohio. An exponential deterioration trend was assumed, and pavement condition data from 1986 to 1990 were used to determine the model parameters. Pavement conditions were assumed to be a function of traffic ESAL, pavement thickness, and estimated modulus of elasticity of subgrade and each pavement layer. The 40 regression equations developed
<table>
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<th>Type of M&amp;R Action</th>
<th>Equation as in Section 101</th>
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<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
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<tr>
<td><strong>RIGID PAVEMENT</strong></td>
<td></td>
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<tr>
<td>All Overlays with and without Repairs</td>
<td>PCR = 96.0 - 3.7*AGE</td>
</tr>
<tr>
<td>CPR</td>
<td>96.2 - 7.0 *AGE</td>
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<tr>
<td>New Rigid Pavement &amp; Unbonded Concrete Overlay</td>
<td>99.1 - 0.9 *AGE</td>
</tr>
<tr>
<td><strong>FLEXIBLE PAVEMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Non-Structural Overlay with Minimal Repairs</td>
<td>98.1 - 3.3 *AGE</td>
</tr>
<tr>
<td>Non-Structural Overlay with Repairs</td>
<td>98.6 - 3.8 *AGE</td>
</tr>
<tr>
<td>Structural Overlay with Minimal Repairs</td>
<td>98.3 - 3.3 *AGE</td>
</tr>
<tr>
<td>Generic Minor Rehabilitation (all of the above)</td>
<td>98.0 - 3.3 *AGE</td>
</tr>
<tr>
<td>Fractured Slab Technique</td>
<td>98.0 - 3.4 *AGE</td>
</tr>
<tr>
<td>New Flexible Pavement</td>
<td>99.5 - 2.0 *AGE</td>
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<tr>
<td><strong>COMPOSITE PAVEMENT</strong></td>
<td></td>
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<tr>
<td>Non-Structural Overlay with Minimal Repairs</td>
<td>96.1 - 4.0 *AGE</td>
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<td>Structural Overlay with Repairs</td>
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<tr>
<td>Generic Minor Rehabilitation (all of the above)</td>
<td>96.0 - 3.7 *AGE</td>
</tr>
<tr>
<td>New Composite Pavement</td>
<td>99.6 - 3.3 *AGE</td>
</tr>
</tbody>
</table>
Predicted PCR = 98 – 3.3 * AGE

Figure 3. Actual versus Predicted PCR Using Straight Line Equation

were for 5 different M&R actions (8 for each action). The M&R actions included were: non-structural AC overlay (less than or equal to 3 inches thick) with and without repairs, structural AC overlay with and without repairs (greater than 3 inches), and crack and seat with AC overlay. The model requires the modulus of elasticity for subgrade and each pavement layer. These modulus values were estimated from the soil classifications and material types used. Actual modulus values vary significantly with temperature and moisture content, and between individual pavements. Therefore, accuracies of these regression models are questionable. Since accurate soil and pavement modulus values are not available for most pavements, this approach is not used in the current study.

The Markov models require defining pavement conditions into a finite number of ‘states.’ For example, a pavement may be in the condition state of excellent, good, fair, poor, or very poor, defined by its PCR values or individual distresses. The probabilities that a pavement may deteriorate from a given condition state to other condition states are assumed to be
constant. These probabilities are called transitional probabilities, and are stored in a Markov Transition Matrix, \( P \), expressed by:

\[
P = \begin{bmatrix}
P_{11} & P_{12} & \cdots & P_{1n} \\
P_{21} & P_{22} & \cdots & P_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
P_{n1} & P_{n2} & \cdots & P_{nn}
\end{bmatrix},
\]

where \( P_{ij} = \Pr[X_t = j \mid X_{t-1} = i] \) is the transitional probability that the pavement deteriorates from condition state \( i \) to state \( j \), and \( n \) is the total number of condition states. The transitional probabilities are subject to the following constraints:

\[
P_{ij} \geq 0, \text{ for all } i \text{ and } j. \tag{2}
\]

\[
\sum_{j=1}^{n} P_{ij} = 1, \text{ for all } i. \tag{3}
\]

If a particular \( P_{ij} \) has value of 1.0, then all the other probabilities in the same row (\( P_{ik}, k = 1, \ldots, n \), but \( k \neq j \)) must all be equal to zero, indicating once a pavement reaches the condition state corresponding to \( P_{ij} \), it will not go to other condition states. This condition state is called a “absorbing state.” In most cases, the poorest distress condition, HE (high severity and extensive extent), should be the absorbing state, unless no pavement ever reach that level of distress condition.

Previous researchers often used assumed transitional probabilities. When historical pavement condition data are available, the transitional probabilities can be estimated based on the mileage of the pavements that deteriorate from one condition state to other condition states in the subsequent year. This approach was employed in the current study.

Pavement condition is typically measured on a yearly basis; resulting in a transition period of one year. The above Markov transition matrix, \( P \), is therefore a one-year transition matrix.
By multiplying the one-year transition matrix, predicted condition in future years can be obtained, i.e. \( P^2 = P \times P, P^3 = P \times P \times P, \ldots, P^n = P \times P \times P \ldots \times P \).

**Task 2 Develop Pavement Condition Forecast Models for Ohio**

The two most common types of pavement forecasting model — the regression models and the Markov transition models — were investigated in this study. Two of the regression models, namely the family regression and the individual regression models, were investigated.

**Family Regression Models**

A “family” regression model is developed for a group of pavements with similar characteristics. In this study, system priority, pavement type, activity performed, and district jurisdictions are used as parameters to form pavement groups, or pavement ‘families’. Pavements in some Districts tend to perform more poorly than those in other Districts, due to differences in subgrade soils, quality of locally available materials, climatic conditions (e.g., average temperature and amount of snow fall), traffic loading, maintenance practices, and rehabilitation decisions.

It has been shown that pavements constructed during different time periods, e.g., those constructed prior to 1995 versus those constructed since 1995, have different performance trends, likely due to improved specifications and quality control practices. Therefore, time period of construction is also a “family” characteristic. However, a “family” must have a significant number of pavements at various condition states in order to have a reliable forecast of future pavement conditions. Therefore, the time period selected should be sufficiently long, say, ten years.

To predict an individual pavement section’s future condition, the corresponding family regression model is modified based on the known current condition of this particular pavement using a method called ‘Age Shift,’ originally proposed by Shahin (1994). Figure 4 illustrates the ‘Age Shift’ method, where a six-year old pavement has a PCR score of 85, which is the typical PCR score for a three-year old pavement in the same pavement “family.”
Therefore, the ‘age shift’ is three years to the right, which means the entire family PCR curve is shifted three years to the right to represent the predicted PCR curve for this particular pavement.

**Figure 4. Adjusting Individual Deterioration in Relation to Family Deterioration**

(Adapted from Shahin 1994)

**Individual Regression Models**

In this approach, a best fit regression curve is fitted for each pavement section that has three or more PCR data points. Future PCR values for the pavement are obtained by extrapolating the fitted curve. When a pavement section has less than three available PCR data points (either because it’s a recently rehabilitated pavement, or because the pavement was rehabilitated before three PCR values were measured), the “family” regression curve that the pavement corresponds to is used to represent the pavement’s “expected” performance. The “Age Shift” method is employed to predict future condition starting from the latest available PCR data.
Markov Models

In this study, the Markov transitional probabilities are derived from the past condition data available in the ODOT pavement database. For a specific group of pavements with similar characteristics (i.e., in the same ‘family’), the transition probabilities are calculated using the following equation:

$$P_{ij} = \frac{\text{Total Miles from State } i \text{ to State } j}{\text{Total Miles in State } i}.$$  \hfill (4)

A pavement currently in condition state $i$ may be in one of several condition states the following year, as long as the corresponding transition probability, $P_{ij}$, is not zero. The condition state that the pavement will most likely to be in can be determined by finding the expected value of the distribution:

$$w^k_{t+1} = \sum_{j=1}^{n} P_{ij} \times W_j,$$  \hfill (5)

where $w^k_{t+1}$ is the expected deduct value of distress $k$ at time $t_{n+1}$, $k = (1, 2, \ldots, 15)$, $P_{ij}$ is the probability that the pavement is moving from state $i$ to $j$ for distress $k$, and $W_j$ is the corresponding deduct value of distress $k$ at state $j$, obtained from the PCR Rating System (ODOT 2004). The final predicted PCR value is obtained by using Equation (6).

$$PCR_{t_{n+1}} = 100 - \sum_{k=1}^{15} w^k_{t+1},$$  \hfill (6)

where $PCR_{t_{n+1}}$ is the predicted PCR value at time $t_{n+1}$.

Dropouts

Pavement performance data are often subject to attrition over time; that is, fewer pavements survive to later ages. This attrition of data is referred to as “dropouts” (Laird 2004). For example, when pavement condition data are arranged according to age (i.e., condition scores for newly rehabilitated pavements are denoted as PCR0, and scores for one year old...
pavements are denoted as PCR1, etc.,) the available PCR data for older pavements are less than for newer pavements, as poorer-performing pavements receive rehabilitation and “drop out” from the analysis. Overtime, only better performing pavements remain, and the PCR values in the later years are biased towards the better performing pavements. Forecasting models that do not consider dropouts tend to overestimate PCR value in the later stages of a pavement’s life. This overestimation of pavement condition increases as the forecasting model predicts pavement conditions further into the future.

Figure 5 shows the actual average and Markov predicted PCR curves for the Priority system flexible pavements after receiving an overlay without repair (treatment activity code 50).

![Markov Predicted PCR for Priority System Overlays without Repair on Flexible Pavements](image)

**Figure 5. Markov PCR Prediction versus Actual Average Trends**

It can be seen from Figure 5 that the differences between the Markov predicted PCR values and the actual average PCR values are very small during the first several years after overlay. In later years, however, the average PCR values are higher than the Markov predicted PCR values. This is due to the tendency of poorly performing pavements receiving repair treatment sooner than better performing pavements. As a result, the average PCR scores in later years are biased towards the better performing and longer lasting pavements. The
dropout phenomenon also causes the Markov prediction to demonstrate decreasing deterioration rates in later years. Dropouts cause overestimation of PCR values (and remaining service life), particularly at the later stage of pavement life span, when a significant portion of poorly performing pavements have been repaired and “dropped out” from the data.

This overestimation can be countered by imputation (Laird 2004), a widely accepted approach for handling dropouts. In its simplest form, imputation is conducted by extrapolating the deterioration trends for those pavement sections that have “dropped out” of the analysis. Figure 6 compares the average actual PCR deterioration trend and the average imputed trend, where all individual pavement deterioration trends are extrapolated by extending their final year PCR deterioration rates. The average actual PCR curve shows a decrease in the deterioration rate starting around six years of age, when poor performing pavements began to be replaced, and even shows an unrealistic upward trend after about 13 years, when very few pavements actually survived. In contrast, the imputed curve shows a more consistent deterioration trend.

Figure 6. Imputed Average and Actual Average
Prediction of Individual Distresses

In this study, the severity and extent of each individual distress is predicted first, and then the deduct values from all the distresses are combined to determine the predicted PCR value.

The ODOT PCR procedure describes pavement distress condition according to its severity and extent. Severity of each distress is classified as either low (L), medium (M), or high (H), whereas the extent is described by three levels: occasional (O), frequent (F), or extensive (E). Furthermore, a NULL rating is given when a distress is not present. Therefore, each distress can be in one the following ten condition states: NULL, LO, LF, LE, MO, MF, ME, HO, HF, HE. A more detailed description of the PCR distress rating procedure can be found in the PCR manual available at the Office of Pavement Engineering web site.

For a group of pavements in the same “family”, the Markov transitional probabilities for each individual distress are generated based on actual distress data collected during a given time period. A separate Markov transition matrix is developed for each distress, and future levels of each distress can then be predicted. By adding the predicted individual distress deducts and subtracting the total deduct from 100, the predicted PCR for future years can be obtained.

A “family” must have a sufficiently large number of pavements in various condition states in order to develop a reliable Markov transition matrix. This requirement is even more important for the Markov model than for the family regression model, and it is the main reason that the Markov model has not been widely used. However, the ODOT pavement management database contains a very large number of pavement sections, allowing many “families” to be formed, except for treatment activities that have not been used extensively. For this study, it was determined that a “family” must have at least 300 pavement sections, otherwise it is ‘merged’ with other similar families.

Table 2 shows the various states and transitional probabilities between these states for rutting distress on District 11 General system flexible pavements after an overlay without repairs (Activity Code 50). This transition matrix is denoted as $P$. 

\[ P \]
Table 2. Transition Matrix for Rutting Distress, District 11, General Flexible Pavements Overlays (Activity 50) Constructed During 1995-2006

<table>
<thead>
<tr>
<th>Current Year Condition</th>
<th>NULL</th>
<th>LO</th>
<th>LF</th>
<th>LE</th>
<th>MO</th>
<th>MF</th>
<th>ME</th>
<th>HO</th>
<th>HF</th>
<th>HE</th>
</tr>
</thead>
<tbody>
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<td>NULL</td>
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<td>0.14</td>
<td>0.03</td>
<td>0.01</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LO</td>
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<td>0.76</td>
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<td>0</td>
<td>0.03</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>0.05</td>
<td>0.69</td>
<td>0.18</td>
<td>0.05</td>
<td>0.02</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0.08</td>
<td>0.01</td>
<td>0.01</td>
<td>0</td>
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<tr>
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</tr>
<tr>
<td>ME</td>
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<td>0</td>
<td>0</td>
<td>0.07</td>
<td>0.64</td>
<td>0.19</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td>HO</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>HF</td>
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<td>0</td>
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<td>1</td>
</tr>
</tbody>
</table>

For example, within this group of pavements, a section with a rutting rating of NULL (non-existent) has a 82% chance to remain at NULL the following year, 14% chance that it will deteriorate to LO (Low Severity, Occasional Extent), 3% chance that it will deteriorate to LF (Low Severity, Frequent Extent), and 1% chance that it will deteriorate to LE (Low Severity, Extensive Extent). Mathematically, the second year probability vector is obtained by multiplying the first year probability vector to the one-year transition matrix, $P$:

$$< 1 0 0 0 0 0 0 0 0 0 > P = < 0.82 0.14 0.03 0.01 0 0 0 0 0 0 >$$  \hspace{1cm} (7)

Since each distress condition level corresponds to a known deduct value, the expected deduct value can be obtained by summing up the product of each probability to the corresponding deduct. The pavement will most likely be in the condition state closest to the expected deduction value the following year.

To predict the condition two years later, the second year probability vector is multiplied to the one-year transition matrix $P$:

$$< 0.82 0.14 0.03 0.01 0 0 0 0 0 0 > P = < 0.67 0.22 0.07 0.04 0 0 0 0 0 0 >$$  \hspace{1cm} (8)
In other words, the same section has a 67% chance to remain at NULL in the third year, 22% chance that it will deteriorate to LO, 7% chance that it will deteriorate to LF, and 4% chance that it will deteriorate to LE (Low Severity, Extensive Extent). The above process is repeated for prediction of any future year conditions and for other distresses.

Figure 7 shows a comparison of the Markov Model predicted deterioration trends versus the actual average trend for rutting distress on General system flexible pavement overlays in District 11. Note the Markov predicted trend is ‘smoother’ than the actual average trend.

Table 3 shows the transition matrix for block and transverse cracking (District 11 General system overlays on flexible pavements). Figure 8 shows the average distress trend and the predicted based on Markov model block and transverse cracking for this group of pavements.
Table 3. Transition Matrix for Block and Transverse Cracking, District 11, General Flexible Pavements Overlays (Activity 50) 1995-2006

<table>
<thead>
<tr>
<th>Current Year Condition</th>
<th>NULL</th>
<th>LO</th>
<th>LF</th>
<th>LE</th>
<th>MO</th>
<th>MF</th>
<th>ME</th>
<th>HO</th>
<th>HF</th>
<th>HE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>.35</td>
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<td>.35</td>
<td>.37</td>
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<tr>
<td>LF</td>
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</tr>
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<td>LE</td>
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<td>.07</td>
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<tr>
<td>ME</td>
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<tr>
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</table>

Markov Predicted Deduct vs. Actual Average Deduct Curve for Block and Transverse Cracking Distress occurring in General System Flexible Pavement with overlays without repair(Activity Code 50) in District 11

![Markov Predicted Deduct vs. Actual Average Deduct Curve](image)

**Figure 8. Predicted and Actual Average Block and Transverse Cracking Deducts in District 11**

By summing up all the distress deducts for a pavement at a particular age, the PCR value can be determined. Figure 9 shows the average PCR deterioration trend and the Markov model predicted PCR trends (with and without imputation) for overlays on District 11 General system flexible pavements.
Comparing the predicted distress and PCR curves with the average curves obtained from actual PCR measurements provides a good indication of the accuracy of the prediction model. It can be seen from Figures 7, 8, and 9 that the Markov model reproduces the actual deterioration trends very well, while smoothing out the actual average curves.

Figures 10-13 show the individual distress deduct trends for three major distresses and the PCR deterioration trend for District 2 overlays (Activity 50) on General flexible pavements constructed between 1995 and 2006. Again, the Markov model can reproduce the average deterioration trends very well.
Markov Predicted Deduct vs. Actual Average Deduct Curve for Rutting Distress occurring in General System Flexible Pavement with overlays without repair (Activity Code 50) in District 2

Figure 10. Predicted and Actual Average Rutting Deducts, District 2

Markov Predicted Deduct vs. Actual Average Deduct Curve for Wheel Track Cracking Distress occurring in General System Flexible Pavement with overlays without repair (Activity Code 50) in District 2

Figure 11. Predicted and Actual Average Wheel Track Cracking Deducts, District 2
Markov Predicted Deduct vs. Actual Average Deduct Curve for

*Block and Transverse Cracking Distress* occurring

in General System Flexible Pavement with overlays without repair

(Activity Code 50) in District 2

![Graph of predicted vs. actual average deducts, District 2](image)

**Figure 12.** Predicted and Actual Average of Block and Transverse Cracking Deducts, District 2

Markov Predicted PCR vs. Average PCR Curve

for District 2 General System Flexible Pavement with overlays

without repair (Activity Code 50)

![Graph of predicted vs. average PCR, District 2](image)

**Figure 13.** Predicted and Actual Average PCR Trends, District 2
Task 3  Determine Remaining Pavement Service Life Based on Appropriate Terminal Pavement Condition

The remaining service life (RSL) of a pavement can be defined as the time it takes for the pavement to deteriorate from its current condition to a specified terminal condition. The RSL provides important information for making various pavement management decisions. Based on the forecasted pavement conditions and a specified terminal condition, the remaining service life of a pavement is determined by counting the number of years from the present year until the year the predicted condition will fall below the specified terminal condition. The terminal condition of a pavement can include multiple criteria, as a pavement may be considered at the end of its service life due to various functional or structural deficiencies. Therefore, the terminal condition may be defined by not only a threshold PCR value, but by a critical distress level or a combination of several critical distresses. For example, a high severity of rutting or a severe and extensive wheel track cracking may both be considered as terminal. Some distresses may be repairable by a specific treatment, but other distresses require more significant rehabilitation. A tool to estimate the remaining service life was developed in this task. The user can specify different terminal conditions for different pavements. The default terminal condition for Priority system pavements is when the PCR value is below 65, and for General system pavements, below 60.

Task 4  Determination of Initial PCR Rating for Rehabilitated Pavements

Currently, a PCR value of 100 is assigned to pavement sections that are being rehabilitated. Even for pavement sections that are actually rated after a rehabilitation treatment, the PCR value may be overrated as some rehabilitation treatments can “mask” certain underlying distresses for a short period of time, but not eliminate them. As a result, depending on the rehabilitation treatment performed and the prior distresses presented, some distresses may resurface quickly within a few years after receiving rehabilitation.

A more realistic estimate of the initial PCR rating is necessary to avoid distorting the average PCR value caused by repair treatments that do not provide long term benefit. This distortion may prevent decision makers from having an unbiased impression of the overall pavement
network conditions. In addition, a more realistic initial PCR rating would avoid having many drastically different ‘rates of deterioration’ (or ‘slopes’) after the same repair treatment due to presence of different distresses prior to repair. The goal of this task was to determine a realistic estimation of initial PCR for newly rehabilitated pavements.

