

# PAVEMENT TYPE SELECTION

62<sup>nd</sup> Annual NJ Asphalt Paving Conference

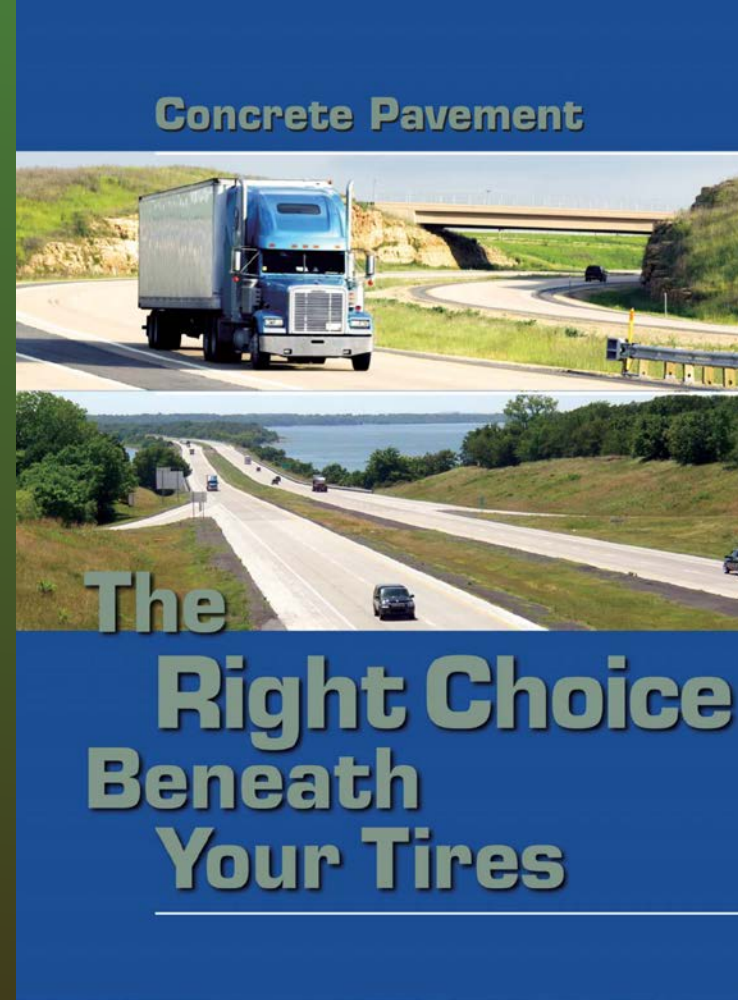


- ▶ Thomas Bennert, Ph.D., Rutgers University-CAIT
- ▶ Susan Gresavage, Executive Manager, NJDOT

## ACKNOWLEDGEMENTS



# PAVEMENT TYPE SELECTION



# PAVEMENT TYPE SELECTION



# BACKGROUND

Pavement Type Selection





EARLY ASPHALT PAVEMENT IN  
NEWARK, NJ



Fig. 115. a.



Fig. 115. b

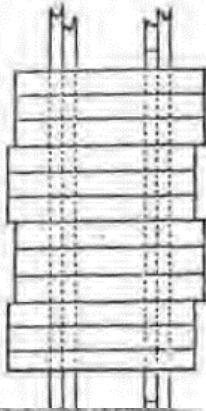


Fig. 115, a, Cross-section.  
Fig. 115, b, Plan, or Top View.

