

## Optimal Timing of Pavement Preventive Maintenance

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# Presentation Overview

- Introductions
- Importance of Optimal Timing
- Pavement Performance and Preventive Maintenance
- Calculating Benefits
- Calculating Costs
- Demonstration of OPTime

**With breaks!**



- Data Collection
- Project/Treatment Selection
- Data Analysis
- Feedback and Reporting



# Topic 1 Importance of Optimal Timing

At the end of this topic, participants will be able to:

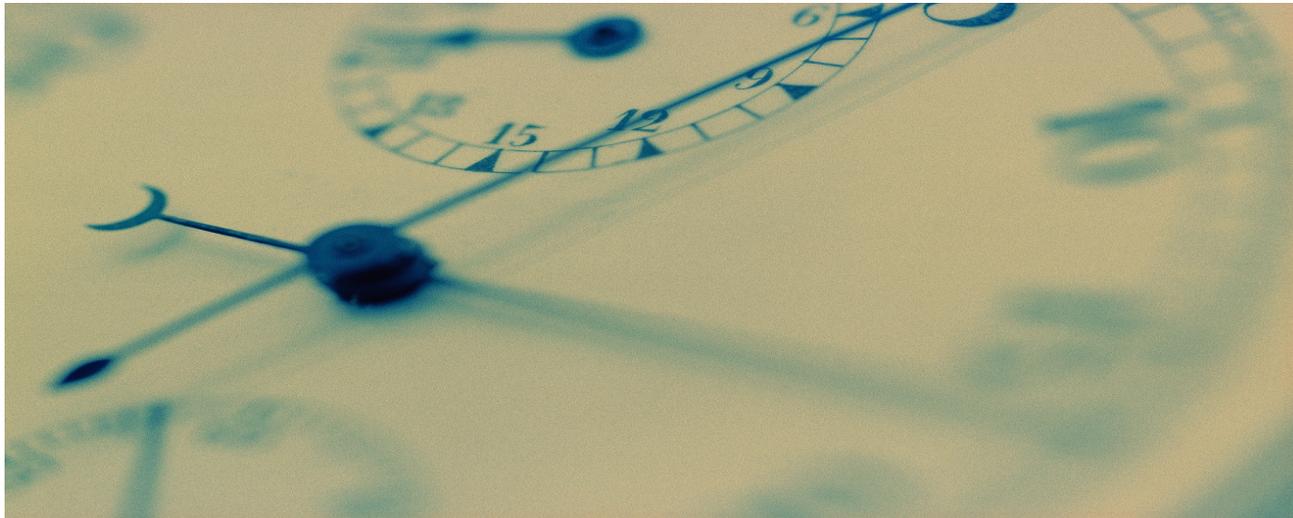
- Explain how an agency might benefit by considering optimal timing in its preventive maintenance practices. In particular, they will be able to describe:
  - Optimal timing concept
  - Typical preventive maintenance or preservation program benefits
  - The importance of performance measured against a “do-nothing” approach
- Describe the function of the OPTime tool



# Agency Pavement Preservation Timing Issues

## Timing pavement preservation or preventive maintenance treatments

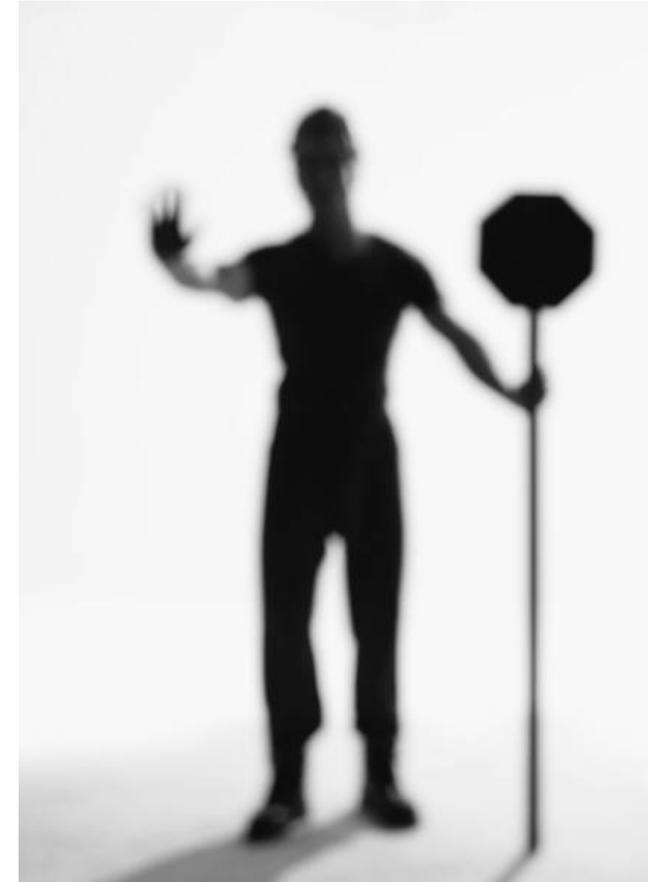
- What results if treatments are applied too soon?
- What results if treatments are applied too late?
- What is the optimal timing for treatments?



# What Is Optimal Timing?

Optimal timing definition for a given treatment:

*The time in the life of the pavement when you apply that treatment which gives you the greatest improvement in benefit for the lowest cost.*



Understandable concept to agencies:

**“Greatest bang for the buck”**



# What's In It For Me?: Why An Agency Performs An Analysis

## Optimal timing for preventive maintenance treatments:

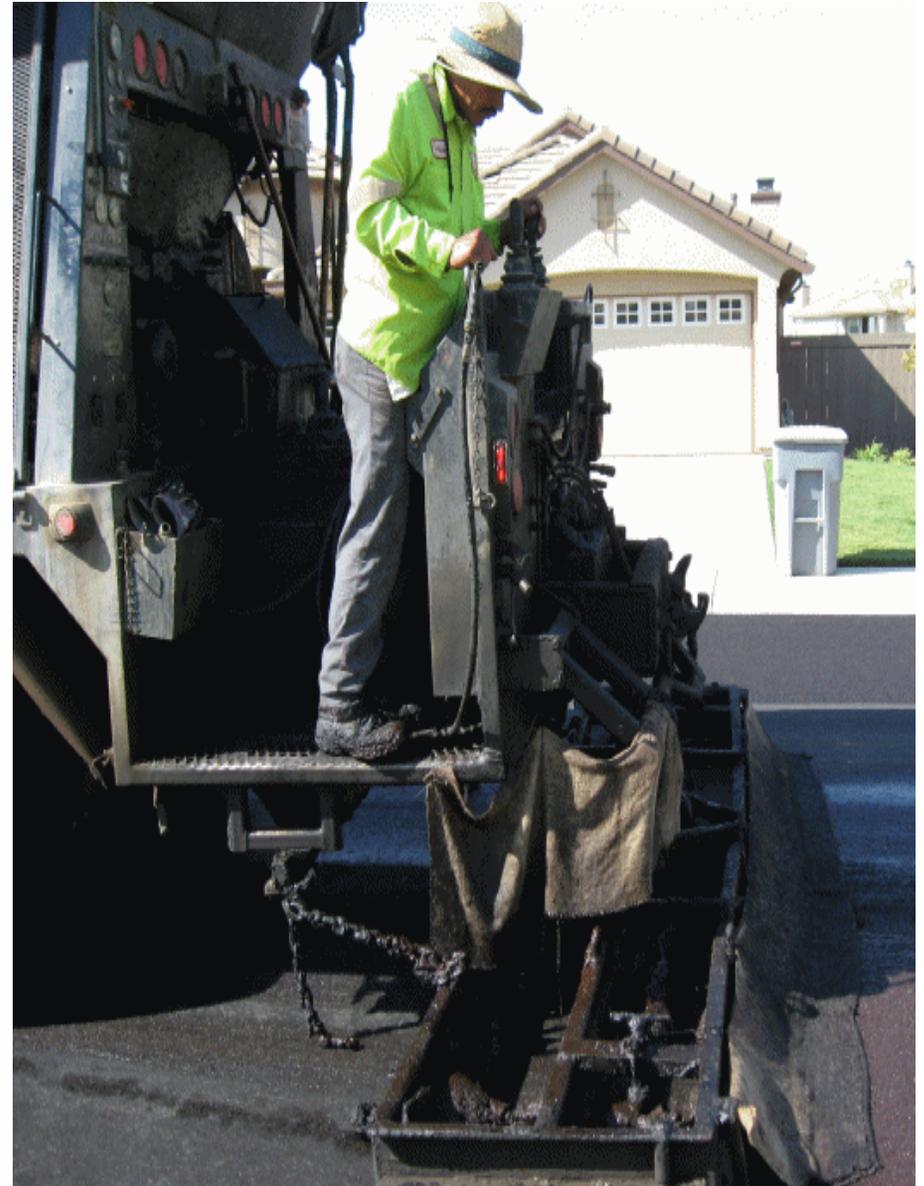
- Best use of limited agency funds
- Promotes management support
- Other benefits:
  - Improved pavement performance
  - Greater customer satisfaction
  - Delayed need for rehabilitation



