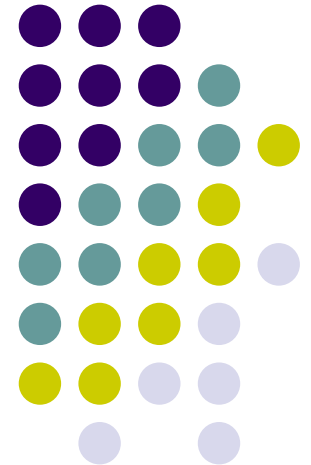


Timing of Pavement Preservation Treatments

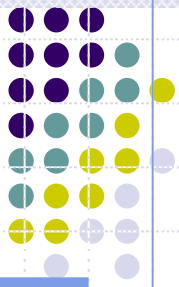
Katie Zimmerman

Applied Pavement Technology, Inc.

kzimmerman@pavementsolutions.com

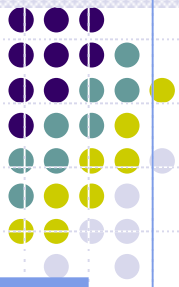


Presentation Topics



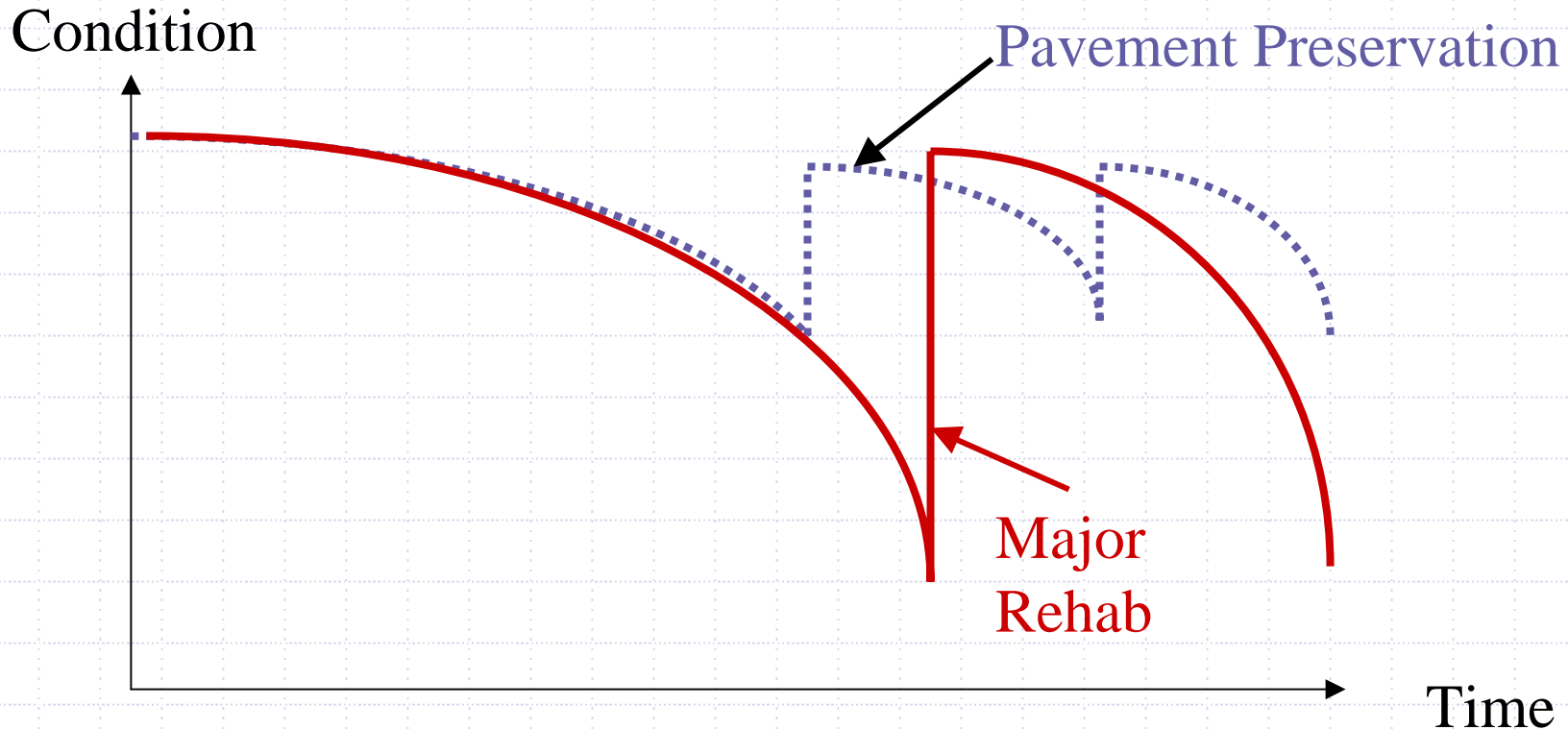
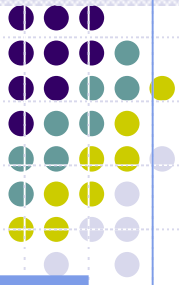
- Characteristics of Pavement Preservation Programs
- Applying Treatments at the Right Time
- Treatment Timing Tools

Pavement Preservation Programs

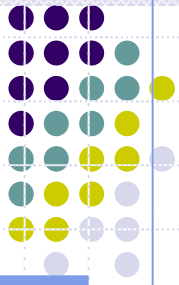


- Activities undertaken to **provide and maintain serviceable roadways** using:
 - Corrective maintenance
 - Preventive maintenance
 - Minor rehabilitation
- Cost-effective strategies for maintaining roadways

Cost-Effectiveness of Pavement Preservation



Total Life Cycle Cost



Net
Present
Cost

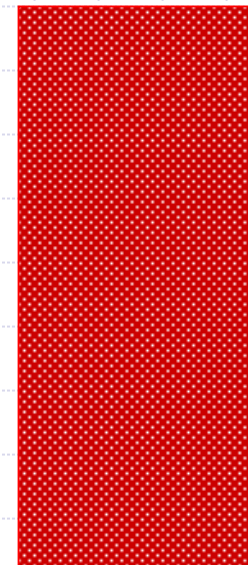
With
Preventive
Maintenance



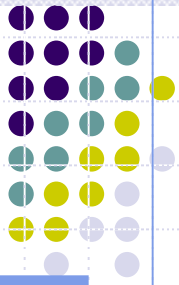
4 to 6 times
difference



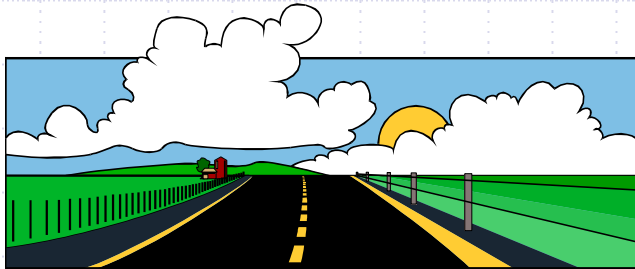
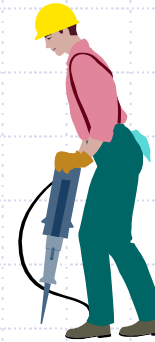
Without Preventive
Maintenance