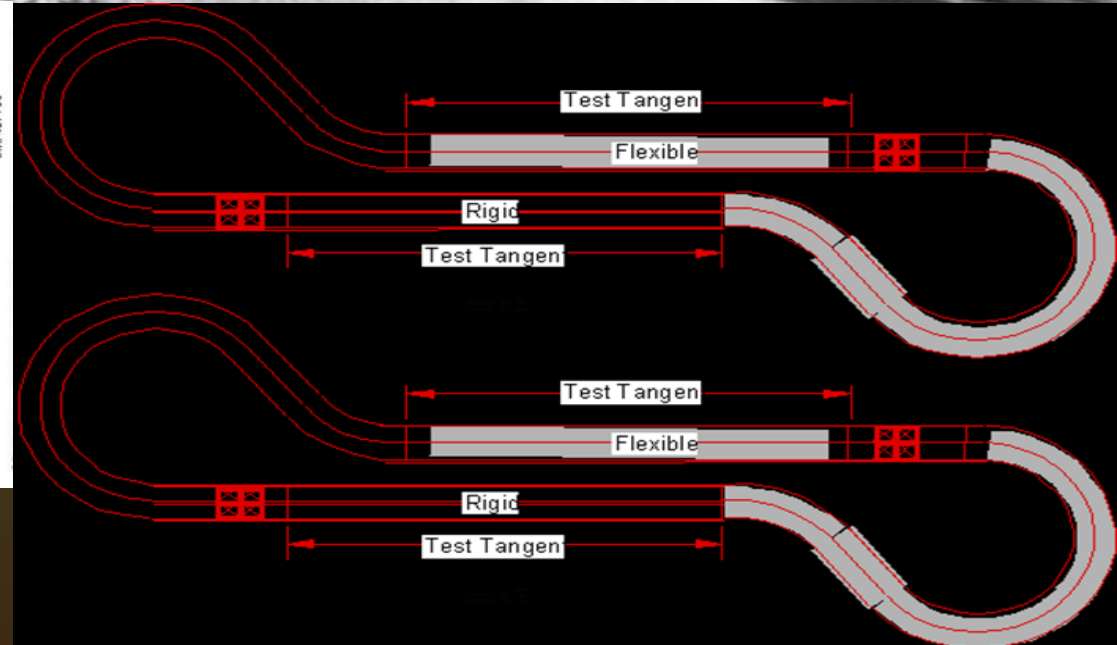
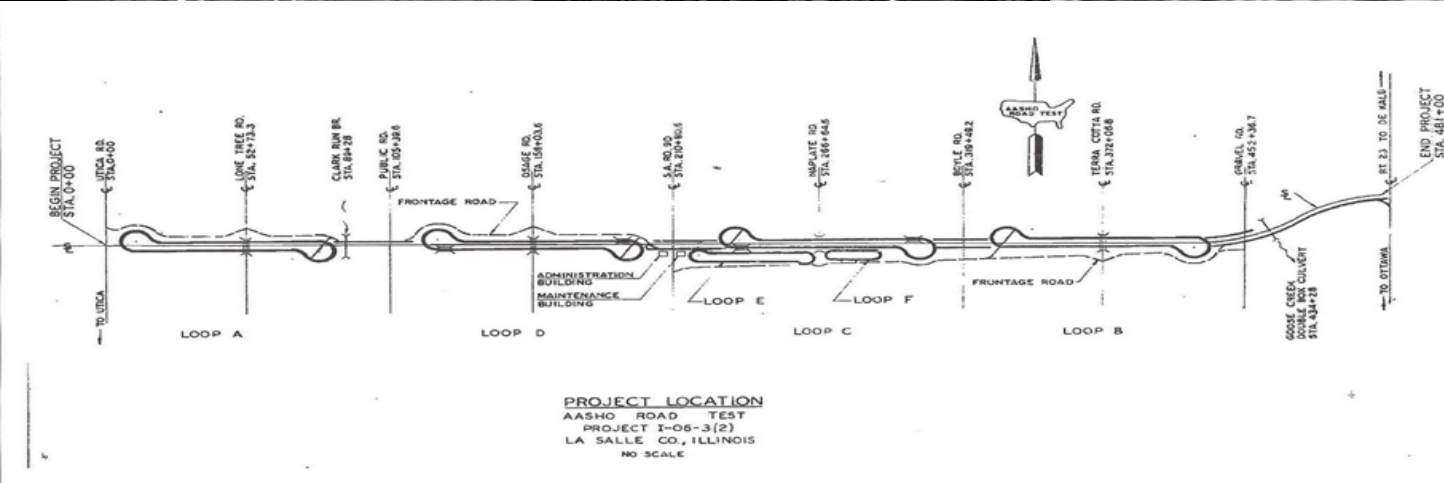
Scale, 10 feet to 1 inch.



