Pavement Management Systems

Dr. Nick Vitillo

PAVEMENT MANAGEMENT SYSTEMS
OVERVIEW
PMS CONCEPTS

DISCUSSION TOPICS

✓ DEFINITION OF PM AND PMS
✓ PMS SUBSYSTEMS
✓ NETWORK & PROJECT LEVEL PMS
✓ PAVEMENT EVALUATION
✓ PERFORMANCE AND ECONOMIC ANALYSES
✓ DATA BASES/DATA MANAGEMENT
<table>
<thead>
<tr>
<th>Pavement Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pavement Materials</strong></td>
</tr>
<tr>
<td><strong>Pavement Design</strong></td>
</tr>
<tr>
<td><strong>Pavement Construction</strong></td>
</tr>
<tr>
<td><strong>Pavement Management</strong></td>
</tr>
<tr>
<td><strong>Pavement Research</strong></td>
</tr>
</tbody>
</table>
PAVEMENT MANAGEMENT SYSTEM
Overview
DEFINITIONS

PAVEMENT MANAGEMENT

"Pavement Management is a program for improving the quality and performance of pavements and minimizing costs through good management practices"
DEFINITIONS

PAVEMENT MANAGEMENT SYSTEMS

"A Pavement Management System is a set of defined procedures for collecting, analyzing, maintaining, and reporting pavement data, to assist the decision makers in finding optimum strategies for maintaining pavements in serviceable condition over a given period of time for the least cost."
A Pavement Management System (PMS) is designed to provide objective information and useful data for analysis so that road managers can make more consistent, cost-effective, and defensible decisions related to the preservation of a pavement network.

While a PMS cannot make final decisions, it can provide the basis for an informed understanding of the possible consequences of alternative decisions.

A PMS does NOT make decisions, Managers DO!
PMS LEVELS

**NETWORK**

*BIRD’S EYE VIEW OF NETWORK PAVEMENTS AS A WHOLE.*
- STATEWIDE PAVEMENT CONDITION SUMMARY
- BUDGET ESTIMATE
- PERFORMANCE PREDICTION

**PROJECT**

*ASSIST DESIGNERS IN CONSTRUCTING, MAINTAINING, OR REHABILITATING A SECTION OF ROADWAY.*
- PREVENTIVE MAINTENANCE
- RESURFACING OR RECONSTRUCTION
- TREATMENTS OPTIONS ALONG THE PROJECT
PMS SUBSYSTEMS

-PMS DATA
  ▪ Inventory
  ▪ Condition - Pavement Evaluation
  ▪ History – Initial, PM, RM, Rehab, Reconstruction
  ▪ Traffic
  ▪ Costs

-MODELING - ANALYSIS
  ▪ Serviceability Rating
  ▪ Performance Predictions
  ▪ Economic Analyses-Budgeting / Programming

-DATA MANAGEMENT
  ▪ Relational Databases
  ▪ Report Generation
REFERENCE SYSTEMS

MILE POSTS

START MP 0.0

MP 1.0

MP 3.0

MP 5.0

MP 7.0

0.0 2.5 4.5 5.75 7.25

Mile Posts

0 1 2 3 4 5 6 7
REFERENCE SYSTEMS

MILE POSTS

Secondary Direction

South & West

Primary Direction

North & East

Length of Route in **Primary** Direction may be different than that in the **Secondary** Direction.
DATA COLLECTION
PMS DATA COLLECTION

DATA TYPES

- INVENTORY,
- PAVEMENT CONDITION
- TRAFFIC/LOADS,
- COSTS - Construction, PM, RM, Rehab, Reconstruction
- HISTORY – Initial Const, PM, RM, Rehab, Reconstruction
  (Last Treatment)
Example Inventory Data

- Route Number
- Route Type (Interstate, US, NJ)
- Functional Class
- Length
- Divided/Undivided Route Section
- Pavement Type
- Number of Lanes and Widths
- Shoulder Type and Width
- County
- Legislative District
PAVEMENT DATA COLLECTION

PAVEMENT CONDITION EVALUATION

- PAVEMENT ROUGHNESS or RIDE QUALITY
- SURFACE DISTRESS
- RUTTING
- SKID RESISTANCE
- STRUCTURAL CAPACITY
Need for Annual Condition Surveys
Ride Quality, Surface Distress, Rutting, Friction

- Evaluating current condition of pavement
- Determining rates of deterioration
- Project future conditions to determine current and future maintenance & rehabilitation needs
- Determining future cost of repairs
Pavement Condition Survey Equipment

Profiler
- roughness, distress, rutting, noise, pavement cracking

Skid Trailer
- Pavement friction

GPR
- Layer Thickness

FWD

Structural Capacity

Equipment Demo
- Last Day
"ROAD ROUGHNESS IS THE IRREGULARITIES IN THE PAVEMENT SURFACE AFFECTING USER COMFORT AND SAFETY"