Pavement Preservation Slogan

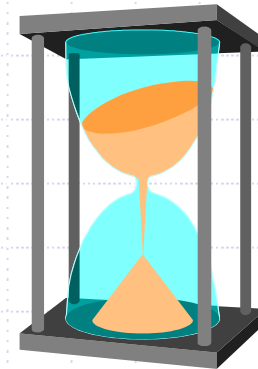


Applying the right treatment

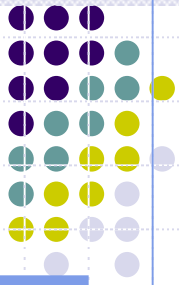


... To the right road

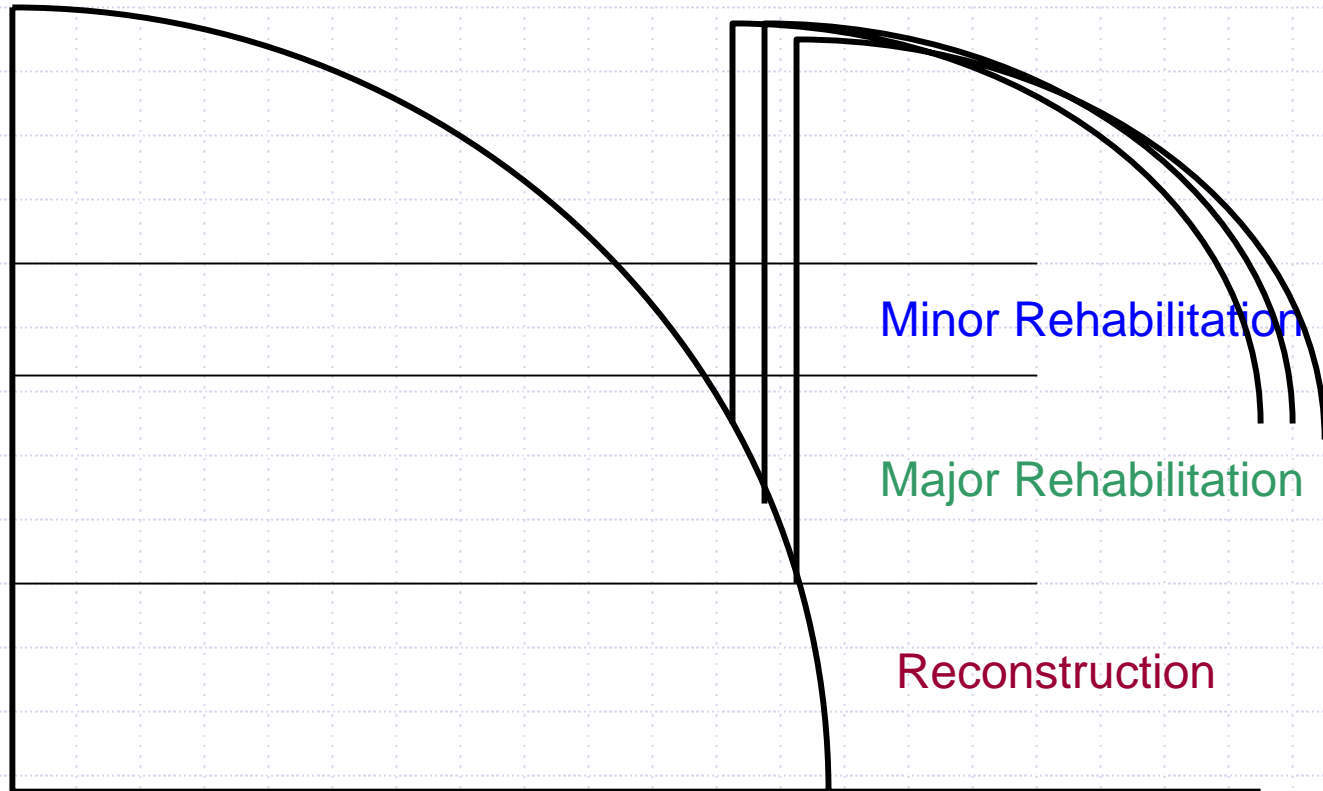
... At the right time



Rehabilitation Treatment Timing

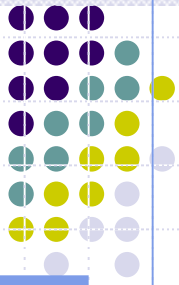


Condition

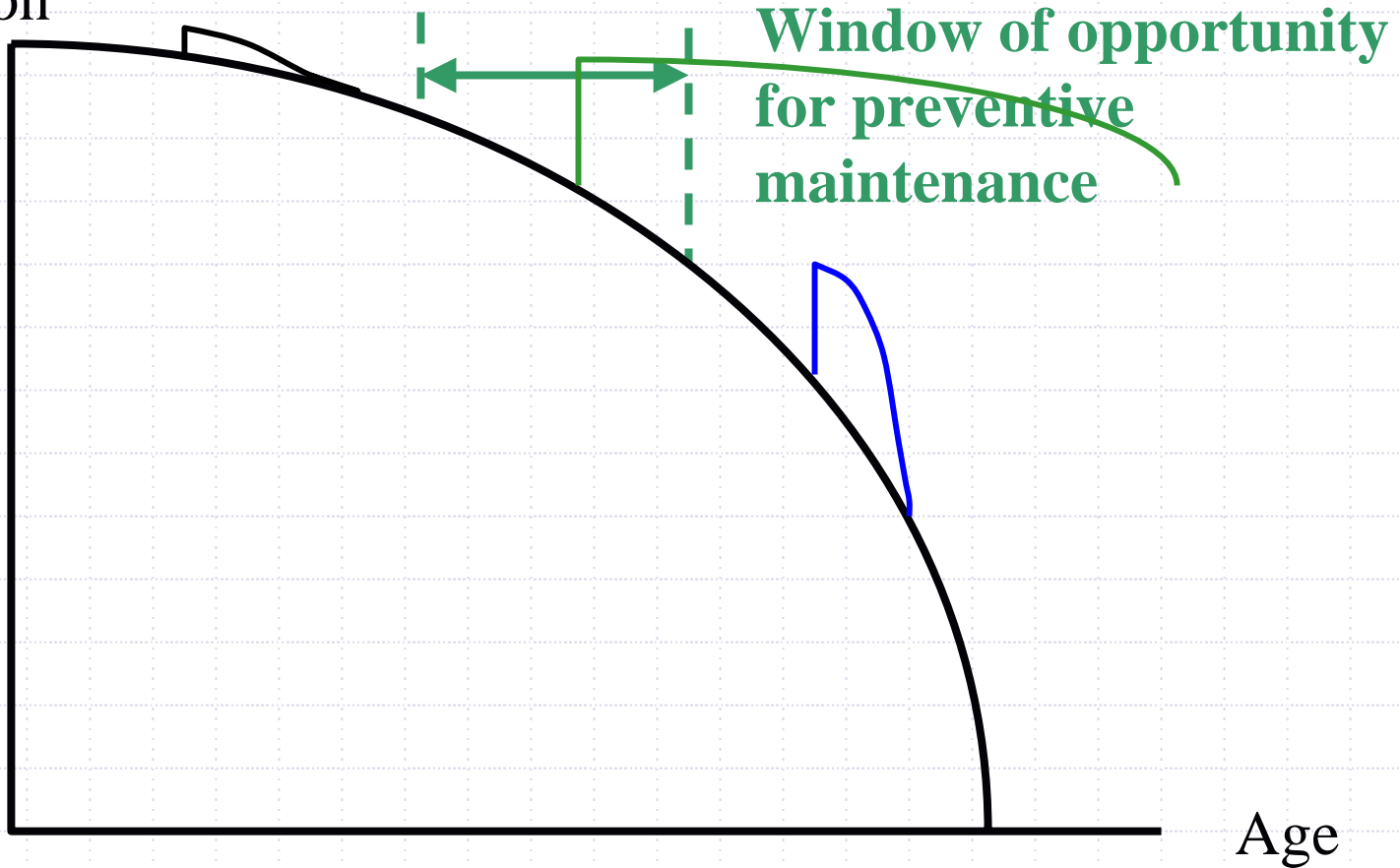


Age

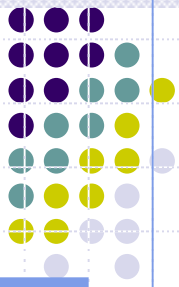
Window of Opportunity