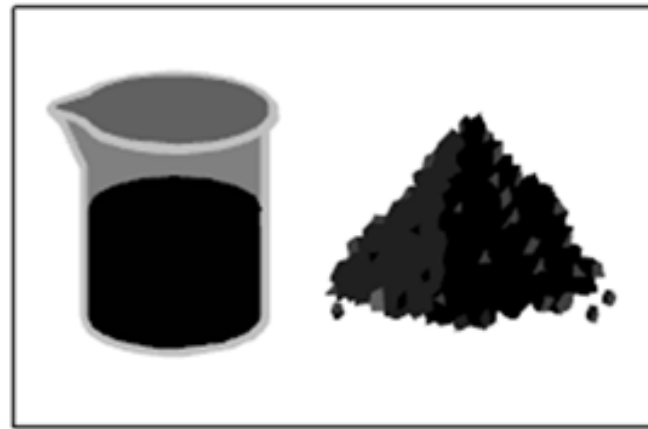
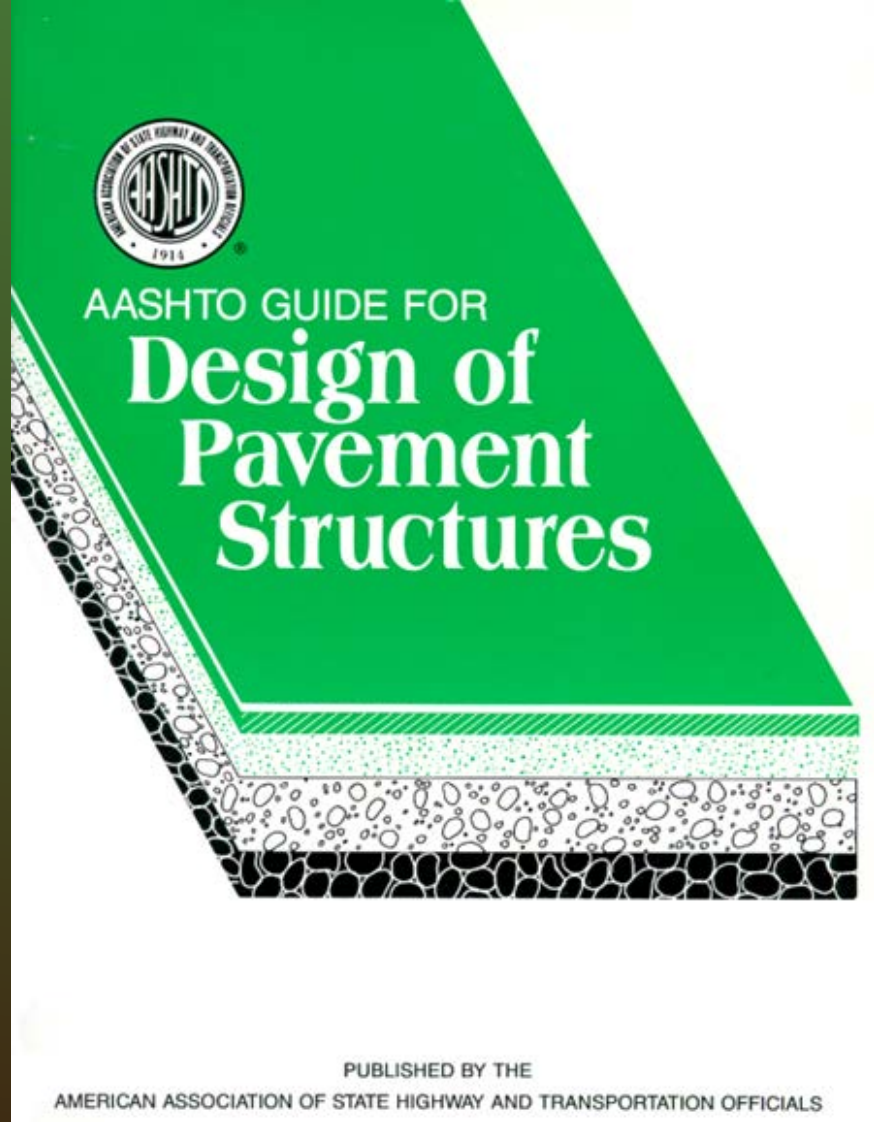
# EARLY PAVEMENT DESIGN