# How Do We Do It?

## The concept is not new

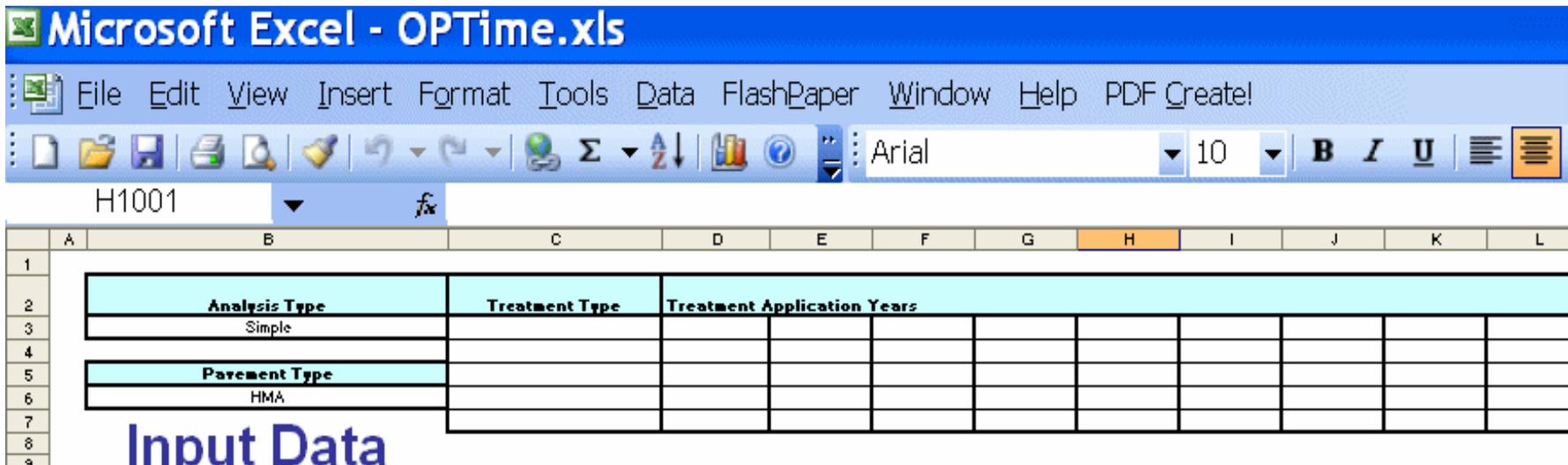
- Analysis may be part of the pavement management system
  - Treatment selection process
  - Optimization routines for treatments and their costs
- May be applied to generate treatments
  - Network management based on optimization concepts
  - Benefit-cost analysis
- Needs to be applied consistently to pavement preservation programs



# A Tool for Determining Optimal Timing

## OPTime

- Excel-based Visual Basic tool
- Developed under Project 14-14 and reported in NCHRP 523
- Methodology for calculating
  - Benefit of applying a treatment
  - Different benefits for treatments applied at different times
  - Costs



The screenshot shows the Microsoft Excel interface for the OPTime tool. The title bar reads "Microsoft Excel - OPTime.xls". The menu bar includes File, Edit, View, Insert, Format, Tools, Data, FlashPaper, Window, Help, and PDF Create!. The toolbar contains various icons for file operations and editing. The active cell is H1001. The spreadsheet shows a table with the following structure:

| Analysis Type | Treatment Type | Treatment Application Years |  |  |  |  |  |  |  |
|---------------|----------------|-----------------------------|--|--|--|--|--|--|--|
| Simple        |                |                             |  |  |  |  |  |  |  |
| Pavement Type |                |                             |  |  |  |  |  |  |  |
| HMA           |                |                             |  |  |  |  |  |  |  |

The text "Input Data" is overlaid on the bottom left of the spreadsheet area.



## Audience Poll

What best illustrates the concept of optimal treatment timing in your agency?

1. I apply treatments when they are least expensive.
2. I apply treatments when I can get a big improvement in pavement performance.
3. Optimal timing is placing a chip seal instead of a thick overlay.
4. Optimal timing is getting the biggest bang for my buck.



## Topic 1 Review

- What is impact of applying treatments too late?
- List four benefits of preventive maintenance.
- What is OPTime?



## Topic 2 Preventive Maintenance and Pavement Performance

At the end of this topic, participants will be able to:

- Define the characteristics of preventive maintenance as differentiated from other maintenance and rehabilitation activities
- Identify factors affecting treatment benefit and describe role of “do nothing” performance data in calculating benefits of treatment application
- Describe links between agency objectives and performance measures



## Are Any of These Preventive Maintenance?

1. "Our agency's preventive maintenance (PM) policy is to place a chip seal on a low volume road once it's falling apart. We have done this for years and years."
2. "We believe that PM is any maintenance that improves the functional condition of the system."
3. "PM must retard future deterioration of the system."
4. "We performed preventive maintenance to the existing road while we widened it to handle the extra traffic from the new mall."
5. "A 1.5-inch hot-mix overlay is the only effective PM treatment available."



# Defining Preventive Maintenance

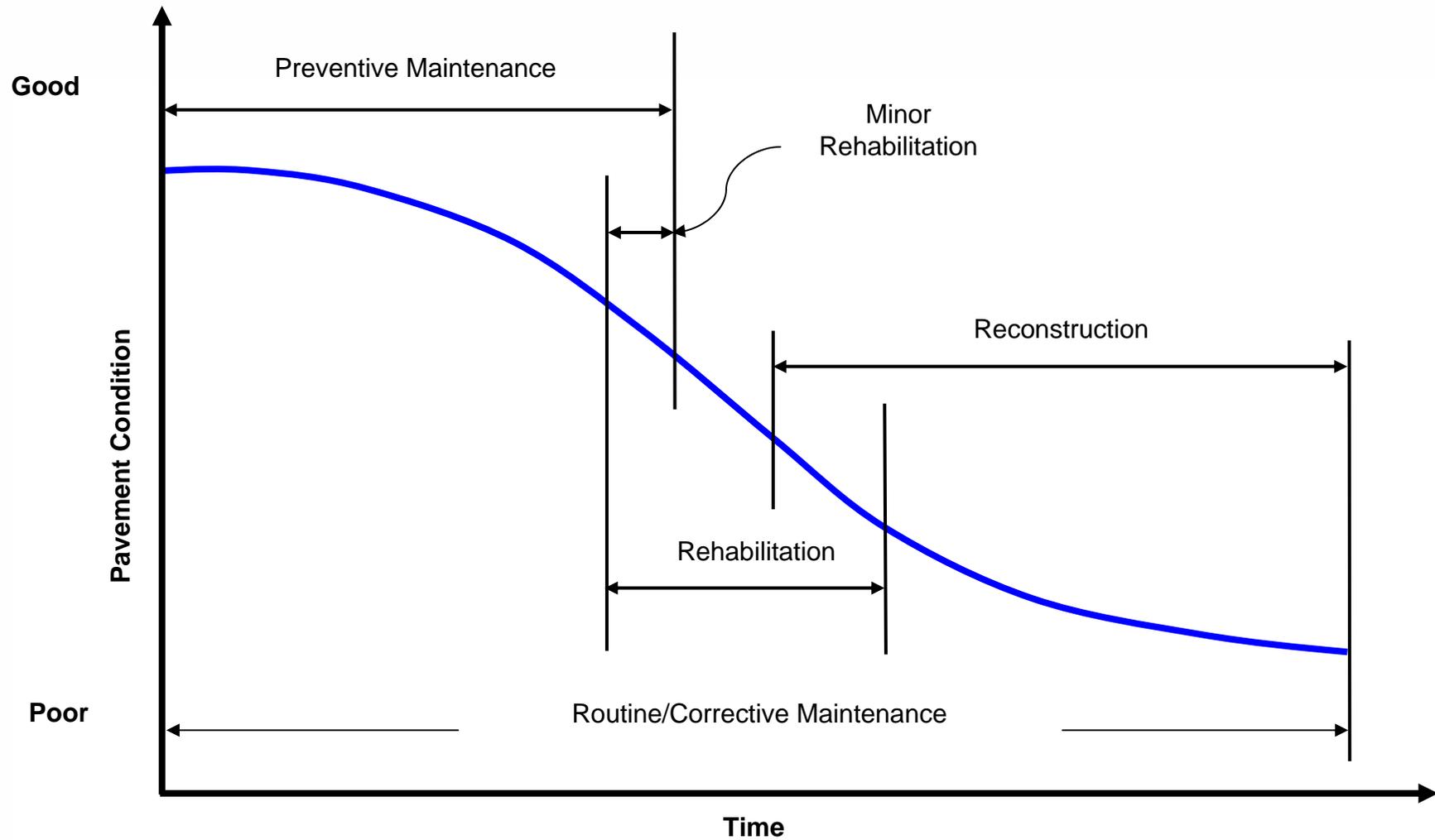
## AASHTO definition of preventive maintenance