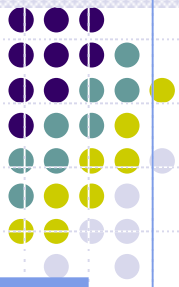
Condition



“Good Candidates” for Preventive Maintenance

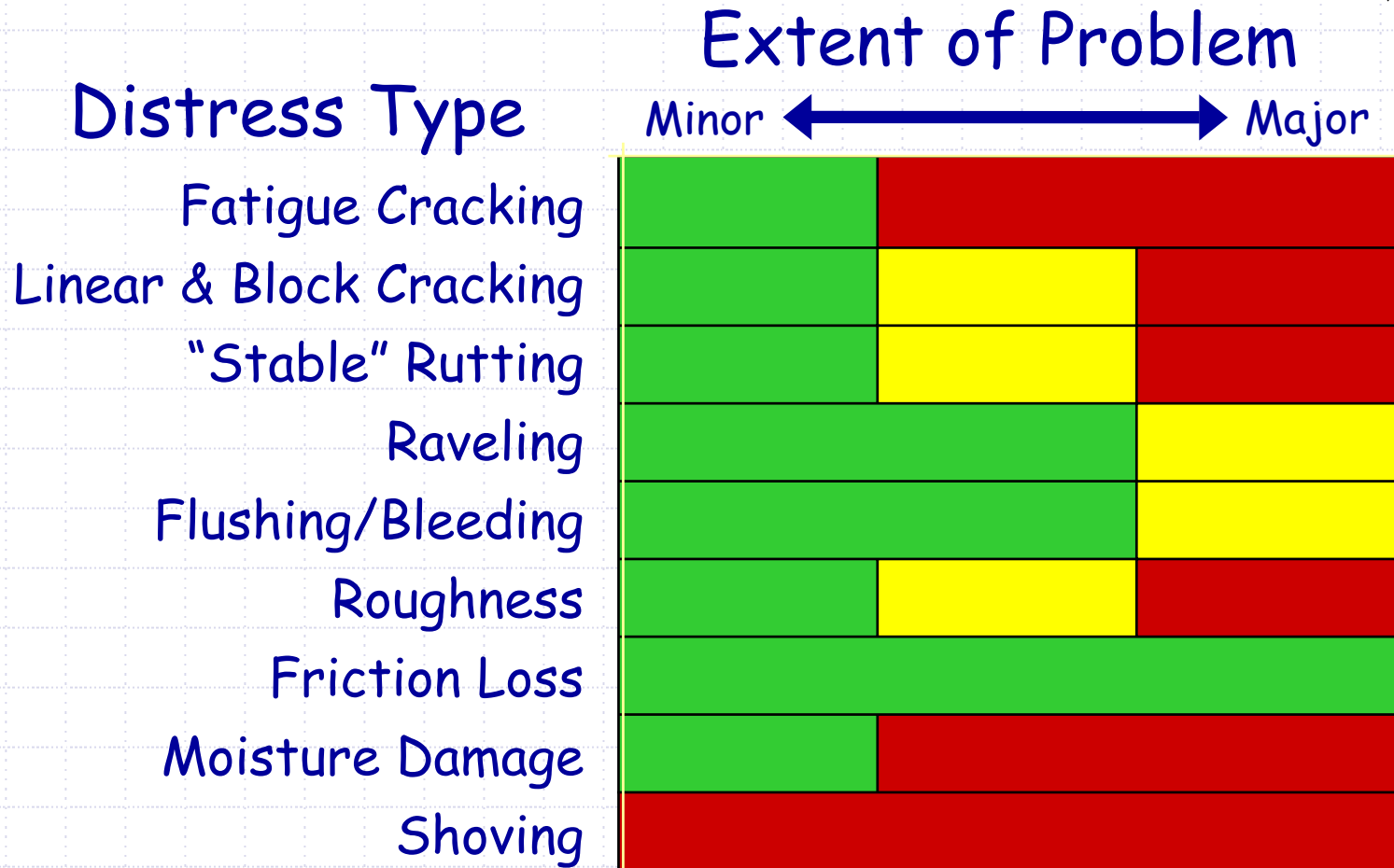


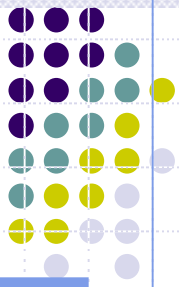
- No structural failures
- Minimal distress (extent and severity)
- Relatively young in age
- Few historical problems with similar projects
- Treatment can be constructed before distress becomes too extensive (considers rate of deterioration and contracting period)