By comparing the distresses prior to repair and the distresses within a few years after repair, the effectiveness of the repair treatment to address a specific distress may be established. Certain distresses, such as transverse cracking, may not be entirely erased by a given treatment, but may only be ‘masked’ or delayed. Therefore, the distress condition is not entirely eliminated. Instead, the ‘residual damage’ may be carried over after a repair treatment. The amount of ‘residual damage’ depends on the repair treatment used and the degree of damage existed prior to repair. By summing up all the residual damages that can not be erased by the specific rehabilitation treatment, a more realistic initial PCR value of a rehabilitated pavement can be determined.

The rehabilitation treatments performed by ODOT can be grouped into three categories: maintenance, minor rehabilitation, and major rehabilitation. Maintenance activities include crack sealing, chip seal, micro-surfacing, etc. Minor rehabilitation treatments primarily involves asphalt concrete (AC) overlays (with or without repairs), and major treatments range from rubblized and roll, unbonded concrete overlay, to new flexible or new rigid pavement. Table 4 shows the complete list of treatment activities performed by ODOT.

Figures 14 and 15 show the distribution of treatments performed on all composite and flexible pavements since 1985. It can be seen that overlays with or without repair (activity codes 50 or 60) constitute the vast majority (85-90%) of treatments, for both composite and flexible pavements. The total length of pavement sections studied was 12104.2 miles. This total length includes multiple counts of the same pavement section that may have been repaired multiple times. Each time a pavement section is repaired, its length is added to the total in this analysis.
## Table 4. Activity Codes

<table>
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<tr>
<th>Treatment Class</th>
<th>Activity Code</th>
<th>Description</th>
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</thead>
<tbody>
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<td>Maintenance</td>
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<td>Reactive Maintenance</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Crack Sealing</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Chip Seal</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Micro-Surfacing</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Double Application Micro-Surfacing</td>
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<td></td>
<td>35</td>
<td>Nova-Chip Resurfacing</td>
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<tr>
<td></td>
<td>38</td>
<td>Fine Graded Polymer AC Overlay</td>
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<tr>
<td></td>
<td>40</td>
<td>CPR</td>
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<tr>
<td>Minor</td>
<td>45</td>
<td>Intermediate Coarse Recycled AC</td>
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<tr>
<td></td>
<td>50</td>
<td>AC Overlay without Repairs</td>
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<td></td>
<td>52</td>
<td>AC Inlay</td>
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<td></td>
<td>55</td>
<td>Double Chip Seal</td>
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<td></td>
<td>60</td>
<td>AC Overlay with Repairs</td>
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<td>Crack and Seat</td>
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<td></td>
<td>73</td>
<td>Break and Seat</td>
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<td></td>
<td>77</td>
<td>Rubblize and Roll</td>
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<td></td>
<td>80</td>
<td>Whitetopping</td>
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<td>90</td>
<td>Unbonded Concrete Overlay</td>
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<td></td>
<td>95</td>
<td>Unbonded Composite Overlay</td>
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<td></td>
<td>100</td>
<td>New Flexible Pavement</td>
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<tr>
<td></td>
<td>110</td>
<td>New Rigid Pavement</td>
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<tr>
<td></td>
<td>120</td>
<td>New Composite Pavement</td>
</tr>
</tbody>
</table>
Figure 14. Mileage Distribution of Repair Type, for Composite Pavements

Figure 15. Mileage Distribution of Repair Type, for Flexible Pavements
Since the PCR is derived from a set of distresses, a study of the individual distresses was necessary to estimate the initial PCR. In order to deduct a fair and reasonable value for each initial individual distress and ultimately, the initial PCR data from 2, 3, and 4 years after a treatment were used to get an average intercept between the y axis (value at year 0) and the best linear fit between these three values. Figure 16 shows the initial value for raveling on priority system overlays on flexible pavements is 2.48, while the actual average from the data is 2.10.

![Figure 16. Initial Value of Raveling from Linear Fit of Years 2, 3, and 4](image)

The same methodology is followed to calculate the initial value of each distress and ultimately the initial PCR value.

Based on the data available in the ODOT pavement database, the appropriate initial ratings for rehabilitated pavement sections are determined taking into account the type and level of distresses presented prior to repair and the repair treatment performed. Since a large number of data are available for overlays (Activity Codes 50 and 60), pavements are grouped according to distress deduct levels prior to the overlay, and within each group, the initial deduct value for each distress was determined. When the initial deduct values among
different groups are different for a specific distress, it indicates that the level of that distress prior to overlay will affect the initial PCR after overlay.

Each pavement type (Concrete, Flexible, and Composite) has 13 to 15 different distresses. These distresses can be structural or functional, or both. ODOT uses Structural Deducts and Cracking Deducts, in addition to overall PCR (which is 100 subtracting total deducts), to help engineers obtain a general impression of the pavement’s condition. Table 5 shows the distresses included in the structural and cracking deducts for each of the pavement type.

### Table 5. Distress Types Included in Structural and Cracking Deducts

<table>
<thead>
<tr>
<th>Type of Deduct</th>
<th>Jointed Concrete Pavement</th>
<th>Flexible Pavement</th>
<th>Composite Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td><strong>Structural Deduct</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faulting (Joints &amp; Cracks)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse Cracking, Reinforced Concrete</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longitudinal Cracking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corner Breaks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse Cracking, Plain Concrete</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Cracking Deduct** | | | | |
| Transverse Cracking, Reinforced Concrete | | | | |
| Longitudinal Cracking | | | | |
| Longitudinal Joint Spalling | | | | |
| Transverse Cracking, Plain Concrete | | | | |

<table>
<thead>
<tr>
<th>Flexible Pavement</th>
<th>Composite Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rutting</td>
<td>Pumping</td>
</tr>
<tr>
<td>Wheel Track Cracking</td>
<td>Shatter Slab (Jointed Base)</td>
</tr>
<tr>
<td>Edge Cracking</td>
<td>Tranverse Cracks (Unjointed Base)</td>
</tr>
<tr>
<td>Random Cracking</td>
<td>Intermediate Transverse Cracks (Jointed Base)</td>
</tr>
<tr>
<td>Potholes</td>
<td>Longitudinal Cracking</td>
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<td></td>
<td>Corner breaks (Jointed Base)</td>
</tr>
<tr>
<td></td>
<td>Punchouts (Unjointed Base)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Composite Pavement</th>
<th>Flexible Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse Cracks (Unjointed Base)</td>
<td>Rutting</td>
</tr>
<tr>
<td>Joint Reflection Cracks (Jointed Base)</td>
<td>Wheel Track Cracking</td>
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<tr>
<td>Intermediate Transverse Cracks (Joined Base)</td>
<td>Block and Transverse Cracking</td>
</tr>
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<td>Longitudinal Cracking</td>
<td>Longitudinal Cracking</td>
</tr>
<tr>
<td>Corner breaks (Jointed Base)</td>
<td>Edge Cracking</td>
</tr>
<tr>
<td>Punchouts (Unjointed Base)</td>
<td>Random Cracking</td>
</tr>
<tr>
<td></td>
<td>Thermal cracking</td>
</tr>
</tbody>
</table>
Task 5  Develop Decision Trees for Selecting Rehabilitation Strategies

A set of decision trees developed by the Office of Pavement Engineering staff for selecting
the most appropriate maintenance and rehabilitation treatment based on pavement type,
system, existing pavement condition and past performance, and traffic level were
implemented within the pavement management information system. These decision trees
were developed after several iterations of revisions to evaluate the various decision criteria.
The entire set of decision trees is shown in Appendix B.

A work plan generating tool was developed to allow the rehabilitation decision trees to be
applied to the current as well as predicted pavement conditions. ODOT decision makers can
use this tool to determine the repair needs in the current and future years. After a specific
work plan is provided by the user, the tool will produce the corresponding future pavement
conditions and repair needs. As a result, the consequence of alternative work plans can be
easily evaluated. The input work plan can be for a single year or multiple years.

Task 6 Revise PMIS to accommodate the PCR procedure updated in 2004

The ODOT PCR procedure was updated in 2004. Several additional distress types were
added. At the same time, a few distress types that rarely occurred were abolished. Since this
change took place after this study had started, it was not anticipated in the original study
proposal. An addendum was approved to incorporate the changes in distress categories to
allow the developed forecasting models to incorporate the updated distresses and PCR scores.

Tables 6 and 7 show the distress types and the corresponding maximum deduct values for
flexible, composite, and concrete pavements.

The Markov model predicts future pavement conditions based on individual distresses. The
distresses included in the 2004 updated PCR procedure are predicted based on the 2004-2006
PCR data.
### Table 6. Flexible and Composite Pavements Distress Codes and Deducts Pre-2004 and Since 2004

<table>
<thead>
<tr>
<th>Distress Code</th>
<th>Distress Name</th>
<th>Maximum Deducts</th>
<th>Distress Code</th>
<th>Distress Name</th>
<th>Maximum Deducts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-2004</td>
<td>Since 2004</td>
<td></td>
<td>Pre-2004</td>
</tr>
<tr>
<td>1</td>
<td>Raveling</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Bleeding</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Patching</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Potholes/Debonding</td>
<td>10</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Crack Sealing Deficiency</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Rutting</td>
<td>10</td>
<td>10</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Settlements</td>
<td>10</td>
<td>---</td>
<td>7</td>
<td>10</td>
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<tr>
<td>8</td>
<td>Corrugations</td>
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<td>5</td>
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<tr>
<td>9</td>
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<tr>
<td>11</td>
<td>Longitudinal Joint Cracking</td>
<td>5</td>
<td>5</td>
<td>11</td>
<td>8</td>
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<tr>
<td>12</td>
<td>Edge Cracking</td>
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<td>10</td>
<td>12</td>
<td>5</td>
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<tr>
<td>13</td>
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<td>5</td>
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<tr>
<td>15</td>
<td>Potholes</td>
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Table 7. Concrete Pavements Distress Codes and Deducts Pre-2004 and Since 2004

<table>
<thead>
<tr>
<th>Distress Code</th>
<th>Jointed Concrete Pavements</th>
<th>Maximum Deducts</th>
<th>Distress Code</th>
<th>Continuously Reinforced Concrete Pavements</th>
<th>Maximum Deducts</th>
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<tr>
<td></td>
<td>Distress Name</td>
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<td>Since 2004</td>
<td></td>
<td>Distress Name</td>
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<td>Surface Deterioration</td>
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<td>10</td>
<td>1</td>
<td>Surface Deterioration</td>
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<td>Popouts</td>
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<td>4</td>
<td>Pumping</td>
<td>15</td>
<td>15</td>
<td>4</td>
<td>Pumping</td>
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<td>Faulting (Joints &amp; Cracks)</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>Settlements and Waves</td>
</tr>
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<td>6</td>
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<td>5</td>
<td>---</td>
<td>6</td>
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<tr>
<td>7</td>
<td>Transverse Joint Spalling</td>
<td>15</td>
<td>10</td>
<td>7</td>
<td>Longitudinal Cracking</td>
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<tr>
<td>8</td>
<td>Joint Sealant Damage</td>
<td>5</td>
<td>---</td>
<td>8</td>
<td>Punchouts or Edge Breaks</td>
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<tr>
<td>9</td>
<td>Pressure Damage</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>Spalling</td>
</tr>
<tr>
<td>10</td>
<td>Transverse Cracking</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>Pressure Damage</td>
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<tr>
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</tr>
<tr>
<td>13</td>
<td>Longitudinal Joint Spalling</td>
<td>---</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Transverse Cracking, Plain Concrete</td>
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<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This task also implements the Pavement Quality Index (PQI) into the existing pavement database. Pavement Quality Index (PQI) combines the two existing measures employed by ODOT to characterize distress and roughness, namely PCR and International Roughness Index (IRI), into one single index. This index may be used for overall pavement condition assessment purpose.

The PQI is calculated by the following formula:

$$\text{PQI} = \text{PCR} - a (\text{IRI})^b$$

(9)

with $a = 0.00003716$, $b = 2.4913$ for priority systems and $a = 0.00004915$, $b = 2.4230$ for general systems.

**Task 7 Incorporating Local Federal Aid Routes**

In recent years, ODOT’s Office of Pavement Engineering has begun collecting pavement condition data for local (county and municipality) routes that receive federal aid. These local routes were not part of the original pavement management database, which contains state highways only. A second addendum was approved to develop a management database for the local federal aid routes.

Pavement condition data for the local federal aid routes are available only since 2003, and no project date or treatment activity records are currently available. Therefore, the type of analysis allowed is much more limited compared with that for the state routes. Nevertheless, a database for local federal-aid routes was developed to support pavement management activities at the county and municipality level. Some of the functions available in the ODOTPMIS were redesigned or modified when appropriate, while others were disabled due to lack of data.

The following were accomplished during this task:

1. The available pavement condition data for local federal aid routes were imported from spreadsheet format into a MS Access database, LOCALPMIS. Besides the fields already
in the spreadsheet, additional fields were added, such as traffic categories, ADT, street names, etc, in anticipation of future data collection and local needs.

2. A method of importing new data and appending additional data to the LOCALPMIS database was developed. This method is described in detail in Appendix D.

3. Various analysis functions and reporting tools were modified for use with the local routes data. A separate menu of functions and tools were developed for the local routes database.

4. The pavement condition data for the local routes were collected on alternate years. Therefore, for most of the local route pavements, only two years of data are currently available. Pavement age information is also not available. Furthermore, pavement design, construction, and maintenance standards and practices vary significantly among counties and municipalities, as compared to that for state highways. Therefore, predicting future pavement condition becomes more difficult, as the Markov model requires a relatively large group of similarly performing pavements to generate a reliable transitional probabilities matrix, and the Family regression model requires pavement age information. A simplified approach of considering the current deterioration rate was chosen, which can predict both future PCR and distress. Since only two (or three) data points are currently available for each pavement, linear regression is used. As more local condition data become available, the prediction method may be refined.
FINDINGS OF THE RESEARCH EFFORT

The findings of this study are presented in this section. They include:

I. Forecasted pavement conditions,
II. Validation of the developed forecasting models,
III. Summary of the estimated remaining service life of pavements,
IV. Estimated initial PCR after various rehabilitation or maintenance treatments,
V. Rehabilitation decision trees and multiyear work plan tool, and
VI. Pavement management database for local routes.

I. Forecasted Pavement Conditions

Future pavement conditions can be forecasted using the developed models. As mentioned earlier, for the Markov model and the Family Regression model, the forecasted conditions are based on the latest available condition measurement, while for the Individual Regression model, a best fit curve for all known PCR values is used to predict future conditions. The Individual Regression model requires at least three PCR data from the same pavement to make a prediction. Therefore, it cannot be used for newer pavements that have less than three years of PCR data.

Table 8 shows an example of the predicted PCR values for four pavement sections in District 11. Figure 17 illustrates the forecasted pavement conditions from the three models for a specific pavement section, COL-39-0-1.06.

For the Markov model, the predictions can also be made with a specified confidence interval. Figure 18 shows that when a 90% confidence interval is specified, the predicted pavement condition can be in a range. Generally, however, only the most likely value is reported.
Table 8. Predicted Pavement Conditions from the Three Models

| District | County | Route | Station | Blog | Ellog | Year | Priority | Pave Type | AC | Model Type | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|----------|--------|-------|---------|------|-------|------|----------|-----------|----|-------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 11       | CAR    | 171R  | UP      | 8.82 | 10.76 | 1995 | G        | 3         | 50 | Actual      | 86   | 87   | 85   | 82   | 78   | 70   | 70   |      |      |      |      |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | I           | 69   | 66   | 63   | 60   | 57   | 54   | 50   | 47   | 46   | 44   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | II          | 67   | 65   | 62   | 59   | 56   | 54   | 51   | 48   | 45   | 43   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | III         | 69   | 69   | 68   | 68   | 67   | 66   | 66   | 65   | 65   | 65   |      |      |      |      |      |      |      |
| 11       | CAR    | 332R  | UP      | 6.48 | 10.31 | 1995 | G        | 3         | 50 | Actual      | 72   | 75   | 75   | 68   | 68   | 60   | 58   |      |      |      |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | I           | 58   | 57   | 55   | 52   | 50   | 48   | 45   | 44   | 42   | 41   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | II          | 55   | 53   | 50   | 47   | 44   | 42   | 39   | 36   | 33   | 31   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | III         | 57   | 56   | 55   | 55   | 54   | 53   | 52   | 52   | 51   | 50   |      |      |      |      |      |      |      |
| 11       | COL    | 039R  | UP      | 0     | 1.06  | 1995 | G        | 3         | 50 | Actual      | 79   | 79   | 76   | 71   | 69   | 70   | 67   |      |      |      |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | I           | 66   | 64   | 62   | 59   | 56   | 53   | 49   | 47   | 45   | 43   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | II          | 64   | 62   | 59   | 56   | 53   | 51   | 48   | 45   | 42   | 40   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | III         | 66   | 65   | 64   | 63   | 62   | 61   | 60   | 59   | 58   | 58   |      |      |      |      |      |      |      |
| 11       | HOL    | 557R  | UP      | 6.57 | 10.23 | 1995 | G        | 3         | 50 | Actual      | 74   | 71   | 71   | 76   | 74   | 66   | 66   |      |      |      |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | I           | 65   | 63   | 60   | 58   | 55   | 52   | 47   | 45   | 43   | 42   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | II          | 63   | 61   | 58   | 55   | 52   | 50   | 47   | 44   | 41   | 39   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | III         | 65   | 64   | 63   | 63   | 62   | 61   | 60   | 60   | 59   | 59   |      |      |      |      |      |      |      |
| 11       | TUS    | 039R  | UP      | 23.92| 24.92 | 1995 | G        | 3         | 50 | Actual      | 87   | 83   | 81   | 78   | 78   | 78   | 77   |      |      |      |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | I           | 76   | 72   | 69   | 66   | 63   | 60   | 55   | 53   | 51   | 49   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | II          | 74   | 72   | 69   | 66   | 63   | 61   | 58   | 55   | 52   | 50   |      |      |      |      |      |      |      |
|          |        |       |         |      |       |      |          |           |    | III         | 77   | 76   | 76   | 76   | 75   | 75   | 74   | 74   | 74   | 74   |      |      |      |      |      |      |      |

I – Markov Model  
II – Family Regression Model  
III - Individual Regression Model  

*AC – Activity Code
Figure 17. Markov Model Predicted PCR for an Individual Pavement Section

Figure 18. Predicted Conditions with Confidence Interval
II. Validation of the Developed Forecasting Models

The predicted results of the Markov and both regression models are validated through comparison with actual observed pavement conditions. For validation purpose, overlays on General system flexible pavements in District 11 were used as the test data set to verify the predicted results. PCR measurements from 1985 to 2001 were used to develop the models, and the predicted PCR values for the 2002 to 2006 period were compared to the actual measured PCR during that same period. If a pavement section was rehabilitated between 2002 and 2006, the initial PCR for that rehabilitation treatment was determined and subsequent PCR values predicted. Table 9 shows the amount of PCR data available for District 11 General System flexible and composite pavements from 1985 to 2001.

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>Total Directional Miles</th>
<th>Total No. of Pavement Sections</th>
<th>Total No. of PCR Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible</td>
<td>634.18</td>
<td>372</td>
<td>1531</td>
</tr>
</tbody>
</table>

Table 9. Data Used for Validation (District 11 General System Flexible Pavement Treated with Activity Code 50 or 60 between 1985 and 2001)

The Markov model needs a transition matrix to predict PCR values. In the present study, two sets of transition matrices were developed. The first set of transition matrices were generated using pavement sections that were repaired before 1994. The second set of transition matrices were generated using pavement sections that were repaired since 1994. It was determined that pavements repaired after mid 90’s performed better than those repaired in previous years. Hence, pavement sections that were repaired before 1994 use the first set of transition matrices, while pavement sections repaired after 1994 use the second set of transition matrices. For the family regression model, data were divided into two sets based on the date of construction/rehabilitation (similar to Markov model). For the individual section regression model, since each pavement section has its own regression equation, there is no need for a separate model to account for improvements in pavement performance in more recent years.
Table 10 shows a sample of the validation data. The actual measured PCR between years 2002 and 2006 are compared to the predicted PCR during the same time period. Figure 19 illustrates the actual versus predicted PCR conditions for a specific pavement section.