- Planned strategy
- Preserves the system
- Retards future deterioration
- Maintains or improves functional condition
- Does not increase structural capacity

*“Keeping good roads in good condition”*



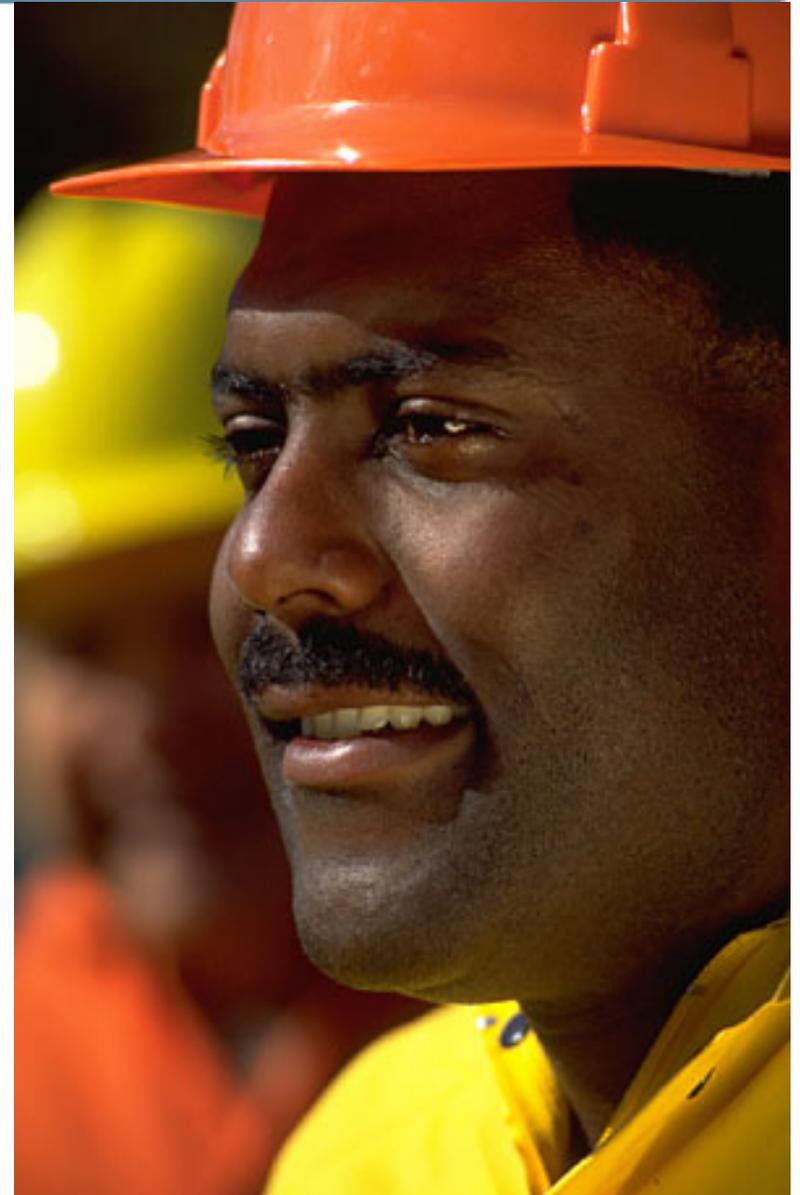
# Illustrating the Definition



# Benefits, Costs, and Analysis

## Our focus:

- Benefits and costs
- Applying the optimal timing methodology
- Goal = Identify the optimal time to apply a specific PM treatment
- Apply at different times
- Benefits differ
  - Different pavement conditions
  - At different times



## Audience Poll

What pavement data are available to you?

- Pavement type
- Pavement age
- Historical pavement condition
- Current pavement condition
- Pavement performance curves
- Treatment life and durability
- Other



# Take Advantage of What You Already Have

## Collecting performance data

- Most agencies have many years of experience with use of treatments
- Over time, treatments will have been applied to wide range of pavements in different conditions
- Opportunity to collect and analyze performance data



# Understanding Pavement Performance

## Deterioration caused by

- Traffic
- Environmental effects
- Material defects
- Construction defects
- Quality of maintenance
- Combination of all these factors

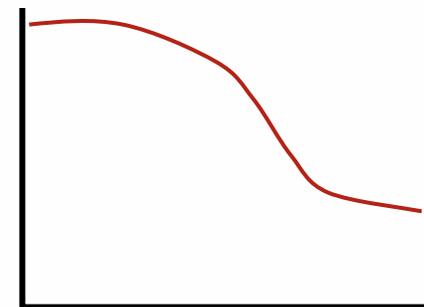
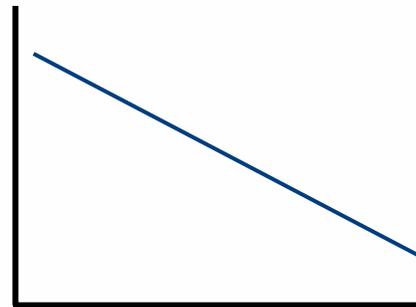
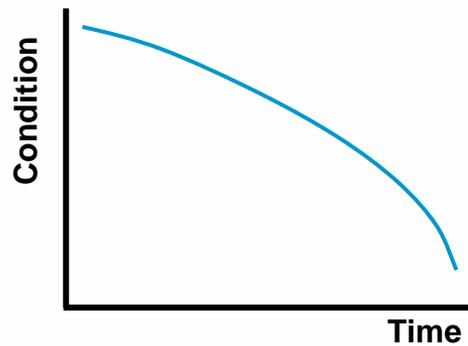