Maximum Allowable Distresses

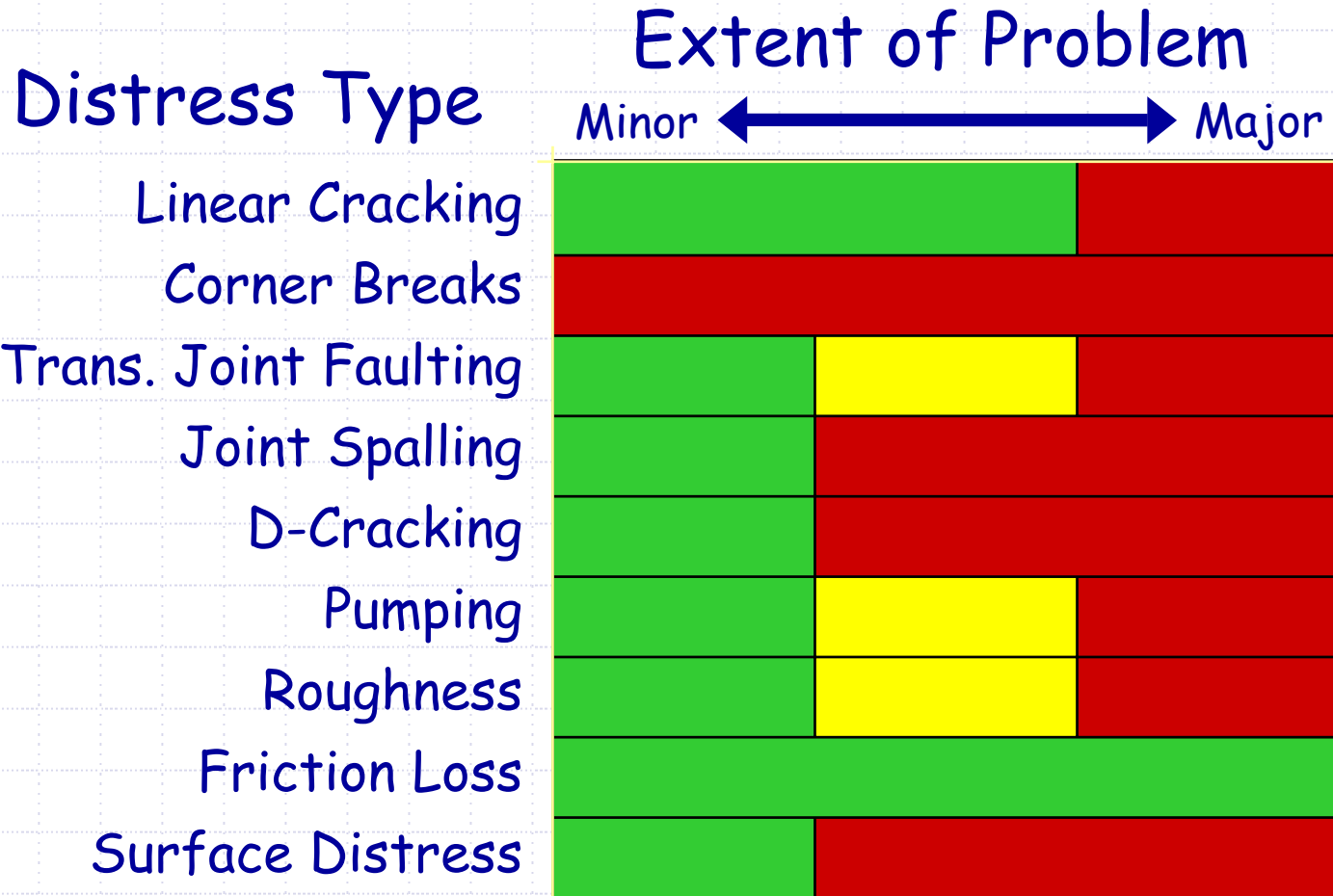
HMA Pavements



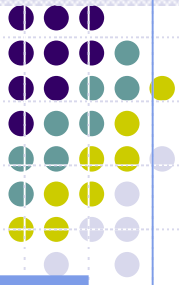


Maximum Allowable Distresses

PCC Pavements

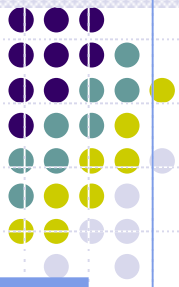


Sample Treatment Guidelines

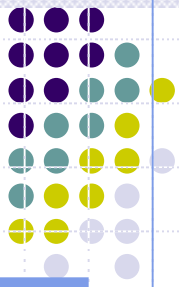


HMA Distresses	Low		Moderate		High	
	Occasional	Frequent	Occasional	Frequent	Occasional	Frequent
Fatigue Cracking	Fog Seal, Do Nothing	Fog Seal, Chip Seal	Chip Seal, Fog Seal, Thin HMA Overlay	Chip Seal, Slurry Seal	Patching, Chip Seal, Thin HMA Overlay	Recon, Patching
Edge Cracking	Do Nothing, Crack Seal or Fill	Crack Seal or Fill, Do Nothing	Crack Seal, Patching	Crack Seal, Patching	Patching	Patching
Longitudinal Cracking	Crack Seal, Do Nothing	Crack Seal, Chip Seal, Do Nothing	Crack Seal, Chip Seal	Crack Seal, Chip Seal	Patching, Crack Seal, Chip Seal	Chip Seal, Crack Seal, Patching
Bleeding	Do Nothing	Do Nothing, Chip Seal	Chip Seal, Do Nothing, Mill	Chip Seal, Mill	Mill + Chip Seal	Mill + Chip Seal, Thin HMA Overlay

Combination of Distress



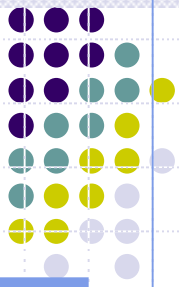
Distress	Combination of Distress (Read Vertically)	
	<i>From Haas, Hudson, Zaniewski</i>	
PSI<4.0	N	N
Major Cracking	N	N
Rutting > 30%	Y	N
Raveling > 30%		Y
Feasible Options	3 in O/L, Mill + chip, Recycle + O/L, Reconstruct	1 in O/L, Recycle + O/L, Mill + O/L, Chip Seal



Time-Based Schedule Example

New York State Initial Guidelines for Treatment Application Cycles

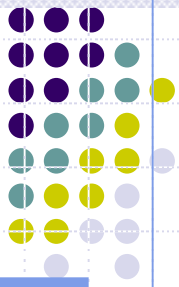
Treatment Type	Appl. Cycle, yrs
● PCC pavement joint and crack sealing	8
● HMA pavement crack sealing	4
● Thin HMA overlays (38 mm [1.5 in])	12
● Surface treatments of HMA pavements	4
● Surface treatments of shoulders	4
● Clean drainage	10