DUE TO VARIATIONS IN HORIZONTAL, VERITICAL, AND TRANSVERSE PROFILES

RIDE QUALITY - USER PERCEPTION OF PAVEMENT ROUGHNESS
PAVEMENT CONDITION EVALUATION

SURFACE DISTRESS

DESCRIPTION

TYPE OF DISTRESS (Cracking, Patching, Rutting)
SEVERITY (Crack Width, Condition Assessment)
EXTENT (Percentage of the Pavement Length)

DATA COLLECTION

CONTINUOUS - WINDSHIELD SURVEY
(COMPUTER RATER KEYBOARD, and VIDEO)
SURFACE DISTRESS

LOAD ASSOCIATED vs. Non-LOAD ASSOCIATED LOCATION

Network Level PMS “Slow” lane in each direction – 4600 directional miles
PAVEMENT CONDITION EVALUATION

SURFACE DISTRESS
BITUMINOUS/COMPOSITE PAVEMENTS

NDI
CRACKING
MULTIPLE
LOGITUDINAL
TRANSVERSE

LDI
CRACKING
MULTIPLE

SURFACE DEFORMATION
RUTTING

MISCELLANEOUS
SHOULDER CONDITION
PATCH CONDITION

Observation of condition in the other lanes
3-5 Point Measurement

Rut Depth Measurement

\[
\text{Rut Depth} = \frac{D_2}{2} + \frac{D_3}{3} - D_1
\]
PAVEMENT CONDITION EVALUATION

SURFACE DISTRESS
CONCRETE PAVEMENTS

CRACKING

JOINT DEFECTS
JOINT SEAL DAMAGE
JOINT CONDITION

MISCELLANEOUS
PATCH CONDITION
SKID RESISTANCE
SAFETY

DESCRIPTION
ASSESSMENT OF THE COEFFICIENT OF FRICTION OF THE PAVEMENT SURFACE (BASED ON SPEED)

DATA COLLECTION
CONTINUOUS - ASTM E274 (LOCK WHEEL) SKID TRAILER
DESCRIPTION
ASSESSMENT OF THE LOAD CARRYING CAPACITY OF THE PAVEMENT STRUCTURE

DATA COLLECTION
DESTRUCTIVE - CORING/BORINGS/LAB TESTS
NON-DESTRUCTIVE TEST –
▪ FALLING WEIGHT DEFLECTOMETER (FWD)
▪ CONCRETE JOINT LOAD TRANSFER EFFICIENCY
▪ GROUND PENETRATING RADAR
QUESTIONS ?
PMS
Performance Analyses
## Condition Surveys

### Ride Quality, Surface Distress, Rutting

<table>
<thead>
<tr>
<th>Pavement Indices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Wheel Path Profile</td>
<td>Ride Quality Index IRI</td>
</tr>
<tr>
<td>Pavement Surface Distresses</td>
<td>Surface Distress Index</td>
</tr>
<tr>
<td>Rutting</td>
<td>Average Pavement Rut Depth</td>
</tr>
<tr>
<td>Structural Capacity Deflections</td>
<td>Structural Capacity Index</td>
</tr>
</tbody>
</table>

Converts collected data to single value
Need for Condition Surveys
Ride Quality Index

- Measure Pavement Wheel Path Profile(s) to assess Pavement Ride Quality
- Convert Pavement Wheel Path Profile (L&R) to Pavement Ride Quality Indices (IRI)

![Graph showing pavement elevation profile with distance in meters and elevation in millimeters]
Pavement Distress Survey

- Type of distress (Cracking, Patching, etc)
- Severity (width of cracks, condition of the patch, etc.)

- Extent - Quantity of distress present on the pavement (percentage of length)
Distress Identification Manual
for the Long-Term Pavement Performance Program

Pavement Models
Pavement Performance Example

Prediction Model

Distress Index

Trigger

Current Time

Site Specific Distress Model

Measured

Predicted

Years


Default Distress Index Model

0 1 2 3 4 5

Distress Index

Pavement Performance Example
PMS
Economics
Analyses
Reporting
**Multi-Year Prioritization (MYP)**

A method of allocating limited resources in an efficient and cost-effective way over a multi-year period (2-10 year’s needs), through an evaluation of long-term impacts.

A PMS process or tool used to objectively identify the best combination of projects over a multi-year program.
Multi-Year Prioritization (MYP)

Prioritization techniques use mathematical modeling tools to achieve the best combination of projects over the specified analysis period:

- Pavement performance Models predict future condition and suggest timing of needed rehab
- Projects are identified with need for PM, Minor Rehab, Major Rehab or Reconstruction
- The most effective timing for the applying the appropriate treatment are identified
ANALYSES

ECONOMIC ANALYSES

Benefits Provided By MYP

- Forecast future conditions
- Analyze timing options
- Evaluate effectiveness of alternative strategy
- Perform economic analyses
- Use of objective measures for prioritizing needs
- Project future budgets
- Predict the impact of each combination of projects on the network over the given analysis period
Effect of Treatment Timing on Costs

Typical Variation of Pavement Condition as a Function of Time

Typical variation of pavement condition over time with key points:
- **Exc**: 40% drop in quality
- **Good**: PM cost here is a fraction of $1.00
- **Fair**: Will cost $4.00 to $5.00 here
- **Poor**: 75% of life
- **Very Poor**: 40% drop in quality
- **Failed**: 12% of life