# Modeling Pavement Performance



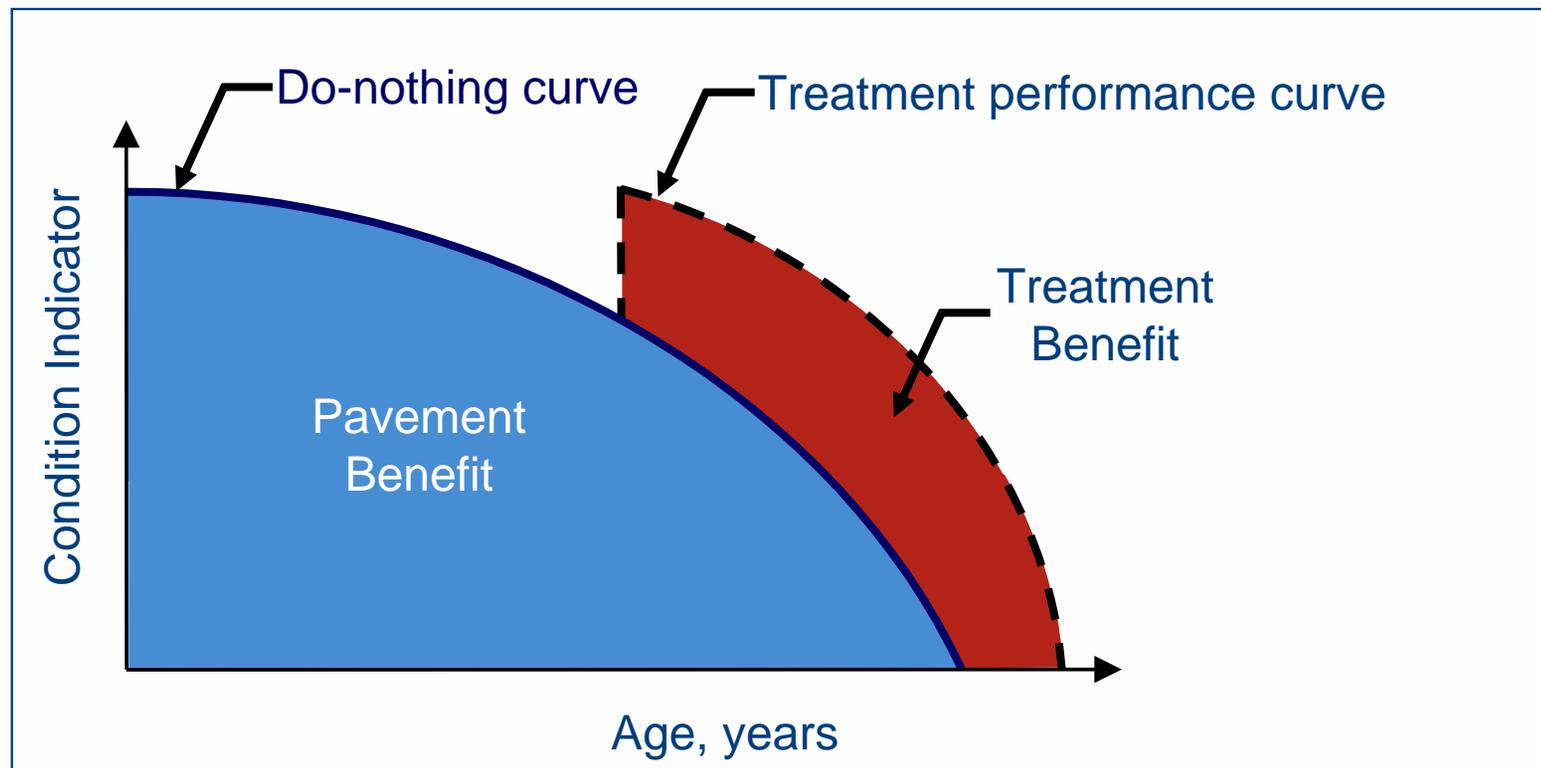
Different pavements

Different environments



# Modifying Pavement Performance

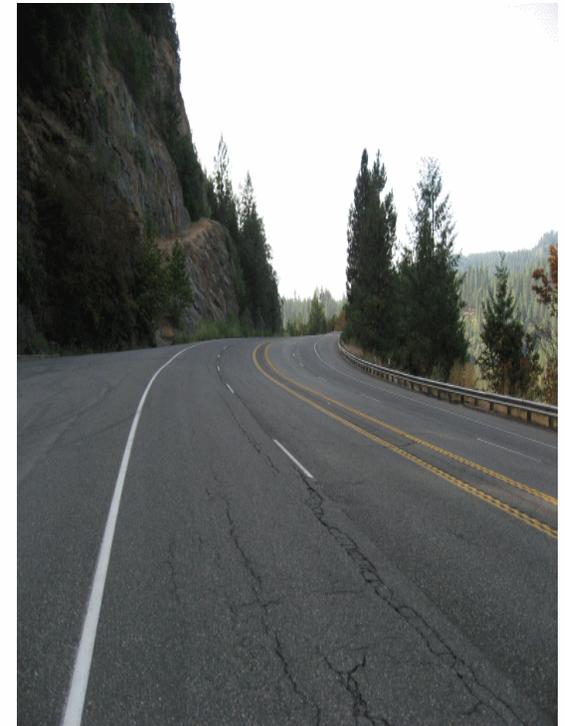
- Improvement from treatment provides some benefit
- That benefit is obtained by comparing treated versus non-treated pavement
- Non-treated pavement performance is modeled by a “do nothing” curve
- Modified treatment performance curve due to treatment application



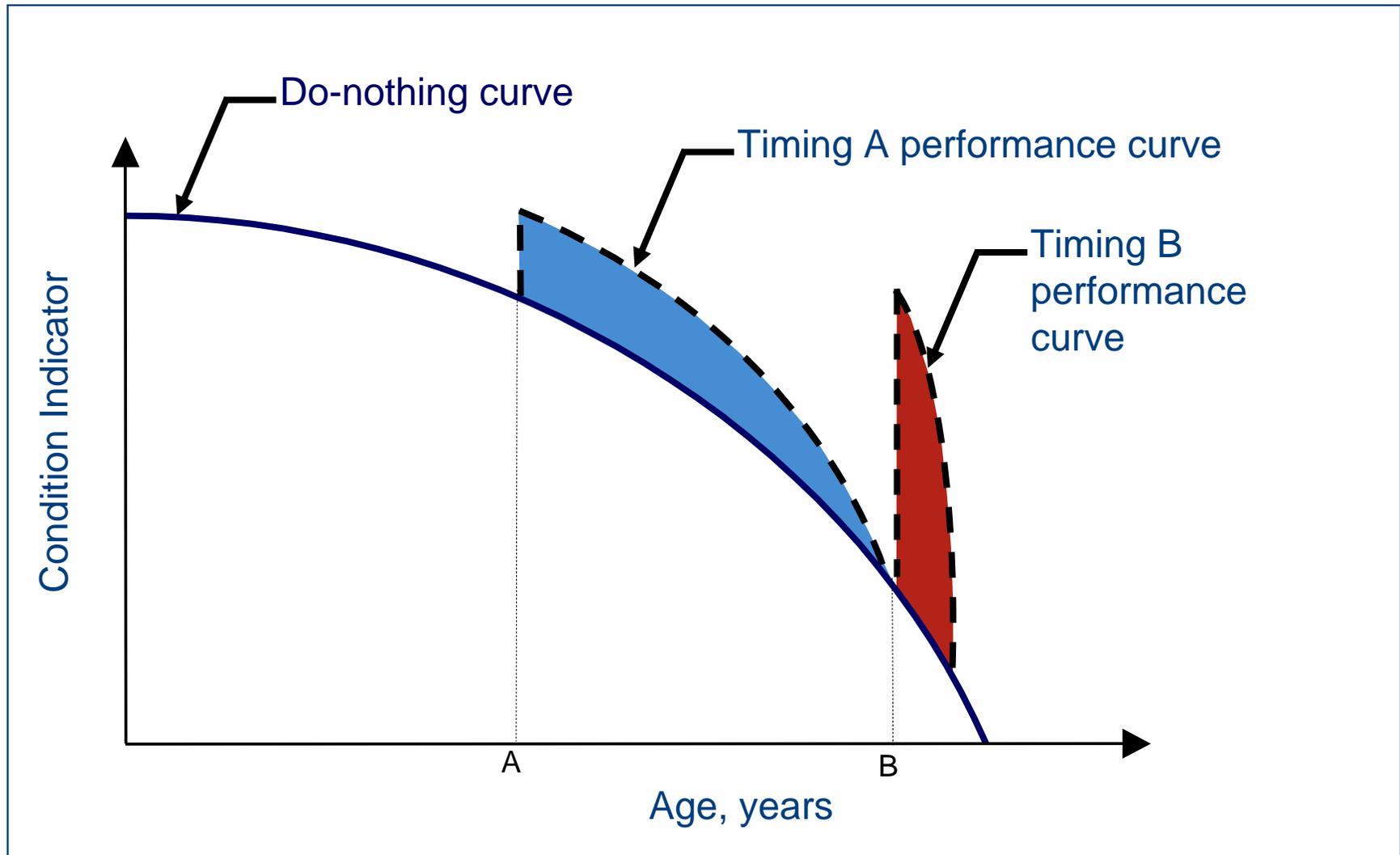
# Early Versus Late Treatments

## Optimal timing concepts

- General: apply treatments earlier in the life of the pavement
- Change in condition, or benefit, different based on timing
- Benefit not the same for treatments applied later
- Performance curve also different
- Late treatments
  - May provide improved pavement performance
  - May look like rehabilitation or reconstruction
  - Improvement does not last long