Timing for First Application

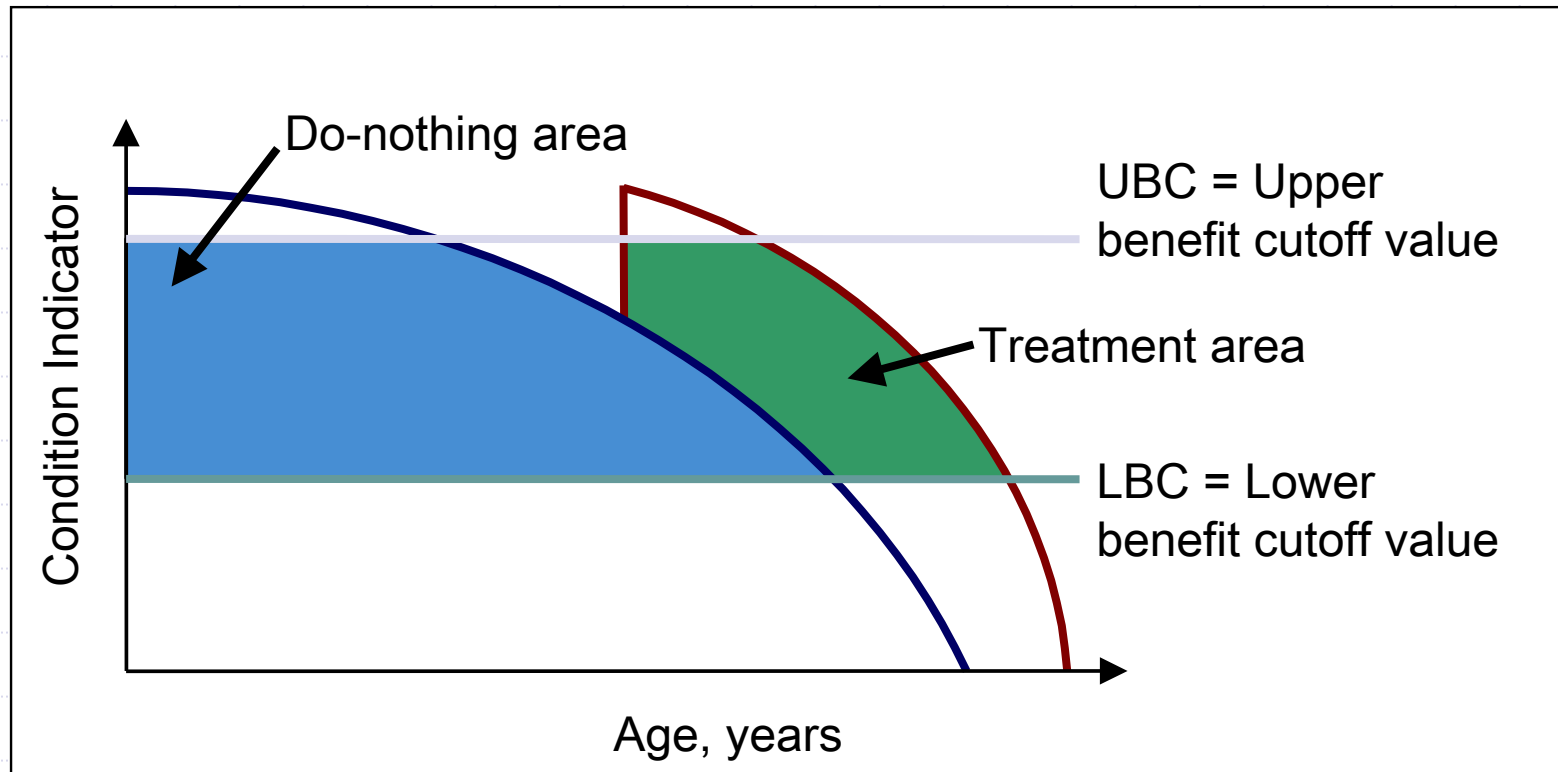
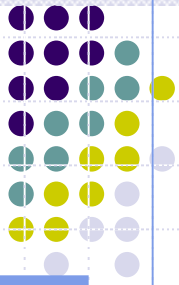
- South Dakota
 - ▶ Crack sealing: 1 to 2 years
 - ▶ Chip seal: 3 years
- Montana
 - ▶ Chip seal: 6 to 8 years
 - ▶ Thin overlay: 10 to 12 years