Time axis from bottom to top:
- **Failed**
- **Poor**
- **Very Poor**
- **Fair**
- **Good**
- **Exc**
You never have enough fish!
Homogeneous Analysis Sections

- Change in pavement type
- Change in pavement structure
- Change in traffic Volume
- Political boundaries
- Change in pavement condition (Dynamic)
- Construction Project limits

Decide the overall condition, timing, costs, and treatment type
Treatment Options in MYP

- Performance Prediction Model
- Benefit or Effectiveness (Area under the curve)
- Predicted Performance
- Condition Increase
- Life Extension
- Marginal Cost Effectiveness
- Incremental Benefit/Cost Ratio
- Age or Traffic Loads

Graph showing the relationship between pavement condition index and age or traffic loads, with various treatment options and effects indicated.
Treatment Options in MYP

- Existing Performance
- Trigger Point for Treatment 1
- Trigger Point for Treatment 2
- Treatment 1 in Years X and Z at $ Cost
- Treatment 2 in Year Y at $S Cost
ECONOMIC ANALYSES

Decision Benefits Provided By MYP

Provide answers for the questions:

1. What condition will be reached for a given level of funding?

2. What budget is needed to reach or maintained a given level of condition?
Example Network Performance

Illustrates Policy Decisions

What are the average projected IRI for the given Budget Levels?

IRI % above trigger

[Graph showing budget scenarios from 2006 to 2018, with different budget levels represented by different lines.]

- $225
- $275
- $290
- $300
- $375
- $600

Years

% above trigger
Example Network Performance

Illustrates Policy Decisions

What will it cost to maintain the current IRI?
Pavement Strategy Development

**Pavement Strategy**

- **Plan of action**
- Comprised of the application of one or more maintenance or rehabilitation techniques
- Designed to improve or maintain the condition of a pavement segment above some predetermined minimum requirement
Requirements for Developing a Strategy

- List of strategy guidelines and treatment options
- Treatment Costs
- Pavement performance models for treatment

Options in Strategy Development

- Project Selection/Treatment Selection - simultaneous or not
- Single treatments or multiple treatments
Single Treatment Strategy

- Most common approach
- Several feasible alternatives may be identified for each section
- Each treatment considered independently
- Most cost-effective treatment generally selected

Multiple Treatment Strategy

- Combination of treatments considered for each section
- Effectiveness of all treatments is representative of effectiveness of entire strategy
- Subsequent treatments affect selection of strategy
- Repeated treatments
Decision Trees

Treatment Selection

Asphalt Pavement

Pavement Condition Index

>4

Preventive Maintenance

Load-Associated Structural Deterioration

Present

Structural Overlay

Not Present

Functional Overlay

= 4 or below

Condition
PMS DATABASES

COMPUTERIZED DATABASE MANAGEMENT SYSTEMS (DBMS)

INTEGRATED RELATIONAL DATABASES
PMS COORDINATED DATABASES

COMPUTERIZED DATABASE MANAGEMENT SYSTEMS (DBMS)

INTEGRATED RELATIONAL DATABASES

- INVENTORY - RT NUMBER, FUNCTIONAL CLASS,
- PAVEMENT TYPE, etc.
- CONDITION - RIDE QUALITY, DISTRESS, FRICTION,
- DEFLECTION
- COSTS
- HISTORY
- TRAFFIC / LOADS
PAVEMENT HISTORY

Initial Construction Data

Date, Cost, Material, Structure, etc.

Preventive Maintenance

Date, Treatment, Cost, Material, Structure, etc.

Rehabilitation

Date, Treatment, Cost, Material, Structure, etc.

Reconstruction

Date, Treatment, Cost, Material, Structure, etc.
COSTS

AGENCY COSTS

- P&E
- DESIGN
- CONSTRUCTION
- PREVENTIVE AND ROUTINE MAINTENANCE
- REHABILITATION / RESURFACING / RECONSTRUCTION
- SALVAGE
PMS DATABASES

DATABASE PRODUCTS/REPORTS

DEFICIENCY REPORTS –
SECTIONS WITH UNACCEPTABLE RQ OR DISTRESS

PERFORMANCE HISTORIES
DISPLAY GIVEN CONDITION PARAMETER OVER TIME OR LOADS

CONSTRUCTION, MAINTENANCE, REHAB HISTORIES

LIST OF BUDGET NEEDS - STATE, MPO, COUNTY, TOLL AUTHORITIES
PMS DATABASES

DATABASE PRODUCTS/REPORTS

[TABULAR, BUSINESS GRAPHICS, GIS MAP, Video]

<table>
<thead>
<tr>
<th>Section</th>
<th>Year</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>2006</td>
<td>$100,000</td>
</tr>
<tr>
<td>47</td>
<td>2008</td>
<td>$237,999</td>
</tr>
</tbody>
</table>
Data Storage

1 Terabyte = 1,024 Gigabytes
THANK YOU