Figure 19. Actual PCR vs. Different Model Predicted PCR for a Pavement Section in District 11 treated with Activity Code 50
Table 10. Actual PCR vs. Different Model Predicted PCR

<table>
<thead>
<tr>
<th>District</th>
<th>County</th>
<th>Route</th>
<th>Station</th>
<th>Blog</th>
<th>Elag</th>
<th>Year</th>
<th>Priority</th>
<th>Pave Type</th>
<th>AC*</th>
<th>Model Type</th>
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<th>1998</th>
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<td>Flexible</td>
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</tr>
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</table>

* AC – Activity Code
Markov Model Results

The predicted PCR values obtained from the Markov model versus the actual PCR values are plotted in Figure 20. Model accuracy is expressed by (1) root mean squared error (RMSE), and (2) coefficient of correlation ($\rho$). The RMSE is defined as:

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (PCR_p - PCR_A)^2}{n}}$$

where $PCR_p$ is the predicted PCR value from the prediction model, $PCR_A$ is the actual PCR measurement and $n$ is the number of observations. Smaller RMSE value indicates a more accurate model.

The correlation coefficient signifies the degree of match between actual and predicted PCR. A perfect match would have a correlation coefficient of 1.0.

![Figure 20. Markov Predicted PCR vs. Actual PCR (2002-2006)](image_url)
It can be seen from Figure 20 that some of the predicted values are quite different from the measured values. After examining the corresponding PCR curves, it was determined that they were due to ‘abnormal’ deterioration trends such as (1) sudden decreases of measured PCR values, or (2) nearly flat or even gradually increasing PCR curves where a series of undocumented maintenance activities may have been performed.

Figure 21 shows an actual pavement section in the data. This is typical of the ‘abnormal’ trends where PCR drops in initial years are consistent, but the rate of deterioration increase significantly after a few years. The Markov and other models can not predict this type of sudden change.

Figure 22 shows another actual case, where the pavement ‘stops’ deteriorating after initially deteriorating at a ‘normal’ rate. This is likely due to undocumented maintenance activities. None of the statistical-based prediction models can predict these abnormal trends.
Predicted versus Actual PCR

PCR Fluctuation

Section: COL 344R UP
Blog - Blog : 1.27- 3

Figure 22. Fluctuation in PCR

Family Regression Model

Separate regression equations were developed for treatment 50 (overlay without repairs) and treatment 60 (overlay with repairs) for General system flexible pavements in District 11. The regression equations are:


\[ \text{PCR}_p = 86.634 - 5.438 \times [(\text{Age} + 1)^{0.728} - 1], \]
\[ n = 3791, R^2 = 0.38 \] (17)


\[ \text{PCR}_p = 98.383 - 9.453 \times [(\text{Age} + 1)^{0.728} - 1], \]
\[ n = 2803, R^2 = 0.72 \] (18)

Activity Code 60 (1985-2001):

\[ \text{PCR}_p = 98.401 - 6.142 \times [(\text{Age} + 1)^{0.728} - 1], \]
\[ n = 1523, R^2 = 0.74 \] (19)
Similar to the Markov model, the last five years of data from 2001 to 2005 are removed. The predicted PCR values versus the actual PCR values during the same time period are shown in Figure 23.

![Family Regression Predicted PCR vs. Actual PCR](image)

**Figure 23. Family Regression Predicted PCR vs. Actual PCR (2002-2006)**

**Individual Section Regression Model**

The individual section regression model is based on fitting a regression between PCR and age for each and every individual pavement section. In other words, each pavement section has its own regression equation. The regression equation has the following form:

$$PCR_p = \text{Intercept} + \text{Slope} \times [(\text{Age} + 1)^{0.728} - 1],$$  \hspace{1cm} (16)

where $PCR_p$ is the predicted PCR value and $[(\text{Age} + 1)^{0.728} - 1]$ is the age transformation used to account for the non linear deterioration trend between PCR and age. As with the Markov model, the last five years of data from 2002 to 2006 were removed for model development, and used for validation. The predicted PCR values versus the actual PCR values during the same time period are plotted in Figure 24.
Figure 24. Individual Regression Predicted PCR vs. Actual PCR (2002-2006)

Table 11 summarizes the RMSE and correlation values for each of the models before and after removing the outliers. The number of PCR data points included in the individual regression model are fewer, because a minimum of three years of PCR data are required to develop the individual section regression equation. Therefore, those pavement sections with less than three years of PCR data are excluded from the analysis.

Table 11. Comparison of Model Accuracies

<table>
<thead>
<tr>
<th>Forecasting Models</th>
<th>Total Directional Miles</th>
<th>Total No. of Sections</th>
<th>Data Points</th>
<th>RMSE</th>
<th>Correlation Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Markov Model</td>
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<td>372</td>
<td>1531</td>
<td>6.55</td>
<td>0.81</td>
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<tr>
<td>Family Regression</td>
<td>634.18</td>
<td>372</td>
<td>1531</td>
<td>7.24</td>
<td>0.80</td>
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<tr>
<td>Individual Regression</td>
<td>570.91</td>
<td>336</td>
<td>1342</td>
<td>8.73</td>
<td>0.76</td>
</tr>
</tbody>
</table>
The error of prediction increases with the time frame of prediction, that is, prediction of near future is more accurate than prediction further into the future. Figure 25 shows the RMSE increases quickly with time period of prediction, especially for the individual regression model. Therefore, the individual regression model is not recommended.

![Figure 25. Prediction Error Increases with Time](image)

From the above analysis, it can be concluded that overall, the Markov model provides better accuracy than the two types of regression models. An important benefit of the Markov model is that it can also predict individual distresses. The Markov model requires a sufficient number of pavements with similar deterioration trends in order to develop a reliable transitional probabilities matrix. Since the ODOT database contains a very large number of pavement sections, this does not present a problem, especially for overlays, which constitute the vast majority of the treatments performed. However, some treatment activities have not been used widely, and the number of pavements that have received the treatment is relatively small. For those cases, a family regression model is recommended.
III. Summary of Estimated Remaining Service Life of Pavements

The remaining service life of a pavement can be estimated based on its current and forecasted conditions. The terminal condition of a pavement, the condition at which a pavement is considered to reach the end of its useful service life, may be defined by several criteria, such as a minimum allowable PCR score and/or specific distress level; for example, rutting distress must be less than H (0.5 inch). A tool has been developed as part of this study to estimate the remaining service life of each pavement. The default terminal conditions are a PCR score below 65 for Priority system pavements, and a PCR score below 60 for General/Urban systems pavements.

Figure 25 summarizes the estimated remaining service life of pavements in each District as of 2007. Pavements with no remaining service life (0 years remaining) are those with current PCR scores already below the terminal thresholds. In other words, these pavements are considered as ‘deficient’.

The Districts with large mileage of ‘deficient’ or ‘near deficient’ pavements are experiencing excessive rehabilitation needs. These include Districts 3, 4, 6, 9, 10, and 11. Note the majority of the pavements in District 12 are Priority system pavements, and a significant number of them require rehabilitation. In contrast, Districts 1 and 7 have notably fewer pavement sections that are deficient or near deficient.

The estimated remaining service life of pavements can be very useful in assessing the overall network condition, estimating rehabilitation needs and funding requirements, and planning and prioritizing rehabilitation projects.
Figure 26-a Remaining Service Life of Pavements in each District

- **Priority System** (Terminal PCR Threshold = 65)
- **General System** (Terminal PCR Threshold = 60)

Estimated Remaining Service Life (in years)
Figure 26-b. Remaining Service Life of Pavements in each District
VI. Estimated Initial PCR after Various Rehabilitation or Maintenance Treatments

The initial PCR value of a pavement after a rehabilitation treatment will depend on the type and level of distress existing prior to the treatment and the effectiveness of that specific treatment’s in addressing those distresses.

Figure 27 illustrates how the average deduct value of a particular distress at the initial year (Year 0) is obtained from the intercept of a linear regression of the average deducts of this distress from two to five years after the rehabilitation treatment. The resulting initial deduct value is then converted to the nearest distress level description. The average initial PCR value after a rehabilitation treatment is obtained by combining all the distress deducts.

Figure 28 shows that for a specific pavement section, the initial distress level is also a function of the level of the same distress prior to treatment. For example, after an overlay, the initial rutting level is likely to be NULL, if the rutting level prior to overlay was LO, LF, LE, or MO. However, if the rutting level prior to overlay was MF, ME, HO, HF, or HE, then the initial rutting level after overlay is likely LO. Initial levels of other distresses are determined in the same way. Therefore, the initial PCR value of each pavement section can be determined from the prior distress level and the treatment applied.

The average distress levels prior to and after various rehabilitation treatments for Concrete Pavements, Priority system flexible and composite pavements, and General system flexible and composite pavements, respectively, are shown in Table 12. The average PCR values before and after various treatment are also shown.
Figure 27. Determine Initial Distress Level from the Distress Levels in Years 2, 3, 4, 5
Figure 28. Initial Distress Level after Overlay as a Function of Prior Distress Level
### Table 12. Average Distress Levels Before and After Treatment and Average Initial PCR Values

#### CONCRETE PAVEMENTS

<table>
<thead>
<tr>
<th>Activity Name</th>
<th>Activity Code</th>
<th>Prior / Immediately After Treatment</th>
<th>Surface Deterioration</th>
<th>Popouts</th>
<th>Patching</th>
<th>Pumping</th>
<th>Faulting Joints &amp; Cracks</th>
<th>Settlements</th>
<th>Transverse Joint Spalling</th>
<th>Joint Sealant Damage</th>
<th>Pressure Damage</th>
<th>Transverse Cracking, Reinforced Concrete</th>
<th>Longitudinal Cracking</th>
<th>Corner Breaks</th>
<th>Longitudinal Joint Spalling</th>
<th>Transverse Cracking, Plain Concrete</th>
<th>Average Cracking Deduct (CD)</th>
<th>Average Structural Deduct (SD)</th>
<th>Average Initial PCR</th>
</tr>
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<tbody>
<tr>
<td>Reactive Maintenance</td>
<td>10</td>
<td>Prior After</td>
<td>LE</td>
<td>LF</td>
<td>*</td>
<td>*</td>
<td>*</td>
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<td>LO</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>O</td>
<td>*</td>
<td>LE</td>
<td>LO</td>
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<td>F</td>
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<td>LO</td>
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<td>*</td>
<td>*</td>
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<td>MF</td>
<td>HO</td>
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<td>MF</td>
<td>*</td>
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## Concrete Pavements

### Average Distress Level Prior and After Treatment (* indicates NULL)

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<th>Surface Deterioration SD</th>
<th>Popouts LF</th>
<th>Patching *</th>
<th>Pumping *</th>
<th>Faulting Joints &amp; Cracks SD</th>
<th>Settlements</th>
<th>Transverse Joint Spalling *</th>
<th>Joint Sealant Damage SD</th>
<th>Pressure Damage SD &amp; CD</th>
<th>Transverse Cracking, Reinforced Concrete SD &amp; CD</th>
<th>Longitudinal Cracking SD</th>
<th>Corner Cracks CD</th>
<th>Longitudinal Joint Spalling</th>
<th>Transverse Cracking, Plain Concrete SD &amp; CD</th>
<th>Average Cracking Deduct (CD)</th>
<th>Average Structural Deduct (SD)</th>
<th>Average Initial PCR</th>
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## PRIORITY SYSTEM  FLEXIBLE PAVEMENT

### Average Distress Level Prior and After Treatment (* indicates NULL)

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<tr>
<th>Activity Name</th>
<th>Activity Code</th>
<th>Prior / Immediately After Treatment</th>
<th>Average Distress Level Prior and After Treatment (* indicates NULL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive Maintenance</td>
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<tr>
<td>Crack Sealing</td>
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<td>Prior MO * LE * LO * O * LO *</td>
<td>Average Structural Deduct (SD) 9.6 79</td>
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<td>Micro-Surfacing</td>
<td>30</td>
<td>Prior MO * LF * MF * E *</td>
<td>Average / Initial PCR 69</td>
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<tr>
<td>Double Application Micro-Surfacing</td>
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<td>Prior MO * LF * O * LE *</td>
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<tr>
<td>Fine Graded Polymer AC Overlay</td>
<td>38</td>
<td>Prior MO * LE * O *</td>
<td>Average / Initial PCR 69</td>
</tr>
<tr>
<td>AC Overlay Without Repairs</td>
<td>50</td>
<td>Prior MO * LE * LF * F *</td>
<td>Average Cracking Deduct (CD) 1.5 1.0 94</td>
</tr>
<tr>
<td>AC Inlay</td>
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<td>Prior MO * LF * O *</td>
<td>Average / Initial PCR 69</td>
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<td>Double Chip Seal</td>
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<td>Prior MO * LF * O *</td>
<td>Average / Initial PCR 69</td>
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*SD* & *CD*
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<th>Activity Name</th>
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<th>Average Distress Level Prior and After Treatment (* indicates NULL)</th>
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<td></td>
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<td>MF</td>
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<td>After</td>
<td>MO</td>
</tr>
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<td>Prior</td>
<td>MO</td>
</tr>
<tr>
<td>Contract</td>
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## PRIORITY SYSTEM COMPOSITE PAVEMENT

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## GENERAL SYSTEM  FLEXIBLE PAVEMENT

### Average Distress Level Prior and After Treatment (* indicates NULL)

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### General System Composite Pavement

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## GENERAL SYSTEM  COMPOSITE PAVEMENT

### Average Distress Level Prior and After Treatment (* indicates NULL)

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<th>Patching</th>
<th>Surface Disintegration/ Debonding</th>
<th>Rutting</th>
<th>Pumping</th>
<th>Shattered Slab (Jointed Base)</th>
<th>Settlements</th>
<th>Transverse Cracks (Unjointed Base)</th>
<th>Joint Reflection Cracks (Jointed Base)</th>
<th>Intermediate Transverse Cracks (Jointed Base)</th>
<th>Longitudinal Cracking</th>
<th>Pressure Damage/Upheaval</th>
<th>Crack Sealing Deficiency</th>
<th>Corrugations</th>
<th>Corner Breaks (Jointed Base)</th>
<th>Punchouts (Unjointed Base)</th>
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V. Rehabilitation Decision Trees and Multiyear Work Plan Tool

A set of rehabilitation treatment decision trees was developed in cooperation with the Office of Pavement Engineering. Separate decision trees were developed for Priority system major rehabilitation candidates, concrete pavements, Priority system composite and flexible pavements, General system composite and flexible pavements, General system low volume pavements, and poor performance and poor condition pavements. These recommended rehabilitation treatment decision trees are shown in Appendix B.

By applying the recommended treatment decision trees to the current and forecasted future pavement conditions, the rehabilitation needs for the current and future years can be obtained. As the available budgets are not likely to satisfy all rehabilitation needs, an actual work plan must be developed with consideration of budget and other constraints such as keeping the percentage of ‘deficient’ pavements below a certain limits.

A tool has been developed to evaluate and compare alternative multiple-year work plans based on their effect on predicted future conditions. Figure 29 shows the View Predicted Pavement Condition with Work Plan menu. The planned future projects are imported from a spreadsheet and saved in a table named DATA_FutureProjects.

Table 13 shows the resulting predicted PCR values after the effects of planned work have been incorporated for a group of selected pavements. Figure 30 shows the existing and predicted PCR trends with and without planned treatment for a specific pavement section.
Figure 29. View Predicted Pavement Condition with Work Plan Tool

Figure 30. Predicted PCR Trend with and without Planned Treatment
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<th>PaveID</th>
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<th>County</th>
<th>Route</th>
<th>Blog</th>
<th>Elog</th>
<th>Pave Type</th>
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</table>

- Actual PCR  85 - Predicted PCR  58 - Predicted PCR below threshold
VI. Pavement Management Database for Local Routes

Table 14 shows a summary of the data contained in the LOCAL PMIS database for local federal-aid routes and the current (or latest) condition based on the available PCR measurements. As can been from Table 14, Districts 1, 2, 6, 7, 8 have PCR data from 2003 and 2005, whereas the other Districts have data from 2003, 2004, and 2006.

Statewide, a total of 11,611 miles of local pavements are included in the database. Approximately 32.9 percent are in very good condition, 24.9 percent are in good condition, 21.7 percent are in fair condition, 12 percent are in poor condition, and 8.5 percent are in very poor (or deficient) condition. On average, local pavements in Districts 1, 6, 7, 8, 9 are in better conditions than the rest of the State. Figure 31 shows the condition distribution of local pavements in each District.

Some of the analysis functions and reporting tools available in the ODOTPMIS had to be disabled due to lack of project history data. The primary tools remaining include current condition report, condition forecasting for a single or a group of pavements, remaining service life estimation, and rehabilitation recommendations based on decision trees.

*Forecasting Pavement Condition by Linear Regression*

Since the database for local federal-aid routes contains only two or three years of PCR data in the most recent past, with no project history or construction dates, a linear regression model is used to calculate the average deterioration rate. The linear regression model predicts both individual distresses and overall PCR value for each pavement section. As more data become available in the future, a nonlinear regression or a Markov model may be adopted.

For pavement sections where the best fit line cannot be drawn from the data or where the resulting PCR slope is abnormal (e.g., positive slope which indicates non-deteriorating condition or PCR is decreasing by more than 10 points a year), prediction is done based on the statewide average. Figures 32 and 33 show the PCR trend based on the actual predicted PCR slope and on District average PCR slope respectively.
Table 14. Summary of Local Pavement PCR Data and Current Condition

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<th>District</th>
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Average Condition
Figure 31-a. Condition Distribution of Local Pavements in Each District
Figure 31-b. Condition Distribution of Local Pavements in Each District
Figure 32. PCR Trend Based on Individual Slope for a Pavement Section

District-9; County-ADA; Route- 100; Blog-Elog: 0-7.37
Estimated Remaining Life-10 years; PCR drop/Year = -1.6

Figure 33. PCR Trend Based on Average Sloped for a Pavement Section

District-4; County-SUM; Route- 100; Blog-Elog: 1.02-2.31
Estimated Remaining Life-3 years; Average PCR drop/Year = -3.5
Estimation of Remaining Life of Pavement

LOCALPMIS uses the predicted PCR and distress information to estimate the remaining life of the pavement. The terminal condition in terms of PCR or distress thresholds can be defined by the user. The default terminal condition is PCR value below 60.

Repair Candidates

The pavement database for federal aid local routes includes four types of pavements: Jointed Concrete Pavement (JCP), Local Pavement (Asphalt), Brick Pavement, and Gravel Pavement. The rehabilitation decision tree for Local Pavement was designed in cooperation with ODOT officials. For JCP, the same rehabilitation decision tree for state highways was used. Decision trees for the brick and gravel pavements are not available at this time.

Based on the repair decision tree and the current PCR and distress information, LOCALPMIS generates a report listing the pavement sections that require Preventive Maintenance (PM), Minor Rehabilitation, or Major Rehabilitation. The report also lists the pavement sections which do not require any repair.

Report

LOCALPMIS can generate both the existing and future pavement condition report and can also generate a graph displaying PCR trend for any individual pavement section. Both the existing and future condition reports contain the section-wise information of PCR and distresses.

More detailed information on the LOCALPMIS is presented in Appendix D.
CONCLUSIONS AND RECOMMENDATIONS

Transportation agencies around the Country must find ways to cope with rapidly rising construction costs, which are unlikely to be offset by highway budget increases in the foreseeable future. Prudent use of available rehabilitation budget is essential to maintain and preserve the existing highway infrastructure during this challenging period. Selection of the most beneficial projects among competing needs and determination of the most cost-effective rehabilitation strategies require knowledge regarding future system conditions. This research study has developed models and tools to forecast future conditions and estimate remaining service life of pavements. The results can be used to support pavement maintenance and rehabilitation planning and management decisions.

Based on the findings of this research study, the following conclusions can be made:

1. Pavement condition can be predicted using the models developed in this study. Having the capability to forecast future conditions and to estimate the remaining service life of pavements provides invaluable decision support in choosing the most cost-effective strategies.

2. The following three forecasting models: the individual section regression, the “family” regression, and the Markov transition models were developed in this project. These statistical models were developed based on past performance data available in the ODOT pavement management database.

3. The family regression model and the Markov transition model require pavements to be grouped into “families” with similar characteristics. In this study, pavements within the same system, pavement type, or District, or those having received the same treatment activity are considered as in the same “family”. However, there still can be fairly large variations in deterioration trends within the same “family”. This “within family” variation is one of the sources of prediction errors.

4. A tool was developed to allow the user to define “families” with different characteristics. This provides more flexibility in choosing the “family” members yielding more accurate prediction. However, each family should include a significant number of pavements with
varying ages for the forecasting to be reliable. A minimum number of approximately 300 sections is recommended.