Analytical Tool to Determine Optimal Timing - OPTime

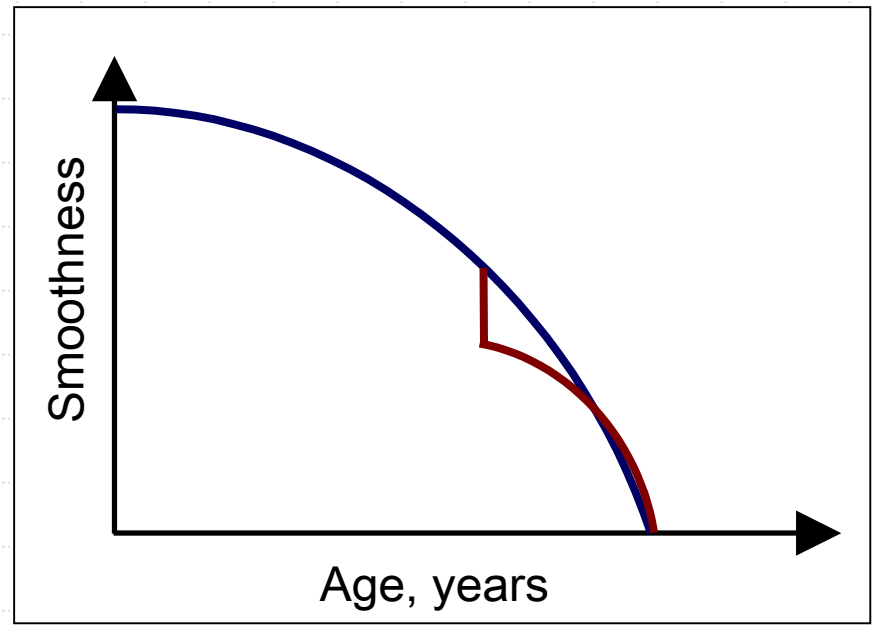
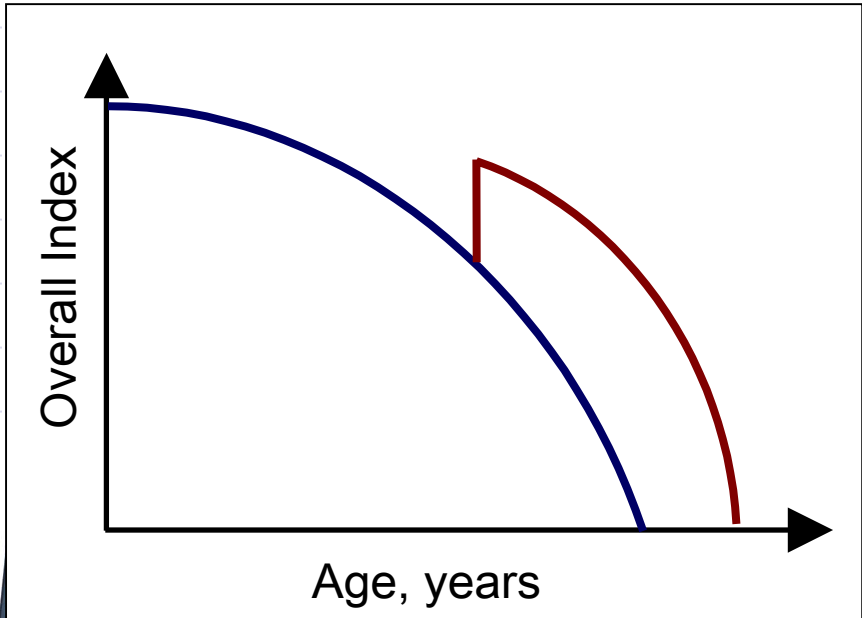
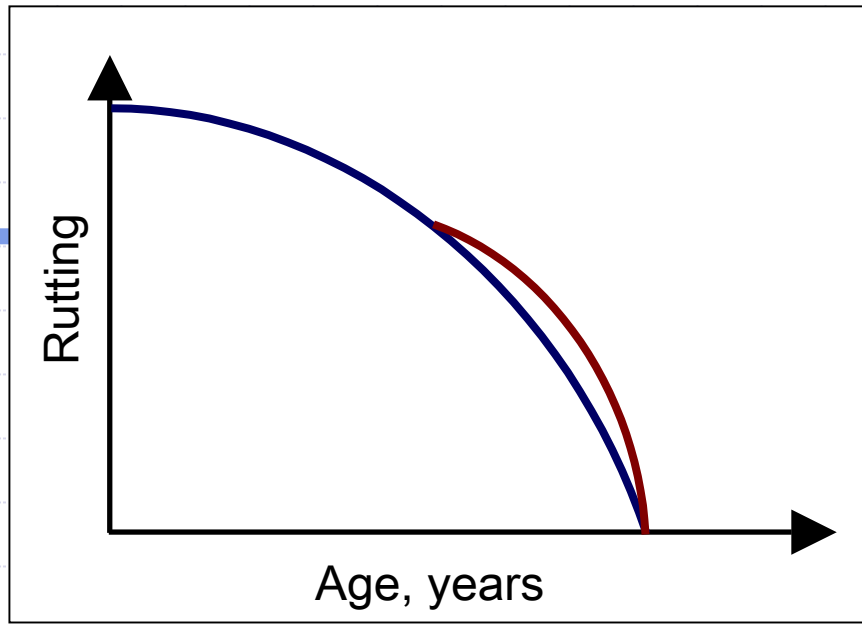
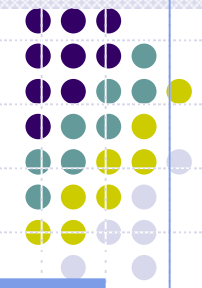


- Developed during NCHRP 14-14, Optimal Timing for Preventive Maintenance
- Macro-driven Excel workbook
- Evaluates benefits and costs associated with a preventive maintenance treatment
- Benefits can be evaluated in terms of more than one condition index
- Detailed or simple analyses available

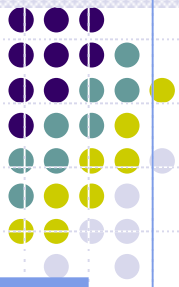
Benefit



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



Combining Multiple “Benefits”



- Calculate benefit area for each condition measure
- Normalize benefit as percent of do-nothing area
- Assign “benefit weighting factors” to different condition measures
- Compute and sum

Condition Indicator	Benefit Value (% of do nothing)	Benefit Weighting Factor	Benefit WF Percentage	Overall Benefit Contribution (%)
Rutting	27	60	0.6	16.2
Cracking	12	30	0.3	3.6
Friction	47	10	0.1	4.7
TOTAL	-	100	1.0	24.5

Costs



- Treatment construction
- Rehabilitation
- Work zone delays
- Additional routine maintenance

After benefits and costs have been defined, a benefit/cost (B/C) ratio is determined for each possible application timing

Effectiveness Index (EI)

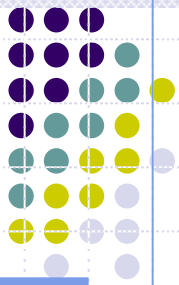
$$EI_i = \left[\frac{(B/C)_i}{(B/C)_{\max}} \right] \times 100$$

i = Index associated with current timing scenario

B/C = Benefit / cost ratio

Example Analysis Session

Condition Indicators



Optimal Timing of Preventive Maintenance Treatments - Selection of Condition Indicators

Selection and Definition of Condition Indicators

After selecting a pavement type, select the condition indicators you want to use to define benefit. Next, set the condition indicator units, equation trends (curve shapes), and lower and upper benefit cutoff values.

Back

Next

Surface Type

HMA-Surfaced PCC-Surfaced

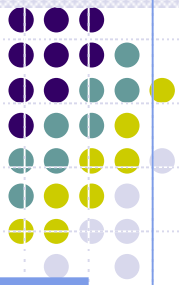
HMA-Surfaced Condition Indicators

Condition Indicators	Units	Trend Over Time	Lower Benefit Cutoff Value	Upper Benefit Cutoff Value
<input checked="" type="checkbox"/> Composite index	0 to 100 scale	Decreasing	50	100
<input type="checkbox"/> Nonload-related cracking	Length of cracking, ft	Increasing		
<input type="checkbox"/> Load-related cracking	Length of cracking, ft	Increasing		
<input type="checkbox"/> Oxidation/raveling	Subjective scale (0 to 5)	Decreasing		
<input type="checkbox"/> Rutting	Avg rut depth, in	Increasing		
<input checked="" type="checkbox"/> Roughness/smoothness	IRI, in/mi	Increasing	40	120
<input type="checkbox"/> Friction	Friction number	Decreasing		
User Defined Condition Indicators				
<input type="checkbox"/> User defined 1	Index	Decreasing		
<input type="checkbox"/> User defined 2	Index	Decreasing		

?

Example Analysis Session

Treatment Selection



Optimal Timing of Preventive Maintenance Treatments - PM Treatment Selection

Preventive Maintenance Treatment Selection

Use these controls to setup your optimal timing experiment. In addition to selecting the treatment of interest, you may choose to include additional routine/reactive maintenance that is expected to affect the analysis.

Back

Next

PM Treatment Selection - HMA

Select the ONE treatment for which you would like to investigate "initial" application timing scenarios.

Thin overlay

Selected Treatment "Initial" Application Ages

Next, define the "initial" application ages that will be compared in the analysis. Note: ages may be entered as specific values (comma-separated) or age ranges (hyphen-separated) (see the example syntax below).