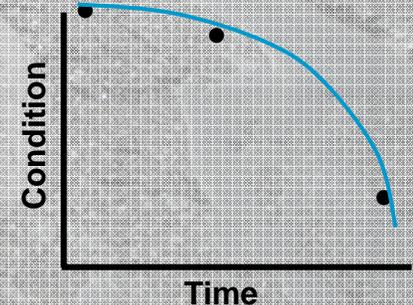
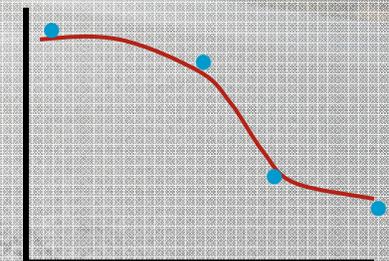
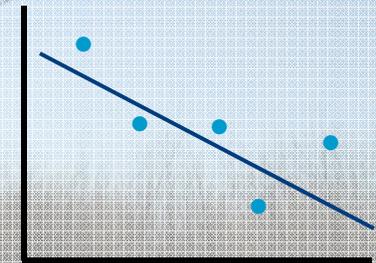
# Illustrating Alternate Treatment Timings



# Generating A "Do Nothing" Curve

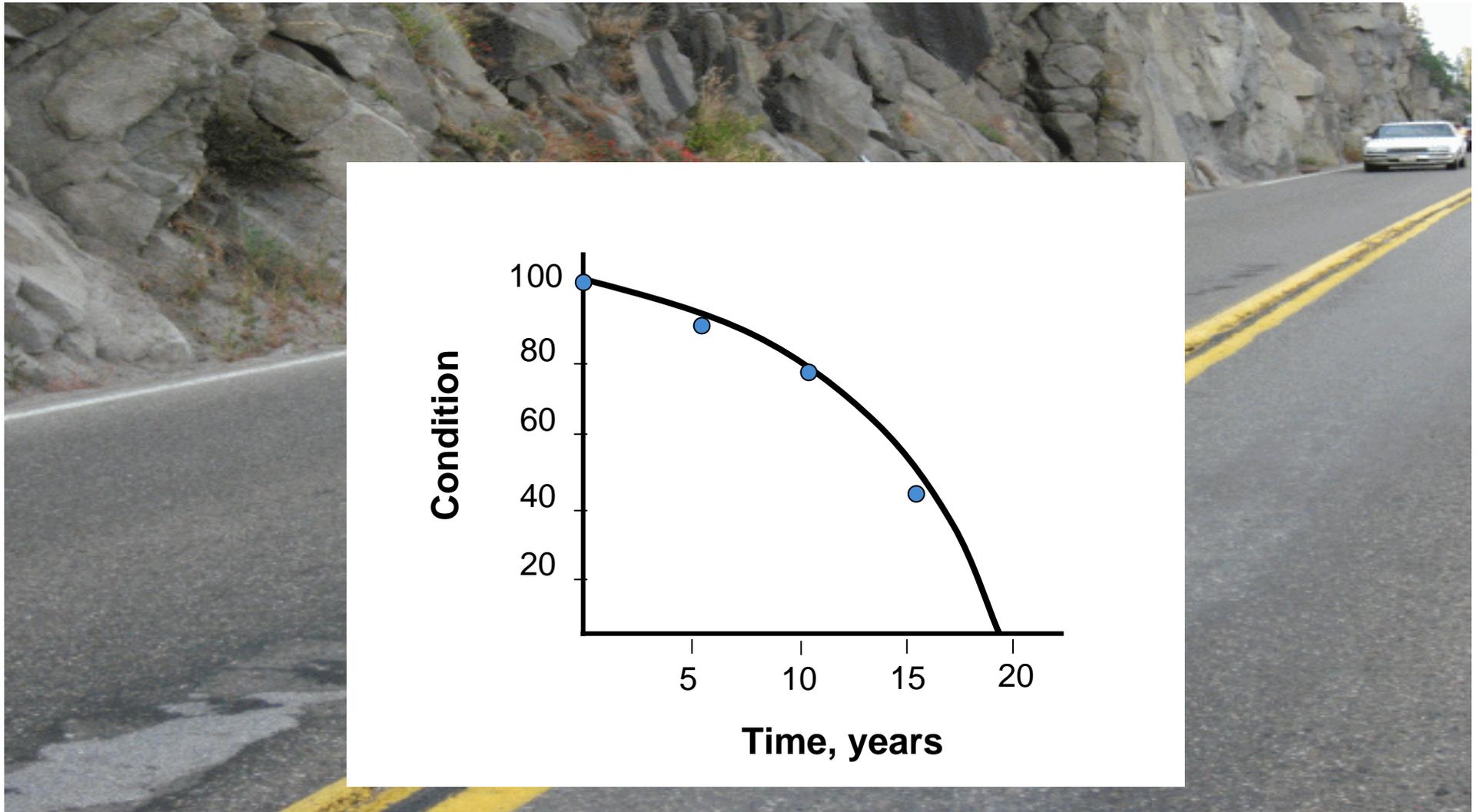
## How to generate "do nothing" curves

- Use existing data
  - Generate different models for different environments
  - Use available models:  
e.g., from pavement management
- When data are not available
  - Expert opinion



## Expert Opinion & “Do-Nothing” Performance Curve

How to generate “do nothing” curves using expert opinion



# Improving the Expert Opinion Approach



## Expert opinions are still subjective

- Expert opinions are only as good as the experts themselves
- Experts differ

## To improve the process

- Involve many knowledgeable people
- Get broader consensus on local performance

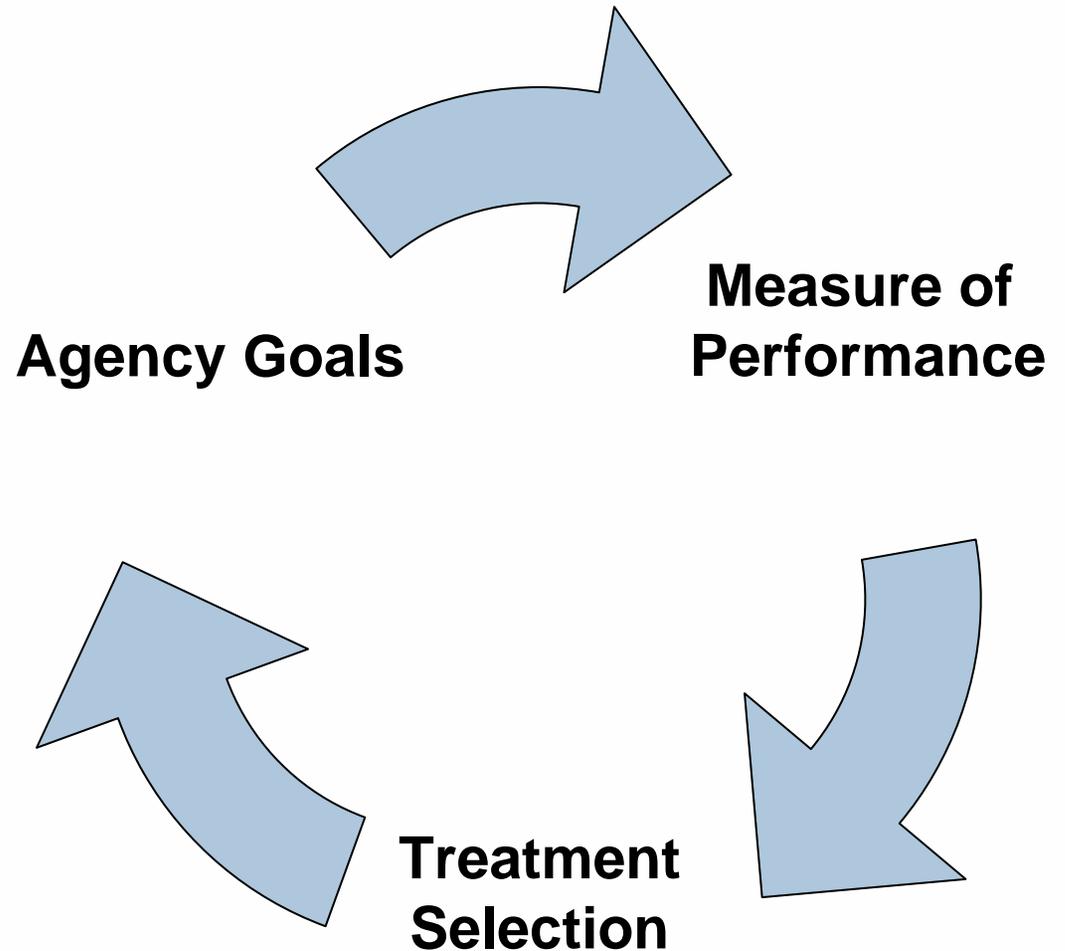


## Measures of performance

- So far, performance curves shown as generic representations
- Agencies use very specific measures
- Some may decrease over time while others increase (roughness, cracking, rutting, and so on)



- Significance of measurement
  - Linked to treatments
  - Linked to analysis
  - Agency objectives:  
Example
- Goals



# Preventive Maintenance Program Goals

## Questions the agency should address:

- Why is the agency considering this optimal timing issue?
- Why do preventive maintenance?
- What are desired results from preventive maintenance?

## Agency should define:

- Goals
  - Pavement preservation
  - Prevention practices
  - Treatment selection
- How to measure performance
- How to optimize treatments



## Examples of Goals

**Example 1:** Achieve a certain condition level for all of our pavements

- 80% of high volume roads in good condition and,
- 70% of low volume roads in good condition, and
- No more than 10% of all roads in poor condition

**Example 2:** An overall network goal of pavement performance

- Reduce crashes or fatalities
- Maintain certain pavement conditions given a fixed budget
- Improve pavement conditions with a specified budget

**Monitor and track your goals**

Achieve those goals with preventive maintenance treatments applied at the optimal time



## Audience Poll

If your goal is to have 80 percent of your road network in good (or better) condition, what should you monitor?

- Cracking
- Rut Depth
- International Roughness Index (IRI)
- Crash Statistics
- Friction
- Pavement Condition Index
- Other



## Topic 2 Review

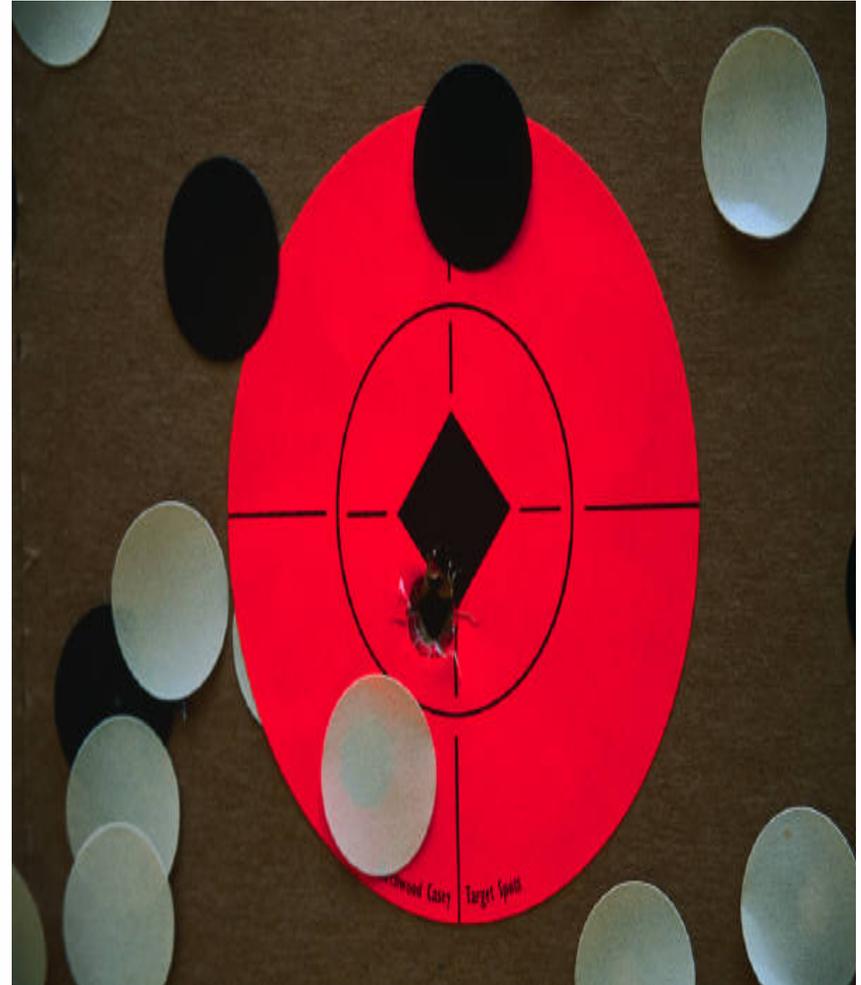
- Identify four factors affecting how pavements deteriorate.
- Describe what's represented in a typical performance curve.
- Identify two characteristics of good agency goals.
- What is a "do nothing" performance curve and what are two ways of producing this curve?



## Topic 3 Calculating Benefit with OPTime

At the end of this topic, participants will be able to:

- List key characteristics of the optimal timing calculation
  1. "Simple" vs. "detailed" analysis.
  2. Calculation of benefit value considering treatment performance and performance of untreated pavement.
  3. Calculation of benefit from multiple performance indicators.
- Describe an approach to collect data that can be used for a detailed analysis.



# OPTime Calculations

- Types of OPTime calculations
- Quantifying benefit in OPTime
- Performance measures



# OPTime: Two Types of Analysis

- Simple analysis versus Detailed Analysis

| Cost Types Included in Analysis |     |
|---------------------------------|-----|
| Treatment Costs                 | Yes |
| Rehabilitation Costs            | No  |
| User Costs                      | No  |

| Project Area Details |     |
|----------------------|-----|
| Project Area         | 1   |
| Area Units           | mi. |

| Treatment and Rehabilitation Details |        |
|--------------------------------------|--------|
| Treatment Unit Cost, \$/units        | \$0.00 |
| Rehabilitation Activity              |        |
| Rehabilitation Unit Cost,            | \$0.00 |

| Design Traffic Details      |        |
|-----------------------------|--------|
| Initial ADT, veh/day        | 10,000 |
| ADT Annual Growth Rate, %   | 2      |
| ADT Growth Rate Type        | Simple |
| Passenger Cars % of ADT     | 60     |
| Single Unit Trucks % of ADT | 20     |
| Combination Trucks % of ADT | 20     |

| Hourly Traffic Distribution, % |     |
|--------------------------------|-----|
| 12:00 AM                       | 1.8 |
| 1:00 AM                        | 1.5 |
| 2:00 AM                        | 1.3 |
| 3:00 AM                        | 1.3 |
| 4:00 AM                        | 1.5 |
| 5:00 AM                        | 1.8 |
| 6:00 AM                        | 2.5 |
| 7:00 AM                        | 3.5 |
| 8:00 AM                        | 4.2 |
| 9:00 AM                        | 5   |
| 10:00 AM                       | 5.4 |
| 11:00 AM                       | 5.6 |
| 12:00 PM                       | 5.7 |
| 1:00 PM                        | 6.4 |
| 2:00 PM                        | 6.8 |
| 3:00 PM                        | 7.3 |
| 4:00 PM                        | 9.3 |
| 5:00 PM                        | 7   |
| 6:00 PM                        | 5.5 |
| 7:00 PM                        | 4.7 |
| 8:00 PM                        | 3.8 |



# Analysis: Single Treatments

## OPTime Analysis

- Fairly simple analysis with either approach
- Significant need for data
- One treatment at a time; e.g. chip seal or slurry, and not chip seal vs. slurry
- Repeat for each type of treatment
- As narrow or as broad as conditions warrant
- Focus is to improve agency practices

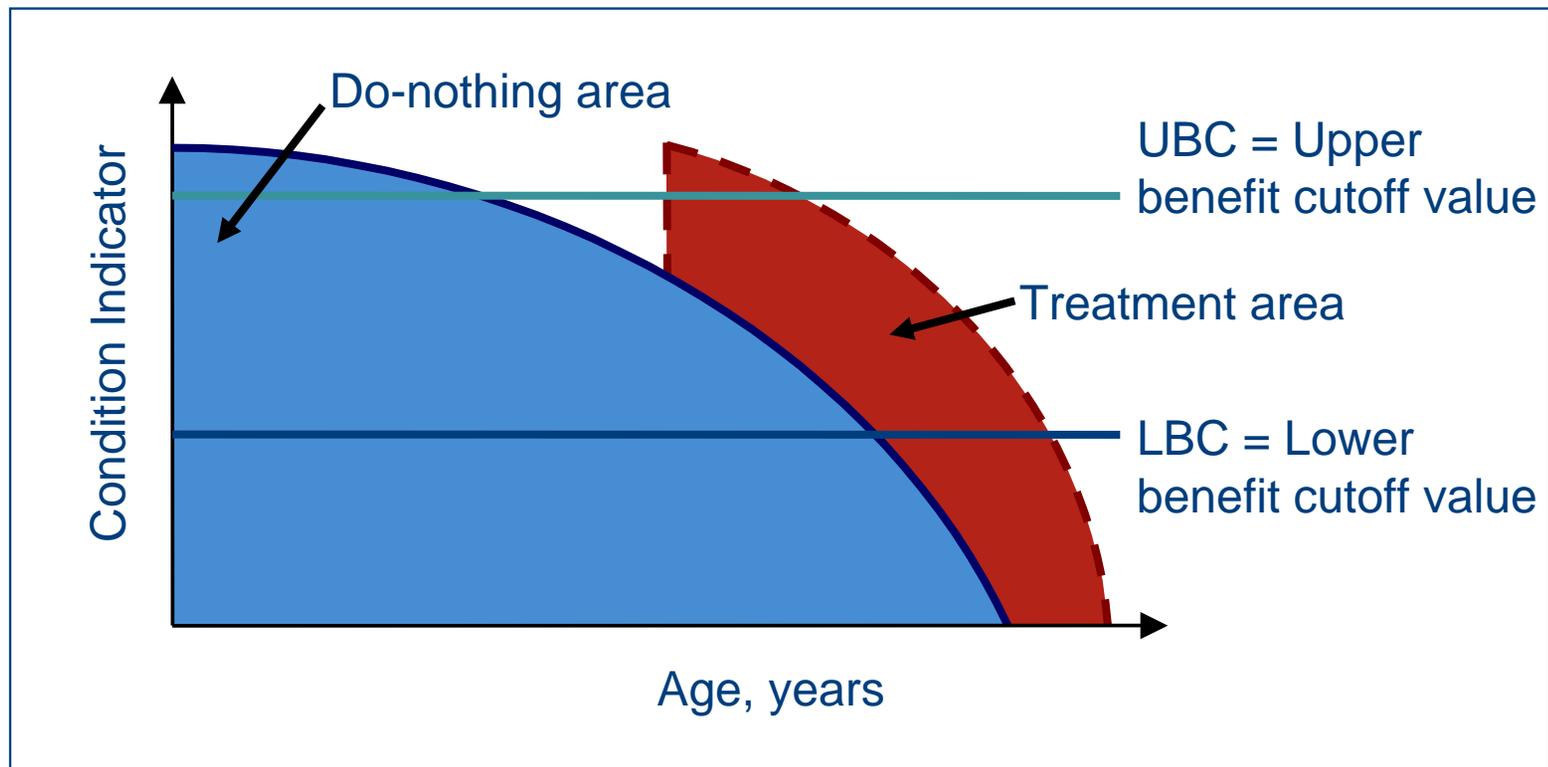


# Treatment Benefit Calculations

## Elements of Benefit Calculations

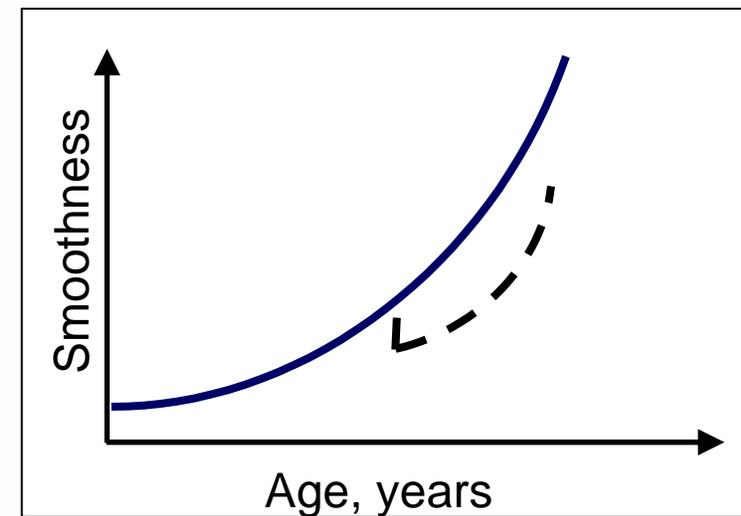
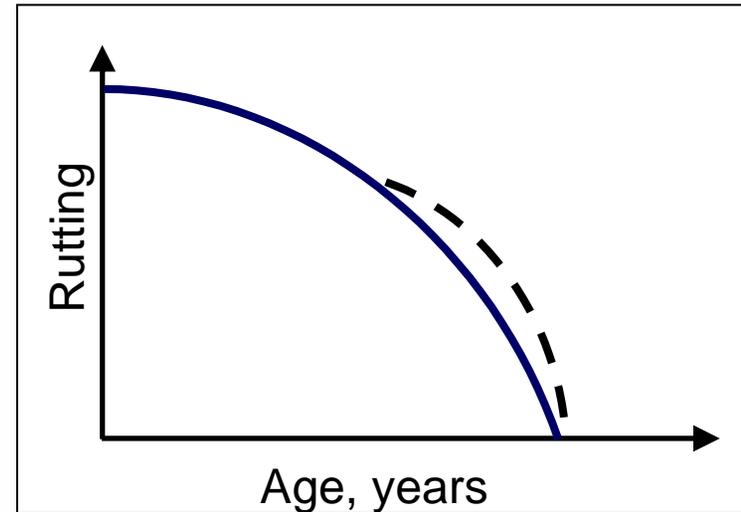
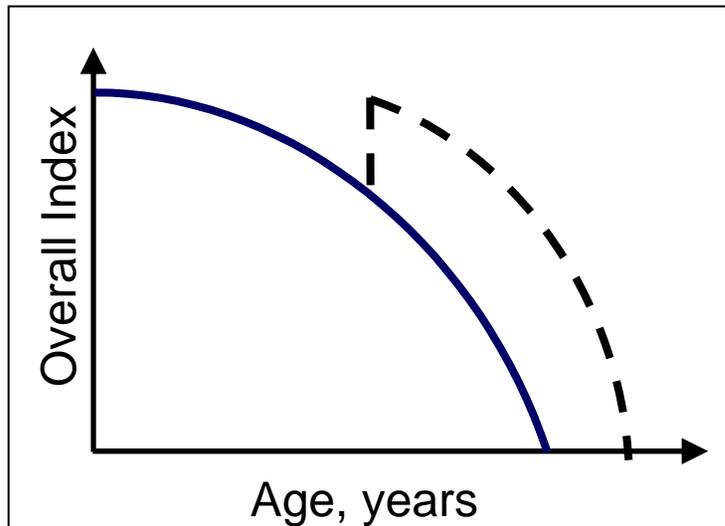
- Upper and lower cutoffs
- An applied example

$$\text{Benefit Value} = \frac{\text{Treatment Area}}{\text{Do-Nothing Area}}$$



## Performance indicators

- Multiple measures of performance



# Benefit Calculations & Performance

## Performance indicators

- Weighting factors
- Adding up to 100% is a rational distribution

**Table 16 Example computation of overall benefit**

| Condition Indicator | Individual Benefit Values % | Assigned Benefit Weighting Factor | Benefit Weighting Factor Percentage | Overall Benefit Contribution % |
|---------------------|-----------------------------|-----------------------------------|-------------------------------------|--------------------------------|
| Rutting             | 27                          | 60                                | $60/100 = 0.6$                      | 16.2                           |
| Cracking            | 12                          | 30                                | $30/100 = 0.3$                      | 3.6                            |
| Friction            | 47                          | 10                                | $10/100 = 0.1$                      | 4.7                            |
| <b>Total</b>        | ---                         | <b>100</b>                        | <b>1.0</b>                          | <b>24.5</b>                    |

**Table from 523 Report, p. 20**



## Data Collection Issues

NCHRP 523 report, Appendix D describes a plan for generating missing data over time through the use of test sections and monitoring.



## Audience Poll

Select all True Statements:

1. All pavements follow some sort of performance (curve).
2. Pavement performance improvement from applying a treatment over time is determined by comparison with the performance curves of other treatments.
3. Performance curves differ based on whether treatments are applied early or late in a pavement's life.
4. Standard methods for measuring pavement performance are used and should be applicable to every agency.



## Topic 3 Review

- What inputs does OPTime require to calculate treatment benefits?
- What is the difference between OPTime's simple and detailed analyses?
- How can preventive maintenance treatment performance data be generated over time?



## Topic 4 Costs

At the end of this topic, participants will be able to:

- Identify at least three types of costs that may be included in the analysis stage of the optimal timing methodology



# Cost Analysis

Costs vary based on:

- Different treatments
- Different application timing
- Different maintenance approaches
- Rehabilitation costs
- User / work zone delay

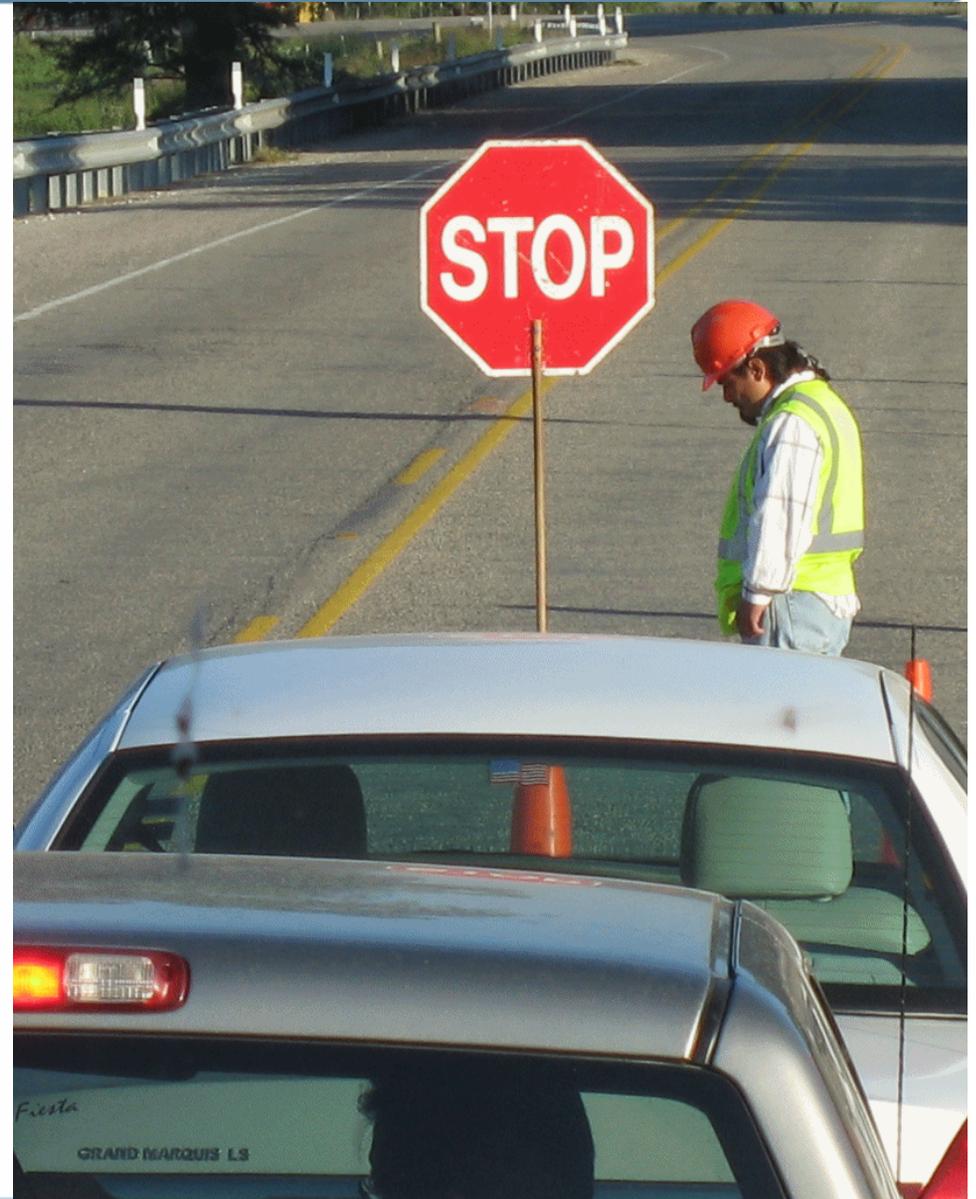
Life-cycle cost analysis considers all of these



# Costs of Maintenance

## Cost analysis—maintenance

- Long term pavement maintenance costs
- Annual maintenance costs
- Routine maintenance related to a treatment



# Life-Cycle Cost Calculations

Based on selected costs, calculations include the following:

- Convert all costs to present worth (PW) \$
- Also calculate equivalent uniform annual cost (EUAC)



## Topic 4 Review

- What factors affect life cycle costs?
- Identify four different costs that might be included in a life cycle cost analysis
- What are the two cost calculations used to compare alternatives?



## Topic 5 Putting It All Together

**At the end of this module, participants will be able to:**

- Describe the effect of timing on pavement preservation treatment performance and program effect
- Specify the inputs for analysis, specifically deciding on:
  - Analysis type
  - Condition indicators
  - Preventive maintenance treatment
  - Definition of treatment timings
  - “Do-nothing” options
  - Defining post-PM relationships
  - Benefit weighting factors



# Putting It All Together

## Interpreting and applying analysis results

- Determining most cost-effective timing
- Our story up to now (review)
  - Typical pavement performance (do nothing)
  - Benefits and costs
  - Quantifying benefit
  - Quantifying costs
- Completing the analysis



# Example/Demonstration

## Timing scenarios

- Chip seal example
- Timing decision making support tool
  - Based on calculated benefit/costs
  - Optimal timing
- OPTime demonstration



# Your Role Supports Optimal Timing

## Agency Role

- Data Collection
- Project/Treatment Selection
- Region/District/Area Engineer
  - Region/District Maintenance Engineer
- Pavement Mgmt Analyst
- Pavement Preservation Engineer
  - Design Engineer
  - Materials Engineer
- Planning & Programming
  - Asset Mgmt
  - Research

## Responsibilities

Data Collection

Project/Treatment Selection

Data Analysis

Feedback & Reporting

## Next Steps



### NHI Training on Pavement Preservation Topics

#### Web-based

- 131110 Pavement Preservation Treatment Construction

#### Classroom

- 131103 Pavement Preservation: Design and Construction of Quality Preventive Maintenance Treatments
- 131104 Pavement Preservation: Integrating Pavement Preservation Practices and Pavement Management
- 131115 Pavement Preservation: Preventive Maintenance Treatment, Timing, and Selection

<https://www.nhi.fhwa.dot.gov/Home.aspx>



Thank You!

For questions or comments:

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