<https://www.state.nj.us/transportation/works/environment/historicroadways.shtm>

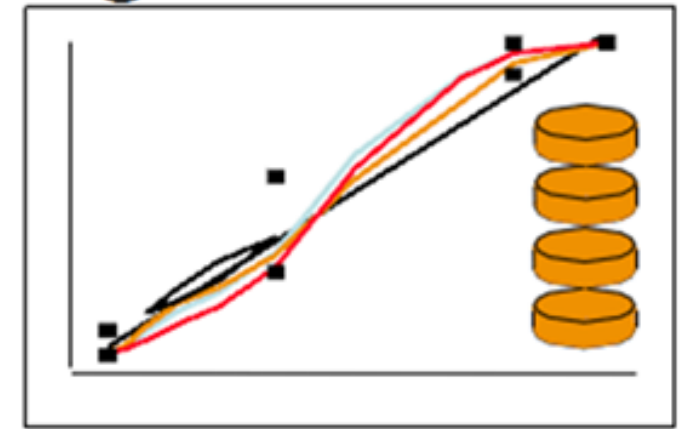




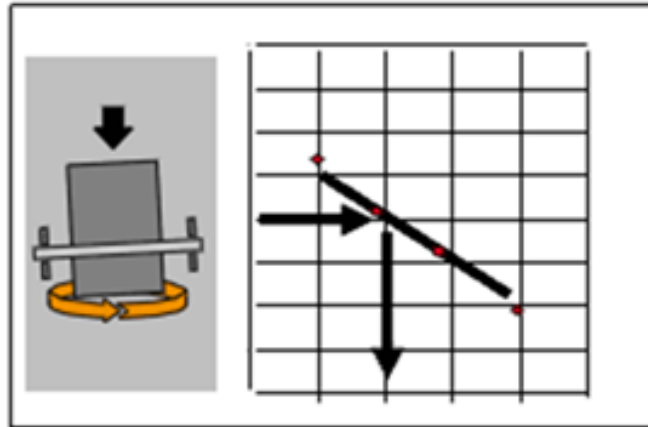
# EARLY PAVEMENT DESIGN



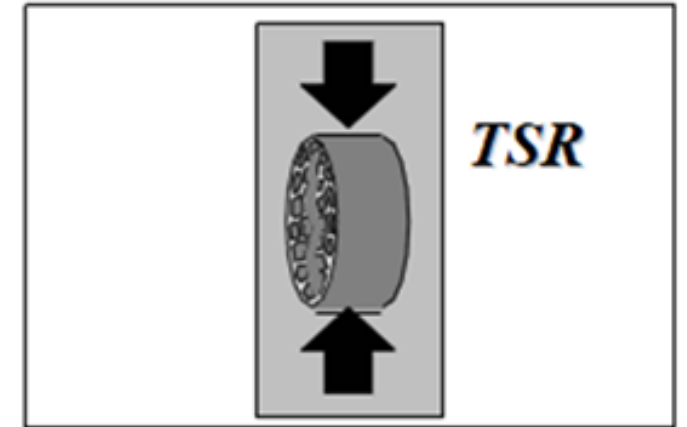
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

SHORTCOMING OF PAVEMENT &  
ASPHALT DESIGN

## Pre-Preservation Era

- ▶ “Worst First” Resurfacing Program Approach
- ▶ Used a hammer for most jobs
- ▶ Mill 2” Asphalt and Pave 2” Asphalt
- ▶ Not many “tools in the toolbox”
- ▶ No dedicated funding for “pavement preservation”

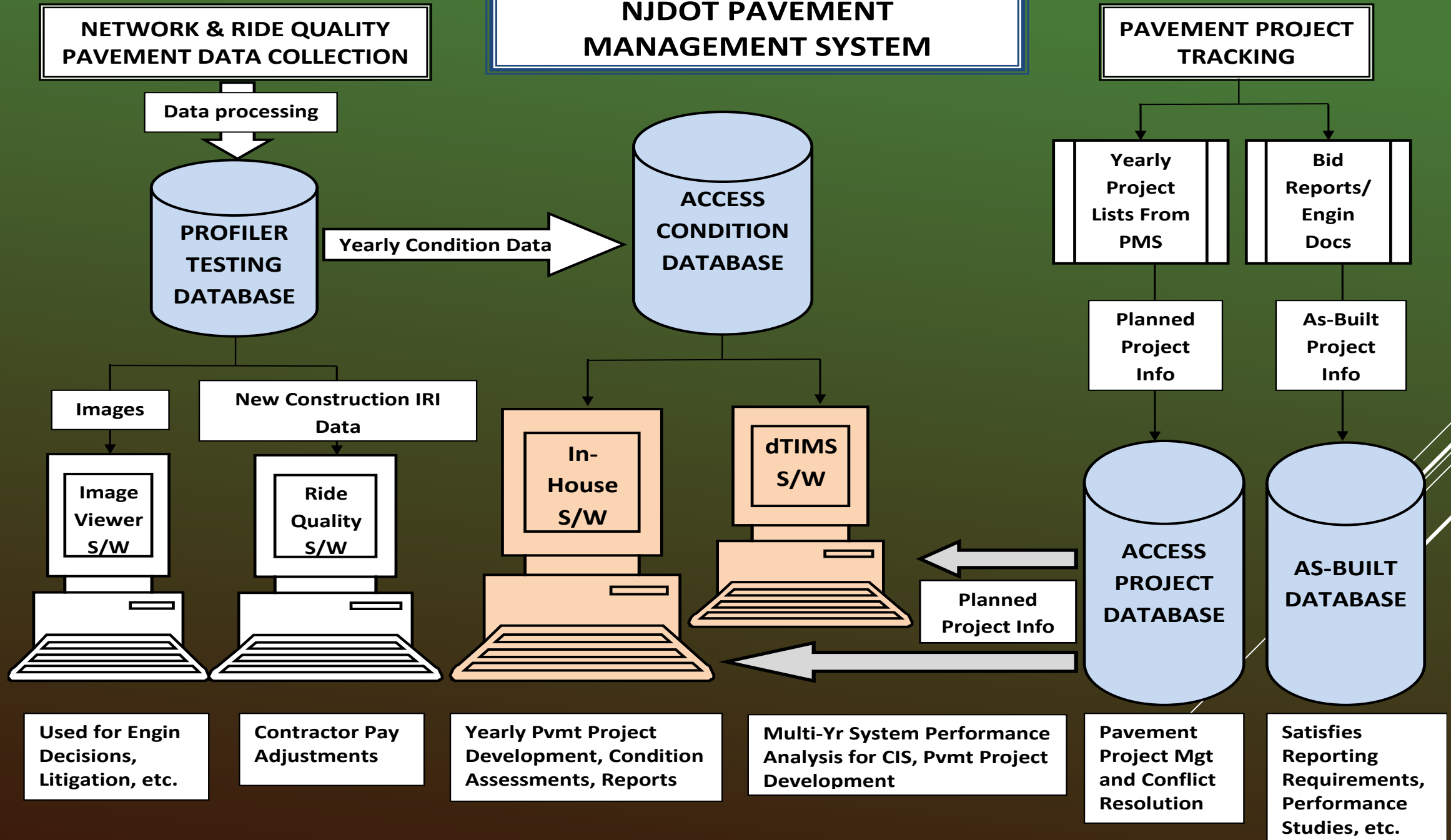
Where we started...