4-8

Example: An analysis of a treatment applied in years 3, 4, 5, 7, and 8 is entered as "3-5,7,8"

Include routine/reactive maintenance (if selected, the costs will be included in the analysis)

Routine/Reactive Maintenance Program Definition

Use these controls to define a schedule of routine/reactive maintenance activities (i.e., although these activities do influence performance, their timing will not be optimized).

Application Method:

- Regular interval
- Specific years

Regular interval details

Application age range

Start Age

2

End Age

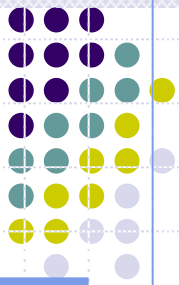
10

Set regular application interval

Apply maintenance every: 2 years

Example Analysis Session

Do-Nothing Curves: Direct Equation



Optimal Timing of Preventive Maintenance Treatments - Definition of HMA "Do Nothing" Curves

Definition of HMA "Do-Nothing" Performance Curves

Use the following controls to define the do-nothing performance associated with each included condition indicator. The do-nothing curves define the expected performance of this pavement if no treatment is applied.

Back

Next

Comp Index | Roughness

Use these controls to define the do-nothing curve for the user-defined composite index.

Data Entry Method

- Enter equation directly
 Fit regression equation through data

Equation Coefficient Definition

Equation type: Linear

Equation Form

Coefficients - Linear
Power model
2nd order polynomial
Exponential
Logarithmic

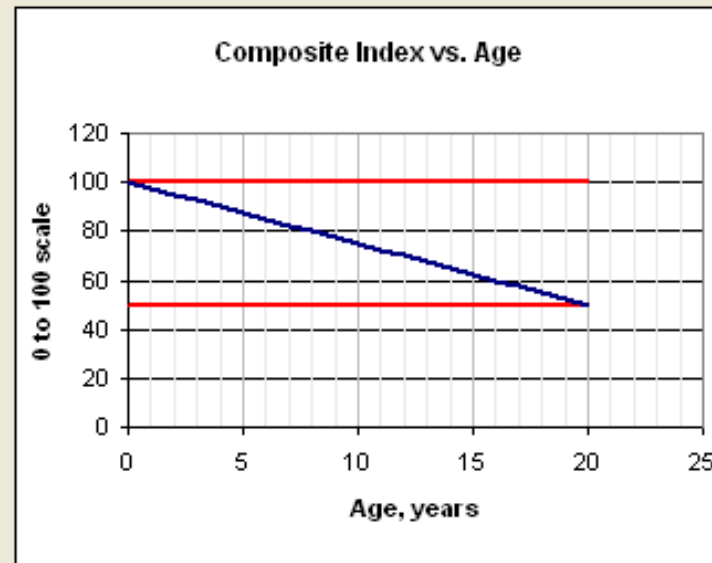
m: -2.5

Equation Details

$$y = -2.500(x) + 100.000$$

Equation Trend: Decreasing

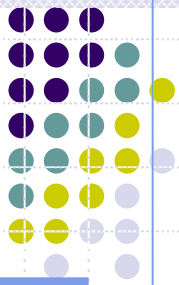
Plot Curve



Benefit cutoff values: Lower = 50 Upper = 100

Example Analysis Session

Do-Nothing Curves: Regression



Regression Equation Data Entry

Use the following data points to define the Do Nothing condition indicator curve. Note: you do not have to enter points for every age.

Year	Value
0	40
1	42
2	44
3	50
5	52
10	70
15	90
20	120

Roughness/Smoothness vs. Age

$R^2 = 0.998$

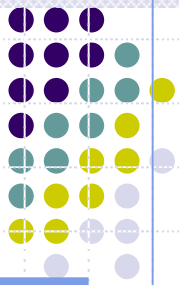
Equation Type: **2nd order polynomial**

- Linear
- Power model
- 2nd order polynomial**
- Exponential
- Logarithmic

Buttons: OK, Back, Cancel, Next, Plot Curve

Example Analysis Session

Treatment Performance Summary List



Optimal Timing of Preventive Maintenance Treatments - Treatment Performance Summary

Treatment Performance Relationship Summary List

The list below summarizes all of the unique post-preventive maintenance performance relationships that you indicated you would define. To define a specific performance relationship, select a row from the list and click the "Edit Details" button.

Performance Relationship Summary List - Detailed Analysis

Treatment Name: [Thin overlay](#)

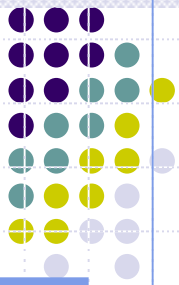
Index	Condition Indicator	Relationship Source	Application Year	Defined Relationship
1	Composite Index	Direct Coefficients	4	$y = -2,500(x) + 100,000$
2	Composite Index	Direct Coefficients	5	$y = -2,300(x) + 100,000$
3	Composite Index	Direct Coefficients	6	$y = -2,400(x) + 100,000$
4	Composite Index	Direct Coefficients	7	$y = -3,000(x) + 100,000$
5	Composite Index	Direct Coefficients	8	$y = -3,500(x) + 100,000$
6	Roughness/smoothness	Regression	4	$y = .191(x^2) + 1.456(x) + 40,000$
7	Roughness/smoothness	Regression	5	$y = .215(x^2) + 1.052(x) + 40,000$
8	Roughness/smoothness	Regression	6	$y = .100(x^2) + 3.500(x) + 45,000$
9	Roughness/smoothness	Regression	7	$y = .339(x^2) + .607(x) + 45,000$
10	Roughness/smoothness	Regression	8	$y = .417(x^2) + 1.250(x) + 45,000$

Relationship 1 of 10 total relationships

Buttons: Back, Next, Edit Details, ?

Example Analysis Session

Cost Summary



Optimal Timing of Preventive Maintenance Treatments - Definition of Costs

Definition of Costs

Use the following controls to define the costs to be included in the analysis. Use the available controls to define specific cost types and their details.

Selection of Cost Types

- Treatment application costs
- Rehabilitation costs
- User delay costs (associated with work zone)

General Inputs

Project Area (or Length):

1 mi.

Discount Rate:

4.0 %

Back

Next

PM Treatments | Rehabilitation | User Delay | **Cost Summary**

The following are the different costs that will be used in the analysis (note: all costs are in today's dollars).

PM Treatment Cost Summary

Treatment Name:

Thin overlay

Total Computed Treatment Cost:

\$40,000

Rehabilitation Cost Summary

Rehabilitation Activity Name:

Mill 2 in. of HMA followed by 3 in. OL

Total Computed Rehabilitation Cost:

\$100,000

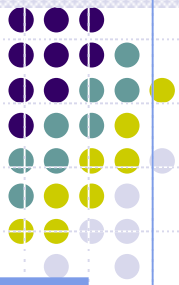
User Cost Summary

Note: all of the user cost numbers presented below are representative of year "0" values only (i.e., both costs and number of vehicles affected will be inflated with time based on your inputs.)