5. The prediction models were validated by comparing the predicted pavement distress and PCR conditions to the measured actual conditions. Predicted pavement conditions for the period of 2002-2006 were compared with measured actual conditions during the same period. In general, the predicted results matched reasonably well with measured data. The Markov model delivers the best overall accuracy, followed by the family regression model.

6. The individual regression model relies only on the available past deterioration trend to predict future conditions. It requires at least a few years of known PCR condition data for a specific pavement section. Therefore, it cannot be applied to newer pavements, where predictions of future conditions would be most useful.

7. Both the family regression and Markov models predict future conditions based on the known current (or latest available) condition. The prediction error increases as the time span increases. That is, prediction of the near future is more accurate. Therefore, condition forecasting should be performed each year based on the latest, most updated current condition.

8. The Markov model developed in this study first predicts the deduct trend of each individual distress. It then predicts the PCR value by summing up the total deducts from all the distresses. The ability of the Markov model to predict the individual distress level (and the likely severity and extent) is an important benefit over the other forecasting models.

9. Attrition of pavement condition data due to fewer pavements with more advanced ages, also called “drop outs”, can cause the average deterioration trend to appear to ‘level off’ and not deteriorate any further beyond a certain age. This can result in overestimation of pavement conditions and possibly cause underfunding of the rehabilitation program. A technique called ‘imputation’ was used to address this problem for both the family regression and Markov models.

10. All three of the developed forecasting models can predict non-linear deterioration trends. The Markov model has the advantage of forming the best-fit non-linear deterioration curve without requiring the non-linear function to be specified.

11. The predictions provided by the forecasting models are not perfect. All three models fail to accurately predict pavement conditions when the deterioration trends are inconsistent,
such as pavements that deteriorate suddenly following a steady deterioration, pavements that stop deteriorating after relatively rapid deterioration, or pavements with fluctuating conditions but no apparent deterioration trend.

12. The Markov model requires a significant number of pavement sections with similar characteristics in order for the developed transition matrix to be reliable. Since the ODOT pavement database contains a large number of pavement sections, this does not present a major problem, especially for the more commonly performed treatment activities such as overlays. For treatment activities that do not have a sufficient number of pavement sections, the family regression model with Shahin’s ‘shift’ method can be used.

13. The remaining service life of a pavement is estimated by counting the number of years between the current year and the year its predicted conditions fall below a specified terminal condition. The default terminal condition for Priority system pavements is PCR value of 65, and for General system pavements, PCR of 60.

14. Pavements with zero years of remaining service life are considered as ‘deficient’. Based on the forecasted pavement conditions and the rehabilitation work planned by ODOT for the next five years, the number of pavements that will be in deficiency will rise substantially in the next few years.

15. Reasonable initial PCR values after various rehabilitation treatments were determined based to on average distress condition progressions after the same rehabilitation treatment. The type and level of distresses presented prior to the rehabilitation were also factored in. The resulting initial PCR values reflect more realistically the actual pavement condition than assigning a perfect score to all newly rehabilitated pavements.

16. A set of rehabilitation recommendation decision trees developed by the Office of Pavement Engineering was used to establish the most appropriate treatment for each pavement section. The recommended rehabilitation treatment, if any, was determined based on the type of pavement structure, traffic volume on the pavement, current pavement distress conditions, past performance, and treatment history.

17. Current and future maintenance and rehabilitation needs can be determined. The future needs are dependent upon the work being performed and planned. A tool has been developed to allow various multiple-year work plans to be evaluated as to their impact on forecasted future network conditions.
18. A separate pavement database for local federal-aid routes has been developed. The amount and type of data available to these local pavements are very different from that of the state highway pavements. Therefore, a separate database and different functions have been developed.

The following recommendations are made based on the findings of this study:

1. Overall, the developed forecasting models provide acceptable accuracy in predicting future pavement conditions. Therefore, it is recommended that ODOT use the predicted conditions to support pavement management decisions such as developing rehabilitation work plans.

2. The Markov transition model is the recommended model for predicting pavement conditions after overlay (with or without repair), which is the predominant rehabilitation treatment, accounting for 85-90 percent of total repair mileage.

3. When the number of pavements in a “family” group is relatively small (for example, less than 300 miles total), family regression model with ‘shift’ is recommended.

4. The individual regression model is recommended for local Federal-aid route pavements, since no pavement age data are currently available. The dependent variable is the PCR value, whereas the independent variable is the calendar year.

5. Further study to refine the “family group” definition is recommended to further improve the prediction accuracy.

6. The predicted pavement conditions and remaining service life estimations should be updated each year based on the latest pavement condition rating. The corresponding rehabilitation treatment recommendations for current and future years and the multiple-year work plan should also be updated on a yearly basis.

7. Continuing yearly collection of pavement condition data in a consistent manner is highly recommended.

8. The initial PCR value estimates after various rehabilitation treatments developed in this study are recommended to be used by ODOT to reflect more realistically the actual pavement conditions.
9. The statewide pavement network conditions are projected to worsen in the next several years based on the forecasted pavement conditions and the scheduled work. It is recommended that ODOT take countermeasures to preserve the existing pavement assets. Such countermeasures may include more careful selection of pavement sections for rehabilitation, applying more cost-effective rehabilitation treatments, and adopting best pavement management practices at both Central and District offices.
IMPLEMENTATION PLAN

The results of this research study can be implemented as follows:

1. The pavement condition forecasting models, the remaining service life estimation function, and the rehabilitation recommendation decision trees have been incorporated into the ODOT Pavement Management Database. Predicted future conditions, estimated remaining service lives, and rehabilitation treatment recommendations for a specified group of pavements or for the entire state highway network can be generated. Alternative multiyear rehabilitation work plans can be evaluated with regard to their impact on future network conditions. The Office of Pavement Engineering has taken a proactive role in leading the efforts to implement the results of this research study. Most of the tools developed in this study have been used by the Office to support pavement management activities.

2. The results of this study may be integrated with findings from other related research projects to support a comprehensive pavement management system. Such a system can fully support the various critical pavement management decisions routinely made by the Central Office as well as District Offices in a timely manner.

3. Local agencies (counties and municipalities) can use the local Federal-aid routes pavement database developed in this study to support local pavement management decisions. Since the same pavement condition rating system is used for both State highways and local roads, more consistency in the pavement management process is possible.
APPENDICES

A. References

B. Rehabilitation Decision Trees

C. PMIS User Manual

D. Local PMIS User Manual
APPENDIX A. REFERENCES


APPENDIX B. REHABILITATION DECISION TREES

FIGURE B-1. Priority System Major Rehabilitation Candidates List
FIGURE B-2. Priority System Concrete Pavements Decision Tree
FIGURE B-3. Priority System Flexible and Composite Pavements Decision Tree
FIGURE B-4. Priority System Flexible and Composite Pavements Decision Tree (Continued)

B-4
FIGURE B-5. General System Decision Tree
FIGURE B-6. General System Decision Tree for Poor Performing and Poor Condition Pavements
FIGURE B-7. General System Decision Tree for Low Volume Pavements
FIGURE B-8. General System Decision Tree for Composite Pavements
FIGURE B-9. General System Decision Tree for Flexible Pavements
APPENDIX C. ODOTPMIS USER MANUAL

The pavement management database (ODOTPMIS) has been extensively updated as part of this study. Several new tools were added and a few of the existing tools were revised. This Appendix provides a detailed user manual to the entire updated ODOTPMIS.

The new tools include: Generate Markov Predictions, Show Predicted Pavement Conditions, Estimate Remaining Life, and Import Planned Projects.

The tools that have been revised are: Derived Performance Trend, Rehabilitation Candidate Lists, Apparent Projects Determination, and Import Pavement Condition Data.
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INTRODUCTION

The Infrastructure Information System Laboratory at the University of Toledo has developed a Pavement Database for the Ohio Department of Transportation using the Microsoft Access database format. The ODOTPMIS includes the database and a set of reporting tools to extract the data necessary for pavement performance analysis.

This section of the user’s manual includes installation procedures of the ODOTPMIS, an introduction to the menu items, and a brief overview of the basic operations.

1.1 System Installation

Three types of installations may be performed: full, lightweight, and executable file only. The full version includes the entire database, and is necessary for new users. The lightweight version is for users who have the database, but wish to update the program and the required runtime components. During installation, click the “Yes,” “Next,” and “OK,” buttons to install ODOTPMIS successfully. The default directory where PMIS is installed is “C:\Program Files\ODOT Pavement Management Information System.” Users can change this installation directory by selecting a different location. Figure C-1 shows the sequential steps in installing ODOTPMIS for the full and lightweight versions.

Users requiring an executable file only installation should download the new executable file from the ODOTPMIS download page and replace the existing executable file (ODOTPMIS.exe) found in the installation directory.

Some program updates may also require updating tables in the database. To replace only these tables in the database:

1. Download the updated tables
2. Open the original database (odot.mdb) in Microsoft Access
3. Delete or rename the tables which will be replaced
4. Under the “File” menu choose “Get External Data” and click “Import”
5. Select the newly downloaded database
6. Select the updated tables
7. Click OK
Newer versions and updates of ODOT PMIS can be downloaded from http://www.eng.utoledo.edu/civil/chou/index.htm under the OdotPMIS Download Page link.

Once ODOTPMIS is installed, it attempts to locate the most recently accessed database. If no database can be found, it prompts the user to locate the database manually. To store this path, go to the “File” menu, choose “Preference,” check the “Load Last Database” and “Save Database Path” checkboxes, and click the “Apply” button. In the future, ODOTPMIS will use this saved path as the default database path.

1.2 Reinstallation
After each reinstallation of the ODOTPMIS, the user must locate the path to the database.

1.3 Uninstallation
ODOTPMIS should be uninstalled before a full reinstallation. When uninstalling an older version of the ODOTPMIS, the database is not deleted automatically. If a database with the same name already exists in the same directory where a full version of ODOTPMIS is to be installed, the new database cannot be copied into the same directory. The user must manually delete the older database. This is done to prevent accidental overwriting of the existing database.

1.4 System Requirements
Recommended software platform requirements for running this package are:

1. Windows 98 / Me / 2000 / XP

Recommended minimum hardware platform requirements for running this package are:

1. Pentium II 300Mhz CPU
2. 128MB RAM
3. 14" color monitor
4. 2GB free hard disk space
5. Mouse
6. Color printer
7. 4MB video memory
8. CD-ROM drive

1.5 Compact Database

Users may find it is necessary to compact the database when its size exceeds 1GB. The database can be compacted by the following process.

1. Choose “Compact and Repair Database” in the “File” menu
2. Open the Access database file “ODOT.MDB” and in the “Tools” menu, choose “Database Utilities,” and click on “Compact and Repair Database”

This operation may take 5 – 10 minutes, depending on the size of the database and the specifications of the computer.
1.6 Required Tables

For the PMIS utility to operate, several Data and Look-Up tables are required in the database. The tables are:

<table>
<thead>
<tr>
<th>Data Table</th>
<th>Look-Up Table 1</th>
<th>Look-Up Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA_Apparent Projects</td>
<td>LU_MarkovFamilyDistress</td>
<td>LU_Slope</td>
</tr>
<tr>
<td>DATA_FutureProjects</td>
<td>LU_MarkovFamilyPCR</td>
<td>LU_STD Base Class</td>
</tr>
<tr>
<td>DATA_InitCond</td>
<td>LU_MarkovTree</td>
<td>LU_STD Surface Class</td>
</tr>
<tr>
<td>DATA_ODOT</td>
<td>LU_Median Type</td>
<td>LU_Structural Number</td>
</tr>
<tr>
<td>DATA_PERF_Analysis</td>
<td>LU_NLFID</td>
<td>LU_Weather</td>
</tr>
<tr>
<td>DATA_PERF_BASE</td>
<td>LU_Parameter Range</td>
<td>LU_STD Surface Class</td>
</tr>
<tr>
<td>DATA_Project History</td>
<td>LU_PaveType</td>
<td>LU_Structural Number</td>
</tr>
<tr>
<td>DATA_Road Inventory</td>
<td>LU_PQIParameters</td>
<td>LU_Weather</td>
</tr>
<tr>
<td>LU_Pavement Layer</td>
<td>LU_Priority</td>
<td>LU_STD Surface Class</td>
</tr>
<tr>
<td>LU_Activity</td>
<td>LU_Project AggType</td>
<td>LU_Structural Number</td>
</tr>
<tr>
<td>LU_Activity Modified</td>
<td>LU_RehabCost</td>
<td>LU_Weather</td>
</tr>
<tr>
<td>LU_AggType</td>
<td>LU_Repair Limits</td>
<td>LU_Structural Number</td>
</tr>
<tr>
<td>LU_BinSummary</td>
<td>LU_Repair Logic</td>
<td>LU_Weather</td>
</tr>
<tr>
<td>LU_Centerline Length</td>
<td>LU_Route_Suffix</td>
<td>LU_Color</td>
</tr>
<tr>
<td>LU_FHWA Surface Class</td>
<td>LU_Deduct_1998</td>
<td>LU_COST</td>
</tr>
<tr>
<td>LU_Functional Class</td>
<td>LU_Distress</td>
<td>LU_Weather</td>
</tr>
<tr>
<td>LU_Inflation</td>
<td>LU_Distress_1998</td>
<td>LU_Deduct</td>
</tr>
<tr>
<td>LU_Jurisdiction</td>
<td>LU_LAYER</td>
<td></td>
</tr>
</tbody>
</table>

PMIS prevents all operations from being performed in the database if any of these tables are missing.
ODOTPMIS was developed using Microsoft Visual Basic 6.0 to replicate common window-based graphical user interfaces. As such, the PMIS interface utilizes drop down menus located at the top of the screen, a number of buttons located beneath the menus, and an object browser to list queries and tables stored in the pavement management database. The following is a screenshot of ODOTPMIS.

**FIGURE C-2. ODOTPMIS User Interface**

**File Menu**

The following figure shows the “File” menu options.

<table>
<thead>
<tr>
<th>Open Database</th>
<th>Ctrl+D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Page Setup…</td>
<td></td>
</tr>
<tr>
<td>Print Preview…</td>
<td></td>
</tr>
<tr>
<td>Print…</td>
<td>Ctrl+P</td>
</tr>
<tr>
<td>Preference …</td>
<td></td>
</tr>
<tr>
<td>Compact and Repair Database</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE C-3. ODOTPMIS File Menu**
3.1 Open Database

This command is used to open the desired database for use within ODOTPMIS. The dialog box shown in Figure C-4 is shown when this option is clicked.

![Open Database Dialog Box]

Choose the database file by selecting the directory from the drop down selector labeled “Look in.” Select the file and click “Open.”

3.2 Print Preview

All the tools in ODOTPMIS have a “Print Preview” option. Check this option to get a preview of the output obtained from the tools (reports, tables, or charts). Figure C-6 shows the preview of the lookup table “LU_Activity.”

To preview the same table, use the following process:

1. In the object browser, select “LU_Activity”
2. In the “File” menu, select “Print Preview”
3. The preview shown in Figure C-6 will be generated
### LU Activity

<table>
<thead>
<tr>
<th>Activity Code</th>
<th>Activity</th>
<th>Legend Color</th>
<th>Class</th>
<th>DN ADD</th>
<th>MAN Lage</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>OS/2 Main</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
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<td>Trans</td>
<td>15</td>
</tr>
<tr>
<td>45</td>
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<td>30</td>
</tr>
<tr>
<td>50</td>
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<td>30</td>
</tr>
<tr>
<td>53</td>
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<td>Minor</td>
<td>Trans</td>
<td>30</td>
</tr>
<tr>
<td>90</td>
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<td>Minor</td>
<td>Trans</td>
<td>20</td>
</tr>
<tr>
<td>90</td>
<td>AC General</td>
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<td>Minor</td>
<td>Trans</td>
<td>20</td>
</tr>
<tr>
<td>73</td>
<td>Core/AC Data</td>
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<td>Minor</td>
<td>Trans</td>
<td>20</td>
</tr>
<tr>
<td>77</td>
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<td>25</td>
</tr>
<tr>
<td>71</td>
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<td>Trans</td>
<td>25</td>
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<tr>
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<td>25</td>
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<tr>
<td>80</td>
<td>AC/AC Data</td>
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<td>Trans</td>
<td>25</td>
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<tr>
<td>95</td>
<td>AC/AC Data</td>
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<td>Trans</td>
<td>25</td>
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<tr>
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<tr>
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<tr>
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</tr>
<tr>
<td>348</td>
<td>AC/AC Data</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>25</td>
</tr>
<tr>
<td>358</td>
<td>AC/AC Data</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>25</td>
</tr>
<tr>
<td>368</td>
<td>AC/AC Data</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>25</td>
</tr>
<tr>
<td>378</td>
<td>AC/AC Data</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>25</td>
</tr>
<tr>
<td>388</td>
<td>AC/AC Data</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>25</td>
</tr>
<tr>
<td>398</td>
<td>AC/AC Data</td>
<td>Dark Blue</td>
<td>Minor</td>
<td>Trans</td>
<td>25</td>
</tr>
</tbody>
</table>

**FIGURE C-6. Print Preview of [LU(Activity)]**

This preview page has the following options:

- **Print Current Page**: Print the current page only
- **Go to first page**: Go to first page
- **Go to previous page**: Go to previous page
- **Current page number**: Current page number
- **Go to next page**: Go to next page
- **Go to last page**: Go to last page
- **Open the print setup window**: Open the print setup window
- **Close the print preview**: Close the print preview

**FIGURE C-7. Preview Page Options**

The “Print Setup” window provides options to customize the document for printing. This allows users to change the layout, column widths, column orders, and other organizational aspects. Figure C-8 shows the “Print Setup” window.
FIGURE C-8. Print Setup Dialog Box – Layout Tab

The “Print Setup” dialog has two tabs: layout and data. The layout tab, shown above in Figure C-8, provides options to select the printer, printed page range, orientation, layout, line spacing, and header and footer spacing and text.

FIGURE C-9. Print Setup Dialog Box – Data Tab

The data tab, shown above in Figure C-9, lists the fields that will be printed, along with options to change their appearance.
Users can click on any of the first three columns to change the font, style, and size of the text as shown below in Figure C-10. The following dialog box will be displayed when one of the options is clicked. Users then select the required font, style, and size in the dialog and click “OK.” The fields will reflect the new changes.

![Figure C-10. Font Dialog Box](image)

The main “Print Setup” window has additional options for users to customize the data printout. These options are explained below.

1. **Color**: Changes the text color of the data in selected column
2. **Width**: Columns are adjusted to a default width based on their length in the printout. The “Width” field allows users to enter a custom width length in inches
3. **Skip**: Select a column to hide or show in the printout
4. **Char**: Shows the character length of the field
5. The buttons on the right of the screen allow users to change the order of the fields that will be on the printout
6. **Preview**: Displays a mockup with the changes applied
7. **Print**: Print and close the “Print Setup” window
8. **Close**: Closes the “Print Setup” window without making any changes

### 3.3 Print

This command under the “File” menu is used for printing a table, chart or a grid.

### 3.4 Preference

This option is used to set the default options for ODOTPMIS as shown in Figure C-11. The presence or absence of a checkmark next to an option indicates its state.

**Startup** options appear when the application is opened. These are explained below.

1. **Show Splash Window**: Displays a window showing application information when ODOTPMIS is opened.
2. **Load Last Database**: Loads the last database opened on ODOTPMIS startup.
Exit options appear when the application is closed. These are explained below.

1. **Confirm Exit**: Displays a warning confirmation window when users attempt to close the application.
2. **Compact Database Before Exit**: Compacts the database before each close.
3. **Save Database Path**: Saves the current database path to allow users to open the same database without reentering the location the next time it is opened.

![FIGURE C-11. Preference Setup Interface](image)

### 3.5 Compact and Repair Database

The “Compact and Repair Database” command activates a utility that compresses the database, which increases the analysis speed. This command should be performed regularly to ensure optimal performance. **WARNING:** If the database is allowed to reach its maximum size of two gigabytes, none of the PMIS functions will function. Furthermore, at two gigabytes, the database cannot be used for executing queries. To prevent or alleviate these problems, compact the database regularly.

### 3.6 Close PMIS

This option is used to exit from the PMIS application.
Edit Menu

The “Edit” menu contains commands for changing, creating, and deleting tables and queries. This menu will affect whichever data type is displayed in the object browser, either a query or table. The commands included on this menu are “Open,” “Design,” “Delete,” and “New.” The following figure shows the drop down menu:

![FIGURE C-12. ODOTPMIS Edit Menu]

4.1 Open

This option opens a table for editing values. To open a table, highlight a table in the object browser and select “Open” in the edit menu.

4.2 Design

The “Design” command allows for the creation and deletion of columns in tables or modification of the SQL in queries. To modify a table or query, select it in the object browser and in the “Edit” menu, choose “Design.”

![FIGURE C-13. ODOTPMIS Design Menu]
To add, click on the “Add Field” radio button in the lower left corner of the window. To delete, select the field and click the “Delete” button in the lower left corner of the window. To modify, select the field. ODOTPMIS will allow users to make the changes directly in the table.

4.3 Delete

This command deletes the selected table or query from the database.

4.4 New

Creating a New Table:
1. Click “New” in the “Edit” menu
2. The dialog box as shown in Figure C-14 will appear
3. Enter the desired table name in the dialog and click “Create”
4. This will display the “Design Table Dialog” shown in Figure C-15. Users can add or delete fields, and set field properties like the field name, data type, and size, as well as toggle whether this field is required and whether a zero length is allowed

FIGURE C-14. New Table Name Input Interface

FIGURE C-15. New Table Name Input Interface
Creating a New Query:

1. Select “Queries” in the sidebar of the object browser
2. Click “New” in the “Edit” menu
3. A dialog box as shown in Figure C-16 will be displayed
4. Enter a name for the query in the “Query Name” text box
5. Type in a query. The typed query must follow the standard syntax as Access SQL
6. Close the dialog to auto-save

![Query Edit Interface](image)

**FIGURE C-16. Query Edit Interface**

Modifying an Existing Query

1. Select a query in the object browser
2. In the “Edit” menu, click “Design”
3. A similar dialog box as above will appear displaying the selected query
4. Change the query and close the dialog box to auto-save
View Menu

The “View” menu contains commands for ensuring that the toolbars and the object browser are updated and visible. The commands include “Show Toolbar,” “Show Object Browser,” and “Refresh Object Browser.”

<table>
<thead>
<tr>
<th>Command</th>
<th>Shortcut Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show Object Browser</td>
<td>Ctrl+O</td>
</tr>
<tr>
<td>Show Toolbar</td>
<td>Ctrl+T</td>
</tr>
<tr>
<td>Refresh Object Browser</td>
<td>F5</td>
</tr>
</tbody>
</table>

FIGURE C-17. ODOTPMIS View Menu

5.1 Show Object Browser (Shortcut Key: CTRL+O)

This option is used to show the object browser. The presence of a check mark next to its name in the “View” menu indicates that the object browser will be displayed in the main ODOTPMIS window.

The object browser displays a list of the tables and queries in the current database. The object browser contains two filters:

1. **Tables**: Displays a list of all the tables in the database
2. **Queries**: Displays a list of all the queries in the database
5.2 Show Toolbar (Shortcut Key: CTRL+T)

This option is used to show or hide the toolbar, which contains the following buttons:

- Print
- Print Preview
- Delete Table or Query
- New
- New
- Sort the records of a table in ascending order for selected column (this button appears only when a table is opened)
- Sorts the records of a table in descending order for selected column (this button appears only when a table is opened)
- Linear Superposition*
- Project History Plot*
- Project History
- Statistical Report*
- Map View of a Table*

*See Part IV: Advanced Features

FIGURE C-19. Tool Bar Options

5.3 Refresh Object Browser (Shortcut Key: F5)

This option is used to refresh the object browser to display updated information.
Data Menu

The “Data” menu contains functions that add or modify tables needed for the successful operation of PMIS.

![Data Menu Diagram]

FIGURE C-20. ODOTPMIS Data Menu

6.1 Import Road Inventory Data

This tool allows users to update the road inventory table with new data from text files. Road inventory tables include the following information: road geometry, classification, priority, system, and traffic volume. These tables should be updated every year. The name of this table in ODOTPMIS is DATA_Road Inventory.

**Table to Apply:** [DATA_Road Inventory]

**Data file type:** Fixed column position text file

**Data format:**

```plaintext
[Value 1][Value 2][Value 3][Value 4] … [Value 55]
[Value 1][Value 2][Value 3][Value 4] … [Value 55]
[Value 1][Value 2][Value 3][Value 4] … [Value 55]
```

To import data, click on the “Data” menu and select “Import Road Inventory Data.” The window shown in Figure C-21 will appear. Select the drive on which the file is stored using the “Drives” drop down menu, or use the “Network” button to select a network drive. Navigate to the directory of the data files using the “Folders” sub-window and use the “File name” sub-window to select the correct text file. Click “OK.”

Users may or may not check the “Read only” box to prevent changes to the data, depending on their uses for this specific table.
FIGURE C-21 Import Road Inventory Data

Note: Field values must be in the order specified in following table.

<table>
<thead>
<tr>
<th>Order</th>
<th>Field Name</th>
<th>Data Type</th>
<th>Column Position</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jurisdiction</td>
<td>Text</td>
<td>1</td>
<td>S</td>
</tr>
<tr>
<td>2</td>
<td>County</td>
<td>Text</td>
<td>2-4</td>
<td>ADA</td>
</tr>
<tr>
<td>3</td>
<td>Route</td>
<td>Text</td>
<td>5-7</td>
<td>032</td>
</tr>
<tr>
<td>4</td>
<td>Route Suffix</td>
<td>Text</td>
<td>8</td>
<td>R</td>
</tr>
<tr>
<td>5</td>
<td>Blog</td>
<td>Text</td>
<td>10-13</td>
<td>0000</td>
</tr>
<tr>
<td>6</td>
<td>Log Point Suffix</td>
<td>Text</td>
<td>14</td>
<td>Space</td>
</tr>
<tr>
<td>7</td>
<td>Road Identification</td>
<td>Text</td>
<td>15</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>Data Type</td>
<td>Integer</td>
<td>16-19</td>
<td>PSTB</td>
</tr>
<tr>
<td>9</td>
<td>Data Status</td>
<td>Text</td>
<td>20</td>
<td>E</td>
</tr>
<tr>
<td>10</td>
<td>Transaction</td>
<td>Number</td>
<td>21</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>Inventory Perpetuation Date</td>
<td>Number</td>
<td>22-25</td>
<td>0100</td>
</tr>
<tr>
<td>12</td>
<td>FIPS Code</td>
<td>Number</td>
<td>27-29</td>
<td>Space</td>
</tr>
<tr>
<td>13</td>
<td>Mile Class</td>
<td>Byte</td>
<td>31</td>
<td>l</td>
</tr>
<tr>
<td>14</td>
<td>Section Length</td>
<td>Text</td>
<td>32-35</td>
<td>0035</td>
</tr>
<tr>
<td>15</td>
<td>System Class</td>
<td>Text</td>
<td>36</td>
<td>M</td>
</tr>
<tr>
<td>16</td>
<td>Standard Surface Classification</td>
<td>Text</td>
<td>38</td>
<td>G</td>
</tr>
<tr>
<td>17</td>
<td>Standard Base Classification</td>
<td>Text</td>
<td>39</td>
<td>L</td>
</tr>
<tr>
<td>18</td>
<td>Summary FHWA Surface Type</td>
<td>Text</td>
<td>40-41</td>
<td>I</td>
</tr>
<tr>
<td>19</td>
<td>Surface Width</td>
<td>Number</td>
<td>42-43</td>
<td>48</td>
</tr>
<tr>
<td>20</td>
<td>Summary Roadway Width</td>
<td>Number</td>
<td>44-45</td>
<td>64</td>
</tr>
<tr>
<td>21</td>
<td>Population (100's)</td>
<td>Number</td>
<td>46-49</td>
<td>0</td>
</tr>
<tr>
<td>22</td>
<td>Left Side Standard Surface Class</td>
<td>Text</td>
<td>50</td>
<td>G</td>
</tr>
<tr>
<td>23</td>
<td>Left Side Standard Base Class</td>
<td>Text</td>
<td>51</td>
<td>L</td>
</tr>
<tr>
<td>24</td>
<td>Left Side FHWA Surface Type</td>
<td>Text</td>
<td>52-53</td>
<td>I</td>
</tr>
<tr>
<td>25</td>
<td>Left Side Surface Width</td>
<td>Number</td>
<td>54-55</td>
<td>24</td>
</tr>
<tr>
<td>26</td>
<td>Median Width</td>
<td>Number</td>
<td>56-57</td>
<td>60</td>
</tr>
<tr>
<td>27</td>
<td>Right Side Standard Surface Class</td>
<td>Text</td>
<td>58</td>
<td>G</td>
</tr>
<tr>
<td>28</td>
<td>Right Side Standard Base Class</td>
<td>Text</td>
<td>59</td>
<td>L</td>
</tr>
<tr>
<td>29</td>
<td>Right Side FHWA Surface Type</td>
<td>Text</td>
<td>60-61</td>
<td>I</td>
</tr>
<tr>
<td>30</td>
<td>Right Side Surface Width</td>
<td>Number</td>
<td>62-63</td>
<td>24</td>
</tr>
</tbody>
</table>
A typical road inventory text file will exhibit the data structure shown in Figure C-22.

![FIGURE C-22 Snapshot of Road Inventory File](image)

6.2 Data_Project History

The [Data_Project History] sub-menu contains tools that update the Data_Project History table. The tools available under this menu are Project History Menu, Populate Structural Number Added, Populate Modified Activity Code, and Calculate Thickness Added.
6.2.1 Project History Entry

Projects performed on pavement each year are recorded in the \textit{DATA\_Project History} table. This table can be updated by selecting “Project History Entry” under the “Project History Menu.” This will launch the data entry form shown in Figure C-23 for users to view, edit, and input the data to be displayed in the \textit{DATA\_Project History} table.

\textbf{Table to Apply:} \hspace{1cm} [DATA\_Project History]

\textbf{Data type and format:} \hspace{1cm} User input

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{C-23_Project_History_Entry.png}
\caption{Project History Entry}
\end{figure}
There are several options provided on the form for browsing, updating and deleting the records. These are as follows:

- Record navigator
- Add a new blank record
- Copy the current record as a new record
- Restore the current record to its original status
- Update current record and make all changes permanent
- Delete current record. The deleted record cannot be restored.
- Close this tool

Comments:

Until the user leaves the input window, the [Restore] button can be used to restore the current record to its original status and discard any changes. To permanently update the current record, the [Update] button must be clicked. To delete the current record, user can use [Delete] button. If a record is deleted, it cannot be restored. You can also locate a record by using the “Record Locator” search tool or the “Entry No.” box. Any field not having a specific input box will appear in the “Extra Parameters” list. This means the user can input more fields into table [DATA_Project History]. However, the total number of fields in any table is limited to 256.

6.2.2 Populate Structural Number Added

This tool calculates the “Structural Number” of every entry in the DATA_Project History table and adds a new field [SN_Add]. The “Structural Number” is calculated according to the definitions in the table [LU_Structural Number].

6.2.3 Populate Modified Activity Code

This tool determines the “Modified Activity Code” for every entry in the DATA_Project History table. “Modified Activity Code” differs from “Activity Code” only in that it distinguishes between “Thin” and “Thick” overlays. If the thickness added of 50 or 60 is less than or equal to 2 inches, its “Modified Activity Code” becomes 41 or 42 correspondingly. This tool facilitates the analysis of thin and thick overlays.

6.2.4 Calculate Thickness Added

This tool calculates the “Total Thickness Added” and stores the result DATA_Project History table. A pavement can contain different layers. The thickness of each added layer is stored separately in the table. Sometimes it is useful to know the total thickness added to a pavement in a project. This tool calculates the total thickness added and stores the result in DATA_Project History table.
6.3 Data_ODOT

The Data ODOT sub-menu contains tools that update the Data ODOT table. The tools available under this menu are Import Pavement Condition Data, Calculate PCR and Deducts, and Calculate PQI.

6.3.1 Import Pavement Condition Data

This tool allows for updating of the DATA_ODOT table. In ODOTPMIS, pavement condition data such as PCR, RN, IRI, PSI, etc. are stored in DATA_ODOT table. This table also stores all road classification and distress data. This pavement condition data should be updated annually. To import condition data correctly, the source data file must have the required format.

**Table to Apply:** [DATA_ODOT]

**Data file type:** Coma delimited text file

**Data format:**

```
Value 1,Value 2,Value 3,Value 4,...
Value 1,Value 2,Value 3,Value 4,...
Value 1,Value 2,Value 3,Value 4,...
```

To import data, click on the “Data” menu and select “Import Pavement Condition Data.” The window shown in Figure C-24 will appear. Select the drive on which the file is stored using the “Drives” drop down menu, or use the “Network” button to select a network drive. Navigate to the directory of the data files using the “Folders” sub-window and use the “File name” sub-window to select the correct text file. Click “OK.” Checking the “Read only” box will prevent any changes to the data.

![FIGURE C-24. Import Pavement Condition Data](image-url)
Note: Field values must be in the order specified in Table C-3.

<table>
<thead>
<tr>
<th>Order</th>
<th>Field Name</th>
<th>Data Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NLFID</td>
<td>Text</td>
<td>SDARUS00036**C</td>
</tr>
<tr>
<td>2</td>
<td>District</td>
<td>Byte</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>County</td>
<td>Text</td>
<td>DAR</td>
</tr>
<tr>
<td>4</td>
<td>Route</td>
<td>Text</td>
<td>036R</td>
</tr>
<tr>
<td>5</td>
<td>Station</td>
<td>Text</td>
<td>UP</td>
</tr>
<tr>
<td>6</td>
<td>Blog</td>
<td>Single</td>
<td>13.41</td>
</tr>
<tr>
<td>7</td>
<td>Elog</td>
<td>Single</td>
<td>13.43</td>
</tr>
<tr>
<td>8</td>
<td>Year</td>
<td>Integer</td>
<td>1996</td>
</tr>
<tr>
<td>9</td>
<td>Priority</td>
<td>Text</td>
<td>G</td>
</tr>
<tr>
<td>10</td>
<td>PCR</td>
<td>Byte</td>
<td>97</td>
</tr>
<tr>
<td>11</td>
<td>TDC</td>
<td>Single</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>STRD</td>
<td>Single</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Pavement Type</td>
<td>Byte</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>Project Number</td>
<td>Text</td>
<td>22871</td>
</tr>
<tr>
<td>40</td>
<td>Rater 1</td>
<td>Text</td>
<td>RS</td>
</tr>
<tr>
<td>41</td>
<td>Rater 2</td>
<td>Text</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Divided - RI</td>
<td>Text</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Divided - PCR</td>
<td>Text</td>
<td>U</td>
</tr>
<tr>
<td>44</td>
<td>Mile Class</td>
<td>Text</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>Urban Area Code</td>
<td>Integer</td>
<td>735</td>
</tr>
<tr>
<td>46</td>
<td>Functional Class</td>
<td>Integer</td>
<td>14</td>
</tr>
<tr>
<td>47</td>
<td>NHS Field</td>
<td>Text</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>National Highway System (NHS)</td>
<td>Text</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Route Type</td>
<td>Byte</td>
<td>2</td>
</tr>
<tr>
<td>50</td>
<td>MPC</td>
<td>Byte</td>
<td>6</td>
</tr>
<tr>
<td>51</td>
<td>Access Control</td>
<td>Text</td>
<td>N</td>
</tr>
<tr>
<td>52</td>
<td>Lanes</td>
<td>Byte</td>
<td>2</td>
</tr>
<tr>
<td>53</td>
<td>Surface Type</td>
<td>Text</td>
<td>1</td>
</tr>
<tr>
<td>54</td>
<td>Surface Width</td>
<td>Byte</td>
<td>24</td>
</tr>
<tr>
<td>55</td>
<td>Sum Road Width</td>
<td>Byte</td>
<td>44</td>
</tr>
<tr>
<td>56</td>
<td>Truck ADT</td>
<td>Long Integer</td>
<td>760</td>
</tr>
<tr>
<td>57</td>
<td>Total ADT</td>
<td>Long Integer</td>
<td>6210</td>
</tr>
<tr>
<td>58</td>
<td>ESALX1000</td>
<td>Long Integer</td>
<td>288</td>
</tr>
<tr>
<td>59</td>
<td>PSI</td>
<td>Single</td>
<td>3.69</td>
</tr>
<tr>
<td>60</td>
<td>LIRI</td>
<td>Integer</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>RIRI</td>
<td>Integer</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>HCS</td>
<td>Integer</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>RN</td>
<td>Single</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>PCR Date</td>
<td>Date</td>
<td>6/10/1996</td>
</tr>
</tbody>
</table>
A typical pavement condition text file exhibits the data structure shown in Figure C-25.

6.3.2 Calculate PCR and Deducts

This tool calculates the “PCR,” “Structural Deduct,” “Cracking Deduct,” and “Rutting Deduct” as well as individual deducts. The original pavement condition data contains “PCR,” “Distress” ratings, “TDC” (Total Deduct), “STRD” (Structural Deduct), and “CRD” (Cracking Deduct). However, individual distress deducts are not provided. This tool enables a user to calculate all necessary fields for future analysis. In fact, any table with distress information can be used with this tool. However, its main purpose is to populate DATA_ODOT table.

Figure C-26 shows the tool interface. Select the table in the “Tables” list box. Check the required deducts to be calculated fields in the “Options” frame, and select the year for which the PCR and deducts need to be calculated. Click “Calculate” to fill the selected table with the selected fields.
6.3.3 Calculate PQI

This tool is used to calculate the Pavement Quality Index (PQI). PQI represents a combination of PCR and IRI (average of LIRI and RIRI). PQI is calculated by Equation C-(1).

\[
PQI = PCR - a \times IRI^b, \quad \text{C-(1)}
\]

Where \(a\) and \(b\) are read from LU_PQIParameters table.

6.4 Apparent Projects Determination

**Note:** This tool must be run before using the “Generating Performance Base Table” and “Generate Performance Analysis Table” functions.

This tool creates a new table called DATA_Project History_Apparent in the database that is similar to DATA_Project History. However, this table contains extra fields such as “App Blog,” “App Elog,” and “App Year” which are determined from matching PCR jumps with treatments. This tool also creates 999’s and 995’s if it finds a PCR jump of greater than or equal to 6, but does not find a corresponding matching treatment. DATA_PERF_BASE and DATA_PERF_ANALYSIS are generated based on this table.

6.5 Generate Performance Base Table

This tool generates the DATA_PERF_BASE table. The DATA_PERF_BASE table is the base of most analysis functions and should be generated before DATA_PERF_ANALYSIS. Note: It is recommended to perform a database compacting operation before and after using this function.

6.6 Generate Performance Analysis Table

This tool generates the DATA_PERF_ANALYSIS table from the DATA_PERF_BASE table. Most of the analysis tools in ODOTPMIS use this table. Note: It is recommended to perform a database compacting operation before and after using this function.

6.7 Generate Cost Lookup Table

To perform an “Average Cost” analysis of projects, a lookup table LU_COST is required to begin analysis. This tool is used to generate the LU_COST table.

6.8 Populate Performance Base Table

The “Populate Performance Base Table” function opens a window to display variances of user specified attributes in DATA_ODOT over time with respect to specified values of DATA_Project History. This tool replaces the “Key” and “Entry” numbers in the DATA_PERF_BASE table. The keys are replaced with the selected values in the “DATA_ODOT” list box and entries are replaced with selected parameter values in “DATA_Project History” list box.
Note: The resultant table cannot exceed 256 columns in width. Thus, if many parameters are desired, the number of years selected should be decreased or conversely, if many years are selected, the number of parameters may need to be reduced.

**Source Table:** DATA_PERF_BASE, DATA_Project History_Apparent, DATA_ODOT

**Output Table:** The default name is Result_Base. However, the user can assign a different table name by changing the text in the “Output Table Name” textbox.

![Populate Performance Base Table](image)

**FIGURE C-27. Populate Performance Base Table**

6.9 Populate Performance Analysis Table

The “Populate Performance Analysis Table” tool determines the changes of selected DATA_ODOT values between consecutive projects on the same pavement section with respect to data in DATA_Project History_Apparent.

This tool replaces the key and entry numbers in the DATA_PERF_ANALYSIS table with the selected values. The Fields Corresponding to Entry-1, Entry and Entry2 List boxes are used to select fields from DATA_Project History_Apparent table and Fields Corresponding to Key List box is used to select fields from DATA_ODOT table. Like the Populate Performance Base Table tool, the resultant table can support a maximum of 256 columns of data.

**Source Table:** DATA_PERF_ANALYSIS, DATA_Project History, DATA_ODOT

**Output Table:** The default name is Result_Analysis. However the user can assign a different table name by changing the text in the “Output Table Name” textbox.
6.10 Populate District Field

This tool is used to populate the district field in a table, provided the selected table contains a “County” field.

6.11 Import Planned Projects

This tool allows the importing of a work plan into ODOTPMIS. Generally, the work plan file contains the planned treatments for the future, project cost, and location information. The imported file is stored in DATA_FutureProjects. Each time this tool is used to import a new work plan, the previous existing work plan in ODOTPMIS is overwritten. To import condition data correctly, the source data file must have the required format.

Stored Table: DATA_FutureProjects
Data file type: Microsoft Excel File
Data format: Shown in Table C-4.
In the work plan file, certain columns can be left empty if they do not contain data. However, the necessary fields (bolded) “PID,” “NLF ID,” “County Begin Number,” “County End Number,” and “Pavement Treatment Type” should contain values.

### TABLE C-4. Work Plan File Format

<table>
<thead>
<tr>
<th>Order</th>
<th>Field Name</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PID</td>
<td>21052</td>
</tr>
<tr>
<td>2</td>
<td>SUM Adjusted Total Amt</td>
<td>8300000</td>
</tr>
<tr>
<td>3</td>
<td>Sale Amount</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>District</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Project Name (ie CRS)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Primary Work Category</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Award Date Current</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Award Date Actual</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Requested STIP Yr</td>
<td>2009</td>
</tr>
<tr>
<td>10</td>
<td>NLF ID</td>
<td>SLUCSR00002**C</td>
</tr>
<tr>
<td>11</td>
<td>County Begin Number</td>
<td>30.23</td>
</tr>
<tr>
<td>12</td>
<td>County End Number</td>
<td>30.8</td>
</tr>
<tr>
<td>13</td>
<td>Actual Priority Miles</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>Actual Urban Miles</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>Actual General Miles</td>
<td>1.14</td>
</tr>
<tr>
<td>16</td>
<td>MAX Pvmt Treat Category Cd</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Pavement Treatment Type</td>
<td>60 - AC Overlay with Repairs</td>
</tr>
</tbody>
</table>

### 6.12 Generic Classification Tool

This tool, shown in Figure C-29, is used to classify numerical fields in a table. If the original field name in the table is [fieldname], a new field called [fieldname classification] will be added to the table.

If the table selected is [DATA_PERF_ANALYSIS], this field will automatically show in the “Group By” list box provided on most of the analysis tools, such as “Average Deterioration Trend,” “Time To Treatment (Actual),” “Time To Treatment Survival Analysis” and “Derived Performance Trend.”
FIGURE C-29. Generic Classification Tool

Value Range Reference Options
Lowest: Lowest value of the parameter
Average: Average value of the parameter
Highest: Highest value of the parameter

Classifications Options

Number of Categories: Number of categories to classify the selected “Fields”
Apply Change (button): Enter number of categories in the “Number of Categories” text box and click this button to change the categories
Lower Bound: Lower bound/limit of a category (This value cannot be changed.)
Upper Bound: Upper bound/limit of a category (This value can be changed. The changed value becomes the lower bound of the next category.)
Description: The description of each category. This description for each category of fields is stored as a new field in the table.

Example:
The following example classifies AvgESAL in [DATA_PERF_ANALYSIS] into two categories: High, if ESAL ≥ 1500 and Low if ESAL < 1500.

1. Open the “Generic Classification Tool”
2. In the “Tables” list select “DATA_PERF_ANALYSIS”
3. In the “Fields” list select “AvgEsal”
4. Change the number of categories to 2 and click the “Apply Change” button
5. Change the Upper bound of Category 1 to 1500 and change its description to “Low”
6. Change the description of Category 2 to “High”
7. Click the “Classify” button
8. Close the tool and open the “Average Performance Trend” under the “Report” menu. “AvgEsal Classification” will be displayed in the “GroupBy” list.

6.13 Linear Superposition

The “Linear Superposition Operation” is a merge of multiple tables to obtain a single dynamically segmented table. The output is stored in the “Output Table.” If the output table named in the input box already exists, the tool will ask the user to replace the existing table or exit from the tool. Figure C-30 shows the user interface.

![FIGURE C-30. Linear Superposition User Interface](image)
Commands

*Tables*: Lists all the tables in the database
*Fields*: Lists all the fields of the table selected under “Available Tables”
*Selected Fields*: Lists all the selected fields from “Fields”

The attributes listed in the “Fields” list box can be added to the query in three ways:

1. Select a field in the “Fields” list and drag it into the “Selected Fields” list (a hand icon will appear when dragging and dropping)
2. Double click a field to be selected under “Fields”
3. Select a field under “Fields” and click

The “Selected Field” window also provides the option of constraining the records selected for merging. The comparison field in the “Selected Field” window provides a drop down list of how the constraint is to be implemented (≥, ≤, >, <, or =). The “Value” column specifies the desired value of the constraint.

Matching Fields

The “Matching Field” sub-window lists the fields required for merging. The default selections are “County,” “Route,” and “Station,” as they typically specify a linear feature. In some situations, “Year” may also be included.

Adding Matching Fields

Two techniques exist for adding additional selections into the “Matching Field” box. To remove a matching field, double click a field in the “Matching Fields” sub-window:

1. Double click on field under “Selected Fields”
2. Select a field under “Selected Fields” and drag it to the “Matching Fields” box

The “Pull Out” option check boxes under “Options” limit the tables used to create internal program indices. Consequently, if DATA_Project History or DATA_ODOT is excluded in the analysis, its respective index should not be pulled out.

The “Unique Route ID” window displays all unique linear features specified in the merge. Each button is assigned a specific operation and described below.
Example 1:

The following example shows how to obtain the PCR History for Route 032R in Adams County.

1. Select DATA_ODOT in the “Tables” list
2. Select PCR in the “Fields” list, and double click it to include it in the “Selected Fields” list
3. Under the “Fields” list, add “County” and “Route”
4. In the “County” row, double click the “Value” column and enter “ADA”
5. In the “Route” row, double click the “Value” column and enter “032R”
6. Click the button

At this point, the “Linear Superposition” window should resemble Figure C-31.
The result should resemble Figure C-32. Note: Not all PCRs are displayed because of the size of the window. Scroll to reveal the hidden PCRs.

**Example 2:**

To obtain the treatment history as well as the PCR history for Route 032R in Adams County, follow this procedure:

1. Select DATA_Project History in the “Tables” list
2. Double click “Activity Code” in the “Fields” list to include it in the “Selected Fields” list.
3. Select DATA_ODOT in the “Tables” list.
4. Double click “PCR” in the “Fields” list to include it in the “Selected Fields” list.
5. Add “County” and “Route” to the “Selected Fields” list.
6. In the “County” row, double click the “Value” column and enter “ADA”.
7. In the “Route” row, double click the “Value” column and enter “032R”.
8. Click the button.
9. After above 8 operations, the interface looks like the following figure.

At this point, the “Linear Superposition” window should resemble Figure C-33.

FIGURE C-33. Get PCR and Treatment History for Route 032R in Adams County

The result should resemble Figure C-34. Note: Not all PCRs are displayed because of the size of the window. Scroll to reveal the hidden PCRs.
6.14 Clean Pavement Data Table

This tool is used to remove redundancy in dynamically segmented tables. For example, the two records in Table C-5 represent consecutive sections in a road and are identical except for the “Blog” and “Elog” figures. Therefore, these two records can be merged.

<table>
<thead>
<tr>
<th>County</th>
<th>Route</th>
<th>Station</th>
<th>Blog</th>
<th>Elog</th>
<th>Year</th>
<th>PCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADA</td>
<td>032R</td>
<td>Down</td>
<td>2.33</td>
<td>2.84</td>
<td>2002</td>
<td>91</td>
</tr>
<tr>
<td>ADA</td>
<td>032R</td>
<td>Down</td>
<td>2.84</td>
<td>6.29</td>
<td>2002</td>
<td>91</td>
</tr>
</tbody>
</table>

6.15 Modify Activity Legend

This tool is used to add new activity codes, modify activity legend colors for project history checking, and ensure data integrity between the activity code and the modified activity code.
To add a new activity code, click “Add.” This will add a new row at the end of the window (Figure C-36). Enter the required information including the “Code” (numerical), “Color,” “Activity,” “Class,” “SN Item,” and “Max Life.” Avoid entering duplicate data.

### FIGURE C-35. Modify Activity Legend

![Modify Activity Legend](image)

### FIGURE C-36. Add New Activity

![Add New Activity](image)

### 6.16 Edit Lookup Table

This tool updates the lookup tables necessary for all analyses in ODOTPMIS.

**Table to Apply:** [LU_XXXXX]

**Tool to use:** [Data] → [Edit Lookup Table]
Users can add, modify, or delete a current record in a lookup table. However, the user cannot change the field name or add/delete a field from a lookup table.

**Example 1:**

In the current ODOT database, only ten distresses are defined for Continuous Reinforced Concrete pavement. To change distress information for distress code 11 for pavement type 1 (Continuous Reinforced Concrete),

1. Select “Edit Lookup Table” under the “Data” menu
2. Select LU_Distress in the “Lookup Table” list
3. Go to “Pavement Type 1” and “Code 11” by using the button in the record navigator. The interface of the tool should resemble Figure C-38.

4. Click the “Field Name” to be changed

![FIGURE C-38. LU_Distress Table](image)

Figure C-39 demonstrates the valid format of the data to be entered.

![FIGURE C-39. Modifying LU_Distress](image)

5. After entering the changes, click “Update”

6. The changes will be made in two tables: LU_Distress and LU_Deduct. ODOTPMIS uses LU_Deduct table to calculate “PCR,” “Structural Deduct,” “Cracking Deduct,” and individual deducts.
7. To restore old values, click “Restore.” This only works if the user clicks the “Restore” button before closing the tool, and only restores one record at a time.
Analysis Tools Menu

This menu contains functions that perform analyses comparing time to treatment, condition deterioration, pavement condition prediction, and remaining life estimation.

<table>
<thead>
<tr>
<th>Time To Treatment(Actual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time To Treatment Survival Analysis</td>
</tr>
<tr>
<td>Derived Performance Trend</td>
</tr>
<tr>
<td>Generate Markov Predictions</td>
</tr>
<tr>
<td>Show Predicted Pavement Condition</td>
</tr>
<tr>
<td>Estimate Remaining Life</td>
</tr>
<tr>
<td>Histogram</td>
</tr>
</tbody>
</table>

FIGURE C-40. ODOTPMIS Analysis Tools Menu

7.1 Exclude activity option

Analysis tools such as “Time To Treatment (Actual),” “Time To Treatment Survival Analysis,” and “Derived Performance Trend” provide an option giving the user the ability to exclude certain activities from the analysis. For example, consider a pavement section with the treatment history as shown in Figure C-41.

![Figure C-41. Example for Exclude Activity](image)

This pavement section will not be included in the analysis if the “From Activity” is set to 50 and the “To Activity” to 50 because this tells the program to search for projects that are Activity 50 (overlay without repairs) and immediately followed by another Activity 50. However, this pavement section is included in the analysis, if both the “From Activity” and “To Activity” are set to 50, and Activity 20 is selected in the “Exclude Activity” list box.

7.2 Time To Treatment (Actual)

This tool is used to determine the average time between types of treatments or the average time to a certain PCR threshold.

**Source Table:** DATA_PERF_ANALYSIS  
**Intermediate Table Generated:** DATA_PERF_AVGLIFE  
**Output Table:** The default name for the output table is “Actual Time to Treatment Analysis.” Users can update this table name by changing the text in the “Output Table name” text box.
FIGURE C-42. Time to Treatment (Actual)

**Example 1:**

To generate the “Average Life of Overlay on Priority System Flexible Pavements,” select the following options on the tool:

1. “All Systems” under “System”
2. “All” under “Priority”
3. “All Districts” under “District”
4. “All Counties” under “County”
5. “All Types” under “Pave Type”
6. “All Directions” under “System”
7. “1985” under “From Year,” and “2006” under “To Year”
8. “Activity Code” under “Activity” list
9. “50” and “60” under “From Activity” list, and “Add All” under “To Activity” list
10. “By Mileage” under “Analysis Options”

Enter an output table name in the “Output Table Name” text box and click “Calculate.”
Figure C-43 shows the mileage of pavements that failed or received treatment in each time period. The average life of an overlay on priority systems, according to the calculations, is 7.6 years.

**Average Life**

System = All Systems / Priority = P / District = All Districts / County = All Counties / Pavement Type = 3 Asphalt / Year = 1985 – 2006

This tool is used to calculate the time to the next treatment based on the Kaplan-Meier Survival Curve method. The advantage of Kaplan-Meier Survival Curve method is that it allows the inclusion of surviving pavement sections in the analysis.

**Source Table:** DATA_PERF_ANALYSIS  
**Intermediate Table Generated:** DATA_PERF_REMLIFE  
**Output Table:** The default name for the output table is “Pavement Survival Life Analysis.” Users can update this table name by changing the text in the “Output Table name” text box.

**FIGURE C-43. Time to Treatment (Actual) Output for Flexible Overlays on Priority System**

7.3 Time To Treatment Survival Analysis

This tool is used to calculate the time to the next treatment based on the Kaplan-Meier Survival Curve method. The advantage of Kaplan-Meier Survival Curve method is that it allows the inclusion of surviving pavement sections in the analysis.
FIGURE C-44. Time to Treatment Survival Analysis User Interface

Analysis Options

Include Open End Projects: Checking this option will include open-ended projects (projects or pavements still in existence)

PCR Threshold: A pavement is considered failed if it undergoes treatment. Checking this option marks all pavements with PCR levels below the threshold as failed.

Output Options

Histogram: This option plots a histogram showing the number of censored and uncensored points for each section.

Survival Analysis Output

In certain scenarios including open ended projects, the survival curve will not reach zero percent surviving. This curve is called a stub survival curve. In the PMIS, a Weibull
survival function is used to complete the survival curve. The Weibull fit, along with the original survival curve, is shown in the output graph.

Example 1:

The following example shows the survival analysis of “Overlay on Priority System Flexible Pavements.” Select the following options on the tool:

11. “All Systems” under “System”
12. “All” under “Priority”
13. “All Districts” under “District”
14. “All Counties” under “County”
15. “All Types” under “Pave Type”
16. “All Directions” under “System”
17. “1985” under “From Year,” and “2006” under “To Year”
18. “Activity Code” under “Activity” list
19. “50” and “60” under “From Activity” list, and “Add All” under “To Activity” list
20. “By Mileage” under “Analysis Options”

Enter an output table name in the “Output Table Name” text box and click “Calculate.”

Figure C-45 shows the “Survival Curve (Raw Data),” the survival curve obtained using the raw data. It can be seen that this survival curve does not reach 0% probability, and any estimates using this curve are not reliable. Hence a “Survival Curve (Weibull Fit)” is fitted to the original curve.

FIGURE C-45. Time to Treatment (Actual) Output for Overlays on Priority System
A histogram showing mileages of projects that have been repaired and still exist can also be generated by selecting “Histogram” under “Output Options.” Figure C-46 shows the mileage histogram for the survival curve in Figure C-45.

FIGURE C-46. Time to Treatment Survival Curve Mileage Histogram

7.4 Derived Performance Trend

This tool analyzes the series of survival curves to determine the pavement condition deterioration of a group of user specified pavement repairs.

Source Table: DATA_PERF_ANALYSIS, DATA_ODOT
Intermediate Table Generated: DATA_PERF_SURVIVAL
Output Table: The default name for the output table is “Derived Performance.” The user can change this table name by updating the text in the “Output Table Name” text box.
FIGURE C-47. Derived Performance Trend

Output Options

**Survival Curve:** Display survival curves for PCR from 100 to 50.

**Example 1:**

The following example shows the Derived Performance Trend for District 3 General System Flexible Pavements with Overlays. Select the following options on the tool:

1. “All Systems” under “System”
2. “G” under “Priority”
3. “All Districts” under “District”
4. “All Counties” under “County”
5. “All Types” under “Pave Type”
6. “All Directions” under “System”
7. “1985” under “From Year,” and “2006” under “To Year”
8. “Activity Code” under “Activity” list
9. “50” and “60” under “From Activity” list, and “Add All” under “To Activity” list
10. “By Mileage” under “Analysis Options”
11. Check “Survival Curve” under “Output Options”

Enter an output table name in the “Output Table Name” text box and click “Calculate.”

Figure C-48 shows the “Derived Performance Curve.”
FIGURE C-48. Derived Median Performance Curve For District 3 General System Flexible Pavements with Overlays

This tool also generates the survival curves used for the “Derived Median Performance Curve” shown in the following figure. It can be seen that Weibull curves are used instead of stub survival curves.

FIGURE C-49. PCR Survival Curves
7.5 Generate Markov predictions

This menu can be used to predict the PCR and distress for every pavement section in the database based on Markov process. However, for certain groups of pavements, the Markov transition matrix cannot be generated since only a few pavement sections are available. In that case, simple linear extrapolation is used for predicting distress and PCR.

The tools available under this menu are “Statewide Rigid Pavements,” “Statewide Flexible Pavements,” “Statewide Composite Pavements,” “Individual Pavement Prediction,” and “Selected Predictions.”

The transition matrix table $DATA\_TransitionMatrix$ is created when using the “Statewide Rigid Pavements,” “Statewide Flexible Pavements,” and “Statewide Composite Pavements” options. Note: It is recommended that the user not delete this table, since it is used in the “Individual Pavement Prediction” and “Show Pavement Prediction” tools.

7.5.1 Statewide Rigid Pavements

This option generates statewide rigid pavement PCR and distress predictions for the next twenty years. Four tables will be generated. Note: It is recommended that the user not delete these tables unless new pavement condition data and/or project data are added in the database.

The tables created are: $DATA\_PredictedPCR\_JRC$, $DATA\_PredictedDistress\_JRC$, $DATA\_PredictedPCR\_CRC$, and $DATA\_PredictedDistress\_CRC$.

7.5.2 Statewide Flexible Pavements

This option generates statewide flexible pavement PCR and distress predictions for the next twenty years. Two tables will be generated. It is recommended that the user not delete these tables unless new pavement condition data and/or project data are added in the database.

The tables created are: $DATA\_PredictedPCR\_Flex$, $DATA\_PredictedDistress\_Flex$.

7.5.3 Statewide Composite Pavements

This option generates statewide composite pavement PCR and distress predictions for the next twenty years. Two tables will be generated. It is recommended that the user not delete these tables unless new pavement condition data and/or project data are added in the database.

The tables created are: $DATA\_PredictedPCR\_Comp$, $DATA\_PredictedDistress\_Comp$.

7.5.4 Individual Pavement Prediction

This tool can be used to view the predicted PCR of an individual pavement section. Markov prediction is combined with Monte-Carlo simulation to generate the PCR predictions and confidence intervals. The user has the ability to choose between various confidence intervals. Figure C-50 shows the user interface.
Source Table: DATA_Transition Matrix
Output Table: The default name for the output table is “Pavement Section Prediction.” Users can update this table name by changing the text in the “Output Table name” text box.

FIGURE C-50. Individual Pavement Section Prediction

Example 1:
To view the predicted PCR for Allen County, Route 030R Up Direction, for the next twenty years with an 80% confidence limit, select following options:

1. “All” under “County”
2. “030R” under “Route”
3. “UP” under “Station”
4. “80” under “Confidence Limits”
5. “20” under “Prediction Years”

Enter an output table name in the “Output Table” text box and click “Execute.”

Figure C-51 shows the output grid which displays the results.
Click on any part of the grid to generate a PCR prediction plot that shows the confidence limits as shown in Figure C-52.

FIGURE C-51. PCR Prediction Grid

FIGURE C-52. PCR Prediction Confidence Limits

7.5.5 Selected Predictions

This tool has the same functionality as the Markov prediction tool, but is designed for more advanced users to select pavement families for transition matrices.

7.6 Show Predicted Pavement Conditions

This tool can be used to view the Markov predicted pavement conditions. Figure C-53 shows the user interface to view the predicted conditions.
Source Table: DATA_Transition Matrix, DATA_PredictedPCR_JRC, DATA_PredictedDistress_JRC, DATA_PredictedPCR_CRC, DATA_PredictedDistress_CRC, DATA_PredictedPCR_Flex, DATA_PredictedDistress_Flex, DATA_PredictedPCR_Comp, DATA_PredictedDistress_Comp, and DATA_FutureProjects

Output Table: The default name for the output table is “PavementCondition_WithPlan.” Users can update this table name by changing the text in the “Output Table name” text box.

FIGURE C-53. View Predicted Pavement Condition

Work Plan Options

Without Work Plan: Analysis based on original PCR and distress predictions
With Work Plan: Analysis based on result from overlay of PCR and distress predictions with DATA_FutureProjects file

Output Options

Start Year: Start year of the analysis
Forecast Upto: End year of the analysis

Example 1:

To view pavement conditions with the plan for District 3, select the following options:

1. “3” under “District”
Enter an output table name in the “Output Table Name” text box and click “Execute.”

This procedure generates two grids: (1) “view pavement condition with planned treatments,” which displays the predicted PCR overlaid with planned treatments and (2) “view pavement condition with planned treatments – recommended treatments,” which displays the recommended treatments from the current year until 2010.

Users can right click the above PCR grid and select “Generate PCR Summary” to generate a “PCR Summary” chart as shown in Figure C-55.

The second grid with recommended treatments is shown in Figure C-56.
FIGURE C-56. View Pavement Condition with Planned Treatments – Recommended Treatments

Users can right click the above grid and select “Generate Cost Summary” to generate a “Cost Summary” chart as shown in Figure C-57.

FIGURE C-57. Cost Summary

7.7 Estimate remaining life

This tool can be used to estimate the remaining life of pavement sections based on certain PCR and/or distress thresholds. Figure C-58 shows the user interface to view the predicted conditions.

Source Table: DATA_PredictedPCR_JRC, DATA_PredictedDistress_JRC, DATA_PredictedPCR_CRC, DATA_PredictedDistress_CRC,
DATA_PredictedPCR_Flex, DATA_PredictedDistress_Flex, DATA_PredictedPCR_Comp, DATA_PredictedDistress_Comp.

**Output Table:** The default name for the output table is “Remaining Life.” Users can update this table name by changing the text in the “Output Table name” text box.

---

**FIGURE C-58. Estimate Remaining Life**

**Rem. Life PCR Threshold**

Enter PCR thresholds in the text boxes. The remaining life is calculated by the time until the current PCR reaches the specified PCR threshold.

**Use Distress Criteria**

Check this option and click “Edit Criteria” to display the window shown in Figure C-59. Users can then enter thresholds for individual distresses. The remaining life is calculated using both the PCR and distress thresholds, whichever occurs first.

**Graph Options**

**Miles:** Analysis will be based on the directional miles
**Sections:** Analysis will be based on the number of pavement sections
Example 1:

To view the remaining life for “General System Pavements” from 2007 based on a PCR threshold of 55, select the following options:

1. “G” under “Priority”
2. “2007” under “Rem Life From Year”
3. “55” in the “General” text box under “Rem. Life PCR Threshold”

Enter an output table name in the “Output Table Name” text box and click “Execute.”
7.8 Histogram

This tool is used to generate a histogram for a selected field in a table.

![Histogram Tool](image)

**FIGURE C-61. Histogram Tool**

**Data Source**
- **Table/Query**: Table or query from which a field is selected to generate histogram
- **Statistical Field**: Field from the selected table
- **Weight Field**: Sum of selected field in each category of statistical field
- **Number of Category**: Number of categories for histogram
- **Use (Elog-Blog) As Weight**: Total mileage under each category.

**Example 1:**

Figure C-62 shows the histogram for PCR, weighted by mileage from DATA_ODOT. This is generated by selecting “DATA_ODOT” in “Table/Query,” “PCR” in “Statistical Field,”
“None” in “Weight Field,” “5” in “Number of Category,” and enabling “Use (Elog-Blog) As Weight.”

FIGURE C-62. Example of a PCR Histogram Tool
Report Menu

This menu contains tools to generate reports of the database.

8.1 Average Performance Trend

This tool generates an average performance report for parameters from DATA_ODOT.

**Source Table:** DATA_PERF_ANALYSIS, DATA_ODOT  
**Intermediate Table Generated:** DATA_PERF_CURVE  
**Output Table:** The default name for the output table is “Average Deterioration Trend Analysis.” Users can update this table name by changing the text in the “Output Table name” text box.
FIGURE C-64. Average Deterioration Trend User Interface

Analysis Options

Include Open End Projects: Enabling this option will include open-ended projects (projects/pavements which still exist)

Change Curve: Enabling this option will generate a graph based on the rate of deterioration.

Output Options

Show Average: Enabling this option calculates and displays an average category based on the current categories displayed on the chart. For example, if the average deteriorations of Districts 1 and 3 are displayed, checking this option will display an additional category that is the average of deterioration trends on Districts 1 and 3.

Example:

The following example shows the average deterioration trend report for PCR and RN for all systems, priorities, pavement types and counties in district 1 for Activity codes 50 and 60 and from 1985 to 2006. Select following options on the tool:

1. “All Systems” under “System”
2. “All” under “Priority”
3. “1” under “District”
4. “All Counties” under “County”
5. “All Types” under “Pave Type”
6. “All Directions” under “System”
7. “1985” under “From Year,” and “2006” under “To Year”
8. “Activity Code” under “Activity” list
9. “PCR” and “RN” under “Parameters”
10. “50” and “60” under “From Activity” list, and “Add All” under “To Activity” list

Enter an output table name in the “Output Table Name” text box and click “Execute.”

Figure C-65 shows the average deterioration trends for PCR and RN.

![Performance Trend Curve](image)

**FIGURE C-65. Performance Trend Curve**

This tool also generates a mileage chart as shown in Figure C-66.
Figure C-67 is generated when the “Change Curve” option is checked in “Analysis Options” and shows the change curve for “PCR” and “RN.” The change curve values are obtained by taking the difference of two consecutive average deterioration values. It represents the rate of deterioration.
8.2 Rehabilitation Candidates

This menu is used to generate a rehabilitation candidate list based on the treatment decision trees provided by ODOT. The tools available under this menu are “Generate Statewide Rehab List,” “Generate U/G Rehab List,” “Generate Priority Rehab List,” “Priority System Major Rehab List,” and “Modify Repair Logic.” For all the tools under this menu, the following tables are used in the background:

**Source Tables:** DATA_ODOT, DATA_Project History_Apparent, DATA_PERF_BASE, LU_Repair Logic, LU_Repair Limits

8.2.1 Generate Statewide Rehab List

This tool generates the recommended treatments for all the pavement sections in the database for the latest available PCR. The user interface is shown in Figure C-68. The output is stored in the table name given in the “Output Table” text box. In addition to this output table, this tool also generates a bin summary table that contains the directional miles that fall under each bin category. If the output table name is [table name], the bin summary table created will be named [table name_Bin Summary].

![Rehab Candidate List](image)

**FIGURE C-68. Rehab Candidates**

8.2.2 General U/G Rehab List

This tool generates the recommended treatments (bin’s) list only for pavement sections on urban and general systems. The user interface is similar to above in Figure C-68, however, in the “Priority” combo box, the default value is “U/G.”
8.2.3 General Priority Rehab List

This tool generates the recommended treatments (bin’s) list only for pavement sections on urban and general systems. The user interface is similar to Figure C-68, however the “Priority” combo box is defaulted to “P.”

8.2.4 Priority System Major Rehab List

This tool generates the candidate sections eligible for major rehab on priority systems based on the decision tree provided by ODOT. The user interface is shown in Figure C-69. The decision tree and repair logic are also shown in the user interface.

![Figure C-69. Priority System Major Rehab List](image)

Include Treatments for Treatments Check
This option allows the user to select the treatments that will be included in the “# of treatments” check in the decision tree.
**Merge Continuous Sections Options**

These options allow the user to control how continuous sections are merged. The options provided are

- **Default**: Two continuous sections are merged into a single record by considering the “Minimum PCR,” “Maximum Total ADT,” and “Truck ADT” between the sections, provided the remaining fields are equal.

- **All Equal**: Two continuous sections are merged into a single record if all the fields are equal.

- **All Min**: Two continuous sections are merged into a single record by considering the “Minimum of PCR,” “Total ADT,” and “Truck ADT” between the sections provided the remaining fields are equal.

- **All Max**: Two continuous sections are merged into a single record by considering the “Maximum of PCR,” “Total ADT,” and “Truck ADT” between the sections provided the remaining fields are equal.

- **All Avg**: Two continuous sections are merged into a single record by considering the “Average of PCR,” “Total ADT,” and “Truck ADT” between the sections provided the remaining fields are equal.

**8.2.5 Modify Rehab Logic**

This tool enables the user to change the decision tree and repair logic provided by ODOT. Figure C-70 shows the interface for modifying decision trees.
To modify a decision tree, choose the category by clicking on the appropriate tab in the “Modify Priority/Urban/General Rehab Logic” sub-window. Text boxes are provided at various stages (for PCR, traffic, etc.). Enter new values in the text boxes and click “Apply” to modify the decision tree.

To modify the repair logic (“Preventive Maintenance,” “Major,” “Minor,” and “Priority Major Rehab”), click “Miscellaneous Criteria.” Select the “Pavement Type,” “Preservation,” and “Priority System” in the “Record Locator” and click “Search.” The “Miscellaneous Criteria” tab provides options to change the “Functional Class,” “PCR Limits,” and “Traffic” as shown in Figure C-71. This is the basic procedure:

Note: If the value for criteria is empty, it is not considered in the repair logic.

1. Change the “Functional Class” in the “Functional Class” list
2. Change the “PCR Limits” in the “PCR Lower Limit” and “PCR Upper Limit” text boxes
3. Change the “Traffic Limits” in the “Total ADT” and “Truck ADT” text boxes
4. Change the “Cracking Index Limit” in the “Max Cracking Index” text box
5. For two lanes, apply the “Two-Lane Only” option
6. Select appropriate distress levels for each code under “Allowable Distress”
7. Click “Apply” to save the changes

To change the logic for a repair check i.e., to include or remove any distress from the repair logic, use the “View and Edit Repair Logic” text box.

Figure C-71 shows the allowable distress for a structural check of a general system, flexible pavement. The repair logic is “6 and 9 and ( 15 or 3 )”. The user can edit the text in this text box to add or remove any distress, however, the default syntax must be used to make any changes. This syntax is shown in Figure C-71.

FIGURE C-71. Edit Repair Logic

Syntax for Editing Repair Logic

1. Enter any distresses by their code numbers
   Example: If the logic is “Rutting” or “Wheel Track Cracking” for flexible pavement, the user should input “6 or 9”

2. Separate text by spaces
   Example: The correct syntax for the command “1or2or3” is “1 or 2 or 3”

3. Separate brackets by spaces
Example: The correct syntax for the text “1 or (2 and 3) or 4” is “1 or (2 and 3) or 4”

8.3 Project Performance

In the “Report” menu, click “Project Performance.” This tool generates the project performance reports.

**Source Table:** DATA_PROJECT HISTORY_Apparent, DATA_ODOT  
**Output Table:** The default name for the output table is “Project Performance.” Users can update this table name by changing the text in the “Output Table name” text box.

Figure C-72 shows the window used for generating this report. The “Analysis Range” frame selects the project number and parameters to be used to generate the report.

**FIGURE C-72. Individual Project Performance**

*Example:*

Figure C-73 shows the Project Performance Report for Project Number 701-99 for PCR and RN (Ride Number). This report is generated by selecting “Project Number 701-99” in the “Project Number” list box, and “PCR” and “RN” in the “Parameter” list box.
8.4 PCR Drop

This tool generates a list of pavement sections with a quantity of PCR drops greater than or equal to a specified value, and with specific treatments performed. PCR Drop for this tool is defined as decrease in PCR value between any two years.

**Source Table**: DATA_Project History_Apparent, DATA_ODOT, DATA_PERF_BASE

**Output Table**: The default name for the output table is “PCR Drop List.” Users can update this table name by changing the text in the “Output Table name” text box.
### FIGURE C-74. PCR Drop Tool

#### Analysis Options

**PCR Drop >=:** When checked, this option will calculate the number of PCR Drops greater than or equal to the value selected in the drop down box and between the values selected in the “From Year” and “To Year” drop down boxes.

**# Of Treatments Performed:** When checked, this option will calculate the number of treatments performed between the values selected in the “From Year” and “To Year” drop down boxes. The treatments selected in “Include Activities” will be counted.

8.5 **Average Cost**

This tool generates an average cost report for each activity. To generate this report, the lookup table LU_COST must exist in the database. In the “Data” menu, click “Generate Cost Lookup Table” to generate LU_COST.

**Source Table:** DATA_Project History, LU_COST

**Output Table:** The default name for the output table is “Unit Cost Analysis.” Users can update this table name by changing the text in the “Output Table name” text box.
FIGURE C-75. Average Cost Analysis Interface User Interface

Example:

Figure C-76 shows the cost report for Activities 50 and 60 per lane mile, for all systems and in each district from 1985 to 2006.

This report is generated by selecting “All Systems” under “System,” “All” under “District,” “1985” under “From Year,” “2006” under “To Year,” “Activity Code” under “Activity,” “District” under “Group By,” “50” and “60” under “Activity,” and “Unit Cost in Dollar Per Lane Mile” under “Cost Unit.”
FIGURE C-76. Average Cost Per Lane Mile for Overlays

8.6 Structural Buildup

This tool generates a current pavement structure report.

**Source Table:** DATA_Project History, DATA_PERF_BASE

**Output Table:** The default name for the output table is “Recent Pavement Structure Report” Users can update this table name by changing the text in the “Output Table name” text box.
Example:

Figure C-78 shows the current pavement structural buildup for Route 032R in Adams County. This report is generated by selecting “ADA” in the “County” list and 032R in the “Route” list.
8.7 Traffic Report

This tool generates the average Traffic, ESAL, and summary statistics report.

Source Table: DATA_ODOT

Output Table: The default name for the output table is “Traffic Report” Users can update this table name by changing the text in the “Output Table name” text box.
FIGURE C-79. Traffic Report User Interface

Example:

Figure C-80 shows the charts for ESALx1000, Total ADT, and Truck ADT for all systems, priorities, pavement types, and routes in District 1 from 1985 to 2006. The tool also generates a report, shown in Figure C-81.

The charts and report are generated by selecting “All Systems” under “System,” “All” under “Priority,” “1” under “District,” “All Counties” under “County,” “All Types” under “Pave Type,” “All Directions” under “System,” “1985” under “From Year,” “2006” under “To Year,” “Year” under “Group By,” “By Mileage” under “Analysis Options,” “Line Chart” under “Output Options,” and “Show Average” under “Output Options.”
FIGURE C-80. Traffic Report Charts
8.8 PCR and Distress

This menu is used to generate the average PCR and distress by project age or calendar year.

Source Tables: DATA_ODOT, DATA_PERF_ANALYSIS

8.8.1 Average by Project Age

This tool generates the average distresses, CRD (cracking deduct), PCR, and STRD (structural deduct) for a project year. The user interface is shown in Figure C-82.
**FIGURE C-82. Average PCR and Distresses by Project Age**

**Example:**

Figure C-83 shows “Year 0” or the condition immediately after overlays, on priority system, flexible pavements. This report is generated by selecting “All Systems” under “System,” “P” under “Priority,” “All” under “District,” “All Counties” under “County,” “3-Asphalt” under “Pave Type,” “1985” under “From Year,” “2006” under “To Year,” “50 and 60” under “Activity,” “0” under “Project Year,” “Add All” under “Activity,” and “By Mileage” under “Analysis Options.”
8.8.2 Average by Calendar Year

This function reports the average distresses, CRD (cracking deduct), PCR and STRD (structural deduct) by pavement type, district, and county for a given calendar year.

FIGURE C-83. Average PCR and Distresses by Project Age Output
FIGURE C-84. Average PCR and Distresses by Calendar Year

Example:

Figure C-85 shows the PCR and Distress Average by Calendar Year report for all distresses in flexible pavements, for all systems, all priorities, in District 1 from 1985 to 2006.
**FIGURE C-85. PCR and Distresses by Calendar Year Output**

8.9 Ride Quality

This report gives the ride quality (in terms of LIRI, RIRI and RN) distribution in miles by pavement type, district, year, etc

**Source Table:** DATA_ODOT, LU_Parameter Range (parameter categories defined by ODOT)

**Output Table:** The default name for the output table is “LIRI Mileage Report.” Users can update this table name by changing the text in the “Output Table name” text box.
Figure C-87 shows the Ride Quality Report in miles for LIRI for categories defined by ODOT in District 1 for each year from 1998 to 2006.

This report is generated by selecting “All Systems” under “System,” “All” under “Priority,” “1” under “District,” “All Counties” under “County,” “All Types” under “Pave Type,” “1985” under “From Year,” “2006” under “To Year,” “LIRI” under “Parameter,” “Year” under “Group By,” and “Stackbar Chart” under “Plot Style.”
8.10 Additional Reports

The tools under this menu are “Project History Plot,” “Statistical Report,” “General Mileage Report,” and “Map View of a Table.”

8.10.1 Project History Plot

This tool, shown in Figure C-88, is used for viewing the changes in data – PCR, for example – from DATA_ODOT over time for a particular route within a county based on the Original Record (Blog and Elog) from DATA_Project History, or Auto Detection (Blog and Elog) from DATA_Project History_Apparent. The tool also uses colored backgrounds to indicate the repair history of the selected route.
The plot shown in Figure C-89 was generated by selecting “ADA” under “County,” “032R” under “Route,” and “Original Record” under “Options.” Figure C-90 was generated with the same settings but using “Auto Detected” under “Options.” Figure C-90 demonstrates that the Activities are adjusted according to PCR jumps.
8.10.2 Statistical Report

This tool is used to calculate average or weighted average values for a user selected parameter. This tool is similar to Traffic Report explained earlier; however in this tool the user can select any parameter from ODOT in addition to traffic and ESAL.

Source Table: DATA_ODOT

Output Table: The default name for the output table is “Statistical Report.” Users can update this table name by changing the text in the “Output Table name” text box.

FIGURE C-91. Statistical Report User Interface
Output Options

- **Bar Chart**: Output shown in bar chart format
- **Line Chart**: Output shown in line graph format
- **Show Average**: Average of all data shown on graph

Example:

Figure C-92 shows the Statistical Report for PCR and RN (Ride Number) for all systems, all priorities, all pavement types, in each county and on all routes in District 1, for each year from 1985 to 2006.

This report is generated by selecting “All Systems” under “System,” “All” under “Priority,” “1” under “District,” “All Counties” under “County,” “All Types” under “Pave Type,” “1985” under “From Year,” “2006” under “To Year,” “PCR” and “RN” under “Parameter,” “Year” under “Group By,” “By Mileage” under “Analysis Options,” and “Line Chart,” “Show Average” and “Print Preview” under “Output Options.”

Figure C-92 shows the generated statistical report. ODOT began collecting RN (ride number) data in 1998, and hence RN data slots are empty prior to 1998.


- **System** = All Systems
- **Priority** = All Priorities
- **District** = 1
- **County** = All Counties
- **Route** = All Routes
- **Pavement Type** = All Types

**State Average:**
- **PCR** = 79.60
- **RN** = 3.40

**Highest:**
- **PCR** = 83.19, Year = 2003
- **RN** = 5.21, Year = 2000

**Lowest:**
- **PCR** = 77.21, Year = 1991
- **RN** = 1.78, Year = 1990

<table>
<thead>
<tr>
<th>Year</th>
<th>PCR</th>
<th>PCR/Mileage</th>
<th>RN</th>
<th>RN/Mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>69</td>
<td>295.25</td>
<td>81</td>
<td>1.31</td>
</tr>
<tr>
<td>1986</td>
<td>68</td>
<td>282.30</td>
<td>81</td>
<td>1.31</td>
</tr>
<tr>
<td>1987</td>
<td>64</td>
<td>276.40</td>
<td>81</td>
<td>1.31</td>
</tr>
<tr>
<td>1988</td>
<td>65</td>
<td>275.70</td>
<td>81</td>
<td>1.31</td>
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<td>1.31</td>
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<td>1994</td>
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<td>81</td>
<td>1.31</td>
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<tr>
<td>1996</td>
<td>83</td>
<td>339.10</td>
<td>81</td>
<td>1.31</td>
</tr>
</tbody>
</table>

**FIGURE C-92. Statistical Report Output**

C-86
Figure C-93 shows the PCR chart with an average line.

![Weighted Average PCR Chart](image1)

**FIGURE C-93. PCR Chart**

Figure C-94 shows the RN chart with an average line.

![Weighted Average RN Chart](image2)

**FIGURE C-94. RN (Ride Number Chart)**

8.10.3 General Mileage Report

This tool calculates the amount of directional mileage covered for a user selected parameter.

**Source Table:** DATA_ODOT,

**Output Table:** The default name for the output table is “PCR Mileage Report.” Users can update this table name by changing the text in the “Output Table name” text box.
FIGURE C-95. General Mileage Report User Interface

Plot Style

Bar Chart Output shown in bar chart format

Stack Bar Chart Output shown in stacked bar chart format

Example:

This report is generated by selecting “All Systems” under “System,” “All” under “Priority,” “3” under “District,” “All Counties” under “County,” “All Routes” under “Route,” “All Directions” under “Station,” “All Types” in “Pave Type,” “1985” under “From Year,” “2006” under “To Year,” “PCR” under “Parameter,” “Year” under “Group By,” and “Stackbar Chart” under “Plot Style.”

Figure C-96 shows the Mileage Report in directional miles for PCR, in categories defined by ODOT in District 3 for each year from 1985 to 2006.
8.10.4 Map View of a Table

This tool allows for mapping of attributes if the table includes “County,” “Route,” “Station,” “Blog,” and “Elog” fields.
FIGURE C-97. Map View of Table User Interface

Legend Options

**Classify:** Set the number of categories  
**Gradient:** Determine the middle category colors by grading the top and bottom category colors  
**Reverse:** Flip the selected colors  
**Background:** Superimpose map against Ohio geographical outline

**Example:**

Figure C-98 shows the map view of PCR data in DATA_ODOT for priority system routes in the entire state for 2006.

This report is generated by selecting “All” in the “District” list which appears when “District” is selected, “All Routes” under “Route,” “DATA_ODOT” under “Table,” “DOWN” under “Station,” “2006” under “Year,” and “PCR” under “Event.”

The user can right click on the map to export it as an image.
FIGURE C-98. Example of Map View
Window Menu

The “Window” menu includes normal Microsoft functions for controlling the simultaneous display of multiple open windows.

FIGURE C-99. ODOTPMIS Window Menu

9.1 Tile Horizontally
Horizontally tile all non-minimized windows.

9.2 Tile Vertically
Vertically tile all non-minimized windows.

9.3 Cascade
Cascade all non-minimized windows.

9.4 Arrange Icons
Arrange icons for minimized windows.

9.5 Close All Windows (Shortcut Key: CTRL+Q)
Close all opened tables and queries.
Help Menu

FIGURE C-100. ODOTPMIS Help Menu

10.1 Contents

Click this option to open the help file. The help file can also be activated by pressing the F1 key. Select the form or tool in question and press F1. Help for that topic will be displayed.

10.2 About

This option provides downloads of the latest updates for ODOTPMIS and specifies the current version number.

FIGURE C-101. ODOTPMIS About Dialog Box
APPENDIX D

LOCALPMIS USER MANUAL
D.1: INTRODUCTION

The Infrastructure Information System Laboratory at the University of Toledo has developed a database of pavements under local systems for the Ohio Department of Transportation. The database is in Microsoft Access database format. The LOCALPMIS includes the database and a set of reporting tools to extract the data necessary for pavement performance analysis.

All the basic operations of LOCALPMIS are similar to the ODOTPMIS. For more information, on the procedure for installation of LOCALPMIS, interface elements, File Menu, Edit Menu, View Menu, Windows Menu, Help Menu and Index Menu kindly refer Appendix-A.

However, the Data Menu, Tools Menu and Report Menu have been changed to synchronize the PMIS tool with the federal-aid local route pavement condition database. Therefore, this manual focuses solely on the detail descriptions of these three revised menus.

D.2: Data Menu

The Data Menu contains functions that add or modify various tables needed for operation of LOCALPMIS.

![Figure D.2-1 LOCALPMIS Data Menu]

D.2.1 IMPORT ADDITIONAL PCR DATA

Import Additional PCR Data sub menu is meant for importing or appending new pavement condition data and subsequently calculate PCR and deducts from the available distresses in the database.

In the Data menu choose and click the Import Additional PCR Data. A browser window as shown in Fig. D.2-2 appears. Select the required *.txt file(s) from the desired location(s) and click the OK button. This allows updating the [Local_PMIS] table. Pavement condition data in terms of Pavement Condition Rating (PCR) and severity and extent of each individual distress like raveling, rutting, settlements etc. are stored in [Local_PMIS] table. This table also stores road classification and all traffic information. Pavement condition data should be updated annually. To import condition data correctly, the source data file must have the required format.
Table to Apply: [Local_PMIS]

Data file type: Coma delimited text file

Data format:
First Line: Field Name 1, Field Name 2, ..., Field Name 64
Second and after: Value 1, Value 2, ..., Value 64

Table D.1 Field Order, Name and Data Format

<table>
<thead>
<tr>
<th>Order</th>
<th>Field Name</th>
<th>Data Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NLFID</td>
<td>Text</td>
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<td>District</td>
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</tr>
<tr>
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<td>County</td>
<td>Text</td>
<td>COS</td>
</tr>
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<td>Priority</td>
<td>Text</td>
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<tr>
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<td>form_number Number</td>
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<td>24</td>
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</tr>
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<td>25</td>
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<td>Text</td>
<td>No (write Yes/No)</td>
</tr>
<tr>
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<td>Under Const Text</td>
<td>Text</td>
<td>No (write Yes/No)</td>
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<td></td>
<td>No (write Yes/No)</td>
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<td>curb_rating Text</td>
<td></td>
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<tr>
<td>56</td>
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<td>63</td>
<td>street_name Text</td>
<td>Text</td>
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<td>street_name_suffix2 Text</td>
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<td>66</td>
<td>street_name_suffix3 Text</td>
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<td>67</td>
<td>surface_type Text</td>
<td>Text</td>
<td>I</td>
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<td>68</td>
<td>surface_width Number</td>
<td>Number</td>
<td>20</td>
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<tr>
<td>69</td>
<td>roadway_width Text</td>
<td></td>
<td></td>
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<tr>
<td>70</td>
<td>pavement_type Number</td>
<td>Number</td>
<td>5</td>
</tr>
<tr>
<td>71</td>
<td>functional_class Number</td>
<td>Number</td>
<td>17</td>
</tr>
<tr>
<td>72</td>
<td>muni_name Text</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td>muni_street_number_suffix</td>
<td>Text</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>Township_Name Text</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>mileage_class Number</td>
<td>Number</td>
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</tr>
<tr>
<td>76</td>
<td>number_lanes Text</td>
<td></td>
<td></td>
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<tr>
<td>77</td>
<td>proposed Text</td>
<td></td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>ADT Category Text</td>
<td>Text</td>
<td>M</td>
</tr>
<tr>
<td>79</td>
<td>ADT Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Truck ADT Category Text</td>
<td>Text</td>
<td>L</td>
</tr>
<tr>
<td>81</td>
<td>Truck ADT Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>Base Text</td>
<td></td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>Notes Text</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
After the new data is appended successfully to the existing [Local_PMIS] table, the PCR, Structural Deduct, Cracking Deduct, and Total Deducts are calculated for the entire database. The original pavement condition data contains PCR, and Distress ratings. After calculation of PCR and deducts, the tool checks for any mismatch between the imported PCR and the PMIS calculated PCR values. If any mismatch persists, the user is prompted to select either the calculated PCR or the imported PCR for all future analysis. The PMIS tool memorize this selected PCR and store it in a new field named *PCR_Ana* in the [Local_PMIS] table. All the analysis in LOCALPMIS is based on the PCR values stored under *PCR_Ana* field in [Local_PMIS] table.

D.2.2 Generate Performance Base AND ANALYSIS Table

In the Data menu click *Generate Performance Base and Analysis Table*. This tool first generates the [DATA_PERF_BASE] table and then generates the [DATA_PERF_ANALYSIS] table.

Both [DATA_PERF_BASE table] and [DATA_PERF_ANALYSIS] table are the basis of most of the pavement condition prediction analysis. Therefore, every time new data are added, user is recommended to generate and automatically update these two tables.

This entire procedure of preparing the base table and the analysis table is very time-consuming. Do not restart the computer while it is in progress. The database size could increase during this procedure. The user is encouraged to perform a database compacting operation before and after using this function.

D.3: Tools Menu

This menu contains functions that pavement condition prediction and remaining life estimation. This menu also contains an option to modify the decision tree to identify the repair of pavement based on the current condition.

<table>
<thead>
<tr>
<th>Future Condition Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modify Repair Decision Tree</td>
</tr>
</tbody>
</table>

**Figure D.3.1 LOCALPMIS Analysis Tools Menu**

D.3.1 FUTURE CONDITION prediction

This sub menu can be used for predicting future pavement condition using linear regression model. Both PCR and distress for every pavement section in the database are predicted for some chosen no. of years. Once the prediction of PCR and distress are
completed, the remaining life of the pavement is estimated based on either PCR or distress, as per the choice of the user.

In the Tools menu click on the submenu *Future Condition Prediction*. The form as shown in the Fig D.3.2 pops up. This form guides the user to do the prediction of pavement condition and estimate the remaining life. For each pavement type the user will have to do the prediction separately. Prediction of pavement can be done either based on system or district or county, as per the requirement of the user. However, if sufficient data which reveals certain drop in PCR in certain county or district is not available, then the results of doing district-wise or county-wise prediction can lead to misleading or no result. In that case, users are advised to include more data from other districts or counties for doing the prediction.

All the features in the prediction form as labeled in Fig D.3.2(a) are described as below:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Label as in Fig 3.1</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>1</td>
<td>Includes either Federal Aid(Local) or Non-Federal Aid(Local) or both. Lists all the 12 districts. The user can either select any particular district or can select <em>All Districts</em> to do the prediction.</td>
</tr>
<tr>
<td>District</td>
<td>2</td>
<td>Lists all the counties in the selected district(s). The user can either select any particular county or can select <em>All Counties</em> in the selected district(s) to do the prediction.</td>
</tr>
<tr>
<td>County</td>
<td>3</td>
<td>Lists all the 7 type of pavements. For each pavement type, the user will have to select the particular pavement and run the prediction separately. There is no option like “All Pavements” in this list. The user can select the start of analysis year. The model includes the data starting from this selected year in the regression model. The default value is kept as 2003.</td>
</tr>
<tr>
<td>Pave Type</td>
<td>4</td>
<td>The user can select the end of analysis year. The model includes the data till this selected year in the regression model. The default value is kept as the latest data year available in the database.</td>
</tr>
<tr>
<td>From Year</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>To Year</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Rem Life</td>
<td>7</td>
<td>The user can select any year from this</td>
</tr>
<tr>
<td>Feature</td>
<td>Label as in Fig 3.1</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>from year</td>
<td></td>
<td>drop box. The remaining life of pavement is then estimated assuming this selected year as the base year. The default value is kept as the current year.</td>
</tr>
</tbody>
</table>

**Prediction Option**

| # of Years | 8                  | The user can select any no. of years of doing the prediction from this drop box. The default value is kept as 5. |

**Rem. Life PCR Thresholds**

<table>
<thead>
<tr>
<th>Use Distress Criteria</th>
<th>10</th>
<th>If the user desires to estimate the remaining life based on distress, then this field must be checked. Clicking this button the user can define the threshold extent and severity of selected distress to estimate the remaining life. On clicking, another form as shown in Fig. D.3.2(a) will pop up. This form will guide the user to define the distress and its threshold extent and severity that influences the life of the pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>9</td>
<td>This field cannot be left blank. The user will have to provide the threshold PCR value, below which the pavement section is deemed to be at the end of its life.</td>
</tr>
</tbody>
</table>

**Output Tables**

<table>
<thead>
<tr>
<th>All output tables</th>
<th>12-15</th>
<th>It is advised to keep the Table Name unchanged. This table names are identified in some program to generate the reports and graphs. The prediction and estimation of life of pavement is initiated by clicking this button. This process is a bit time consuming. So users are asked to be patient while running this model. If this button is clicked the form as displayed in Fig D.3.2(a) is unloaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
Fig. D.3.2(a) Future Condition Prediction Form
D.3.2 MODIFY REPAIR DECISION TREE

This sub menu helps the user to modify the repair decision tree prior to determine the recommendations for repair for each pavement section. The treatment logic for Local Pavement is shown in Fig. D.3.3 (a) below. The user can change the threshold PCR and Structural Deduct in this logic form. As the decision tree for Brick and Gravel pavements are not available, currently the decision trees for Jointed Concrete Pavement and Local Pavement are only included. To modify the logic for distress, the user will have to click the Miscellaneous Criteria, labeled as “1” in Fig D.3.3 (a). The form for Miscellaneous Criteria is shown in Fig. D.3.3 (b). In this form the user can first find the default setup for the distress logic using the record locator option. Selecting the desired pavement type and clicking the Search button will help the user to get the Allowable Distress. User can then change the desired extent and level of each available distress for the selected pavement type. The repair logic to consider the distress types using “AND / OR” can be set up in the View and Edit Repair Logic field. After doing all the necessary changes, the user should either click the APPLY or the OK button to make the changes in the [LU_Repair Logic]. The recommendation of treatment is then based on this new logic setup by the user.
Fig D.3.3 (a) Treatment Logic form

Fig D.3.3 (b) Treatment Logic for Distress
D.4: REPORT Menu

This menu contains tools for to generate specific reports and graphs of the database.

Figure D.4.1 LOCALPMIS Report Menu

D.4.1 GENERATE CURRENT PAVEMENT CONDITION REPORT

This submenu generates the existing pavement condition report. User can generate the report either district-wise or for any particular county. The form as shown in Fig. D.4.2 guides to generate this report. The grid table generated contains the existing PCR and distress for the pavement sections in the selected district or county. The grid table can be exported to Microsoft Excel® by clicking anywhere within the grid table.

Fig. D.4.2 Current Pavement Condition Report Form
A glimpse of the generated grid table for existing pavement condition is shown in Fig D.4.3 below:

<table>
<thead>
<tr>
<th>Section</th>
<th>NEID</th>
<th>District</th>
<th>County</th>
<th>Route</th>
<th>Station</th>
<th>End</th>
<th>muni_name</th>
<th>Street_Name</th>
<th>Year</th>
<th>PCR</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>3045094</td>
<td>2</td>
<td>SAN</td>
<td>D-12</td>
<td>312</td>
<td>UP</td>
<td>0</td>
<td>BELLEVUE</td>
<td>SOUTHWEST RD</td>
<td>5</td>
<td>Local</td>
</tr>
<tr>
<td>23</td>
<td>3045095</td>
<td>2</td>
<td>SAN</td>
<td>698</td>
<td>UP</td>
<td>0</td>
<td>BELLEVUE</td>
<td>YORK ST</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>24</td>
<td>3045096</td>
<td>2</td>
<td>SAN</td>
<td>40</td>
<td>UP</td>
<td>0</td>
<td>BELLEVUE</td>
<td>C-48 Rd</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>25</td>
<td>3045097</td>
<td>2</td>
<td>LUC</td>
<td>519</td>
<td>UP</td>
<td>0</td>
<td>TOLEDO</td>
<td>ERIE ST</td>
<td>2</td>
<td>Jointed Concrete</td>
<td>2005</td>
</tr>
<tr>
<td>26</td>
<td>3045098</td>
<td>2</td>
<td>LUC</td>
<td>542</td>
<td>UP</td>
<td>0</td>
<td>TOLEDO</td>
<td>STOWE AND ST</td>
<td>2</td>
<td>Jointed Concrete</td>
<td>2005</td>
</tr>
<tr>
<td>27</td>
<td>3045099</td>
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<td>LUC</td>
<td>578</td>
<td>UP</td>
<td>0</td>
<td>TOLEDO</td>
<td>ERIE ST</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>28</td>
<td>3045100</td>
<td>2</td>
<td>LUC</td>
<td>546</td>
<td>UP</td>
<td>0</td>
<td>TOLEDO</td>
<td>SCOTT ROAD</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>29</td>
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<td>HOLLOWAY RD</td>
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<td>Jointed Concrete</td>
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</tr>
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<td>2005</td>
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<td>LUC</td>
<td>552</td>
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<td>MAUMEE RD</td>
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<td>Local</td>
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</tr>
<tr>
<td>43</td>
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<td>LUC</td>
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<td>JEFFERSON AVE</td>
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<td>sonst</td>
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</tr>
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<td>EUROPE AVE</td>
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<td>Local</td>
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<td>0</td>
<td>sonst</td>
<td>MAUMEE</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>49</td>
<td>3045121</td>
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<td>LUC</td>
<td>543</td>
<td>UP</td>
<td>0</td>
<td>MAUMEE</td>
<td>KEYS ST</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>50</td>
<td>3045122</td>
<td>2</td>
<td>LUC</td>
<td>550</td>
<td>UP</td>
<td>0</td>
<td>sonst</td>
<td>JEFFERSON AVE</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
<tr>
<td>51</td>
<td>3045123</td>
<td>2</td>
<td>LUC</td>
<td>540</td>
<td>UP</td>
<td>0</td>
<td>sonst</td>
<td>SURVEY AVE</td>
<td>5</td>
<td>Local</td>
<td>2005</td>
</tr>
</tbody>
</table>

**D.4.2 PCR DROP**

This sub-menu lists all the pavement sections whose yearly change in PCR is more or equal to the selected PCR Drop value. Fig. D.4.4 below illustrates the PCR Drop form.
D.4.3 show predicted pavement condition

Under this sub-menu two more menus are available: *Generate PCR Grid Table* and *Show Section-wise PCR Trend*

**Generate PCR Grid Table**

This option helps the user to generate PCR grid table either district-wise or for any particular district. On clicking the form as in Fig D.4.5 will pop up.
The grid table contains all the following fields:

- District
- County
- Route
- Station
- Blog
- Elog
- Pavement Type
- Base
- Surface Type
- Remaining Life
- Remarks
- PCR

The surface type field lists whether the pavement section has asphalt or brick or concrete or gravel surface. The Remarks column in the grid table indicates whether the predicted distress predominates in the estimation of remaining life. If the cell under Remarks column is blank, then it indicates that the future PCR plays dominant role in estimation of remaining life.

The PCR field lists the year-wise existing and predicted PCR values. The predicted values are displayed till the year the prediction was done using the Future Condition Prediction submenu under Tools menu.

This grid table can also be exported to MS Excel ®.
A glimpse of the grid table generated for District – 5 can be seen in Fig D.4.6.

**Fig D.4.6 Predicted PCR Grid Table**

*Show Section-wise PCR Trend*

This option helps the user to generate PCR trendlines for any selected pavement section. On clicking this menu, the form as shown in Fig D.4.4 pops up. As seen in the form, user can select any particular route within any county and can then select the desired pavement section from the Blog-Elog list of the selected route. Both existing and predicted PCR trends are then plotted for the chosen section when the PLOT button is clicked. The graph depicting PCR trends for the section displayed in the Fig D.4.7 is shown in Fig. D.4.8.

**Fig D.4.7 Generate PCR Trendline form**
Fig D.4.8 Graph showing PCR Trend

For display purpose, the user can change some settings, as shown in Fig D.4.9 by clicking the right button of the mouse.

Fig D.4.9 Customizing PCR Trend Graph

The scale of the axes can be changed by clicking the Customization Dialog… option as seen in Fig D.4.9 and then going to the Axis option within the dialog form. The Max/Min options should be clicked to change the scale of PCR axis.

User can also use the Export Dialog… to export the graph in JPEG or PNG or BMP or txt format. The graph can also be printed by using the PRINT button available within the Export Dialog form.
D.4.4 REPAIR CANDIDATES

This submenu is used to generate the recommendation report of repair of the pavement sections. The recommendation is based entirely on the repair logic set up by the user. Currently there is no default logic set up for the Brick and the Gravel pavements. Therefore, the report displays the recommended repair for only local pavement and jointed concrete pavement sections.

![Repair Candidates Form](image)

Fig. D.4.10 Repair Candidates Form