# PAVEMENT PRESERVATION PROGRAM



# NJDOT PAVEMENT MANAGEMENT SYSTEM

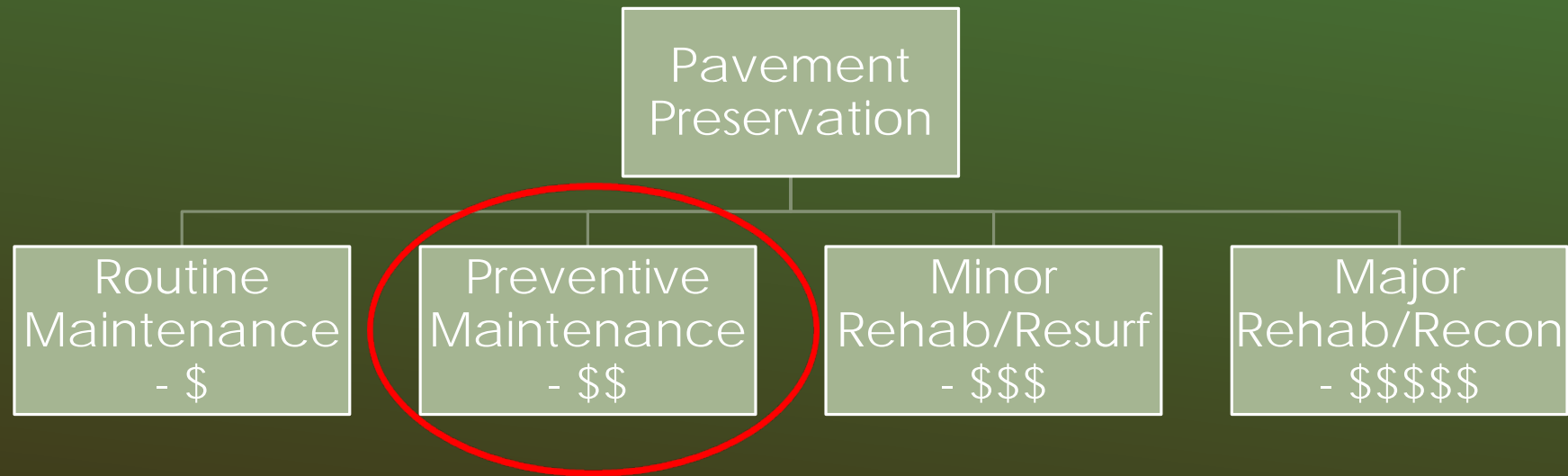


**Pavement Preservation  
Technical Appraisal**

**New Jersey Department of Transportation  
September 2005  
Trenton, New Jersey**



**Partnering Infrastructure Preservation**



# NJDOT PAVEMENT PRESERVATION PROGRAM

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