Vehicle Category	No. of Vehicles	Cost per Vehicle, \$	Total Costs by Category, \$
Passenger Cars:	4,374	\$0.96	\$4,192
Single Unit Trucks:	1,458	\$3.08	\$4,496
Combination Trucks:	1,458	\$9.38	\$13,669
Total (All Categories)	7,290		\$22,356

Example Analysis Session

Benefit Weighting Factors



Optimal Timing of Preventive Maintenance Treatments - Benefit Weighting Factors

Benefit Weighting Factors

If multiple condition indicators are selected, an individual benefit is calculated for each and they are all used to determine optimal treatment timing. Weighting factors are used to differentially weight the individual benefits associated with the included condition indicators. For consistency, all benefit weighting factors must total to 100.

Back

HMA-Surfaced Pavement - Benefit Weighting Factors

Condition Indicator	Benefit Weighting Factors
Composite index	75
Nonload-related cracking	0
Load-related cracking	0
Oxidation/raveling	0
Rutting	0
Roughness/smoothness	25
Friction	0
User defined 1	0
User defined 2	0
TOTAL	100

(Note: the individual benefit weighting factors must total to 100.)

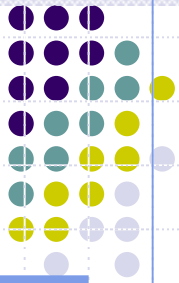
Click on the "Conduct Analysis" button to run the analysis.

Conduct Analysis

Close Workbook



Tabular Output



Output Data

Pavement Surface Type: HMA
 Treatment Type: Thin overlay
 Application Years: 4, 5, 6, 7, 8
 Expected Do-Nothing Service Life (yrs): 20.0

Benefit Summary

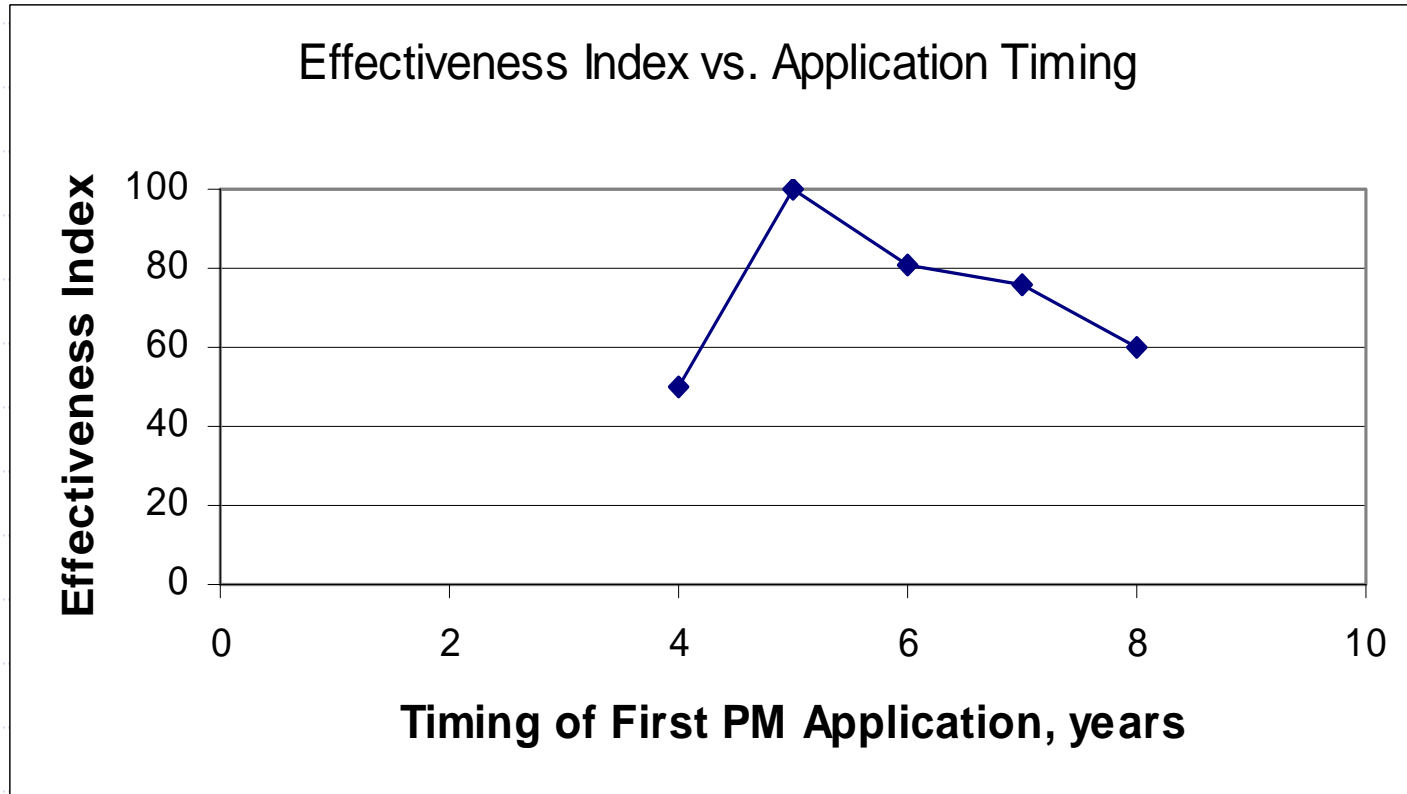
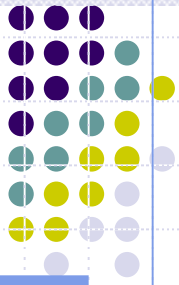
Benefit Ranking Factors =>		Individual Benefit Summary	
		75	25
Application Age, yrs	Total Benefit	Composite Index	Roughness/Smoothness
4	0.11	0.08	0.22
5	0.22	0.20	0.31
6	0.19	0.21	0.12
7	0.18	0.16	0.25
8	0.15	0.13	0.20

Cost Summary

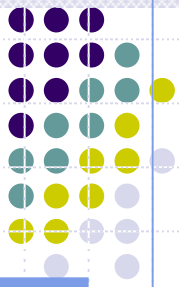
Effectiveness Summary

Application Age, yrs	Effectiveness Index	Total Benefit	EUAC, \$	Expected Life, yrs	Expected Extension of Life, yrs
4	50.40	0.11	\$7,366	21.0	1.0
5	100.00	0.22	\$7,269	22.0	2.0
6	80.50	0.19	\$7,487	21.0	1.0
7	76.07	0.18	\$7,765	21.0	1.0
8	60.00	0.15	\$8,028	20.0	0.0

Graphical Output



Wrap-Up



- Pavement preservation programs can be very cost-effective when treatments are used at the right time
- Determining the right time to apply preventive maintenance treatments is a challenge
 - Construct test sections
 - Monitor pavement conditions
 - Update agency guidelines
- Be sure preventive maintenance treatments are used in a preventive manner
- OPTime can be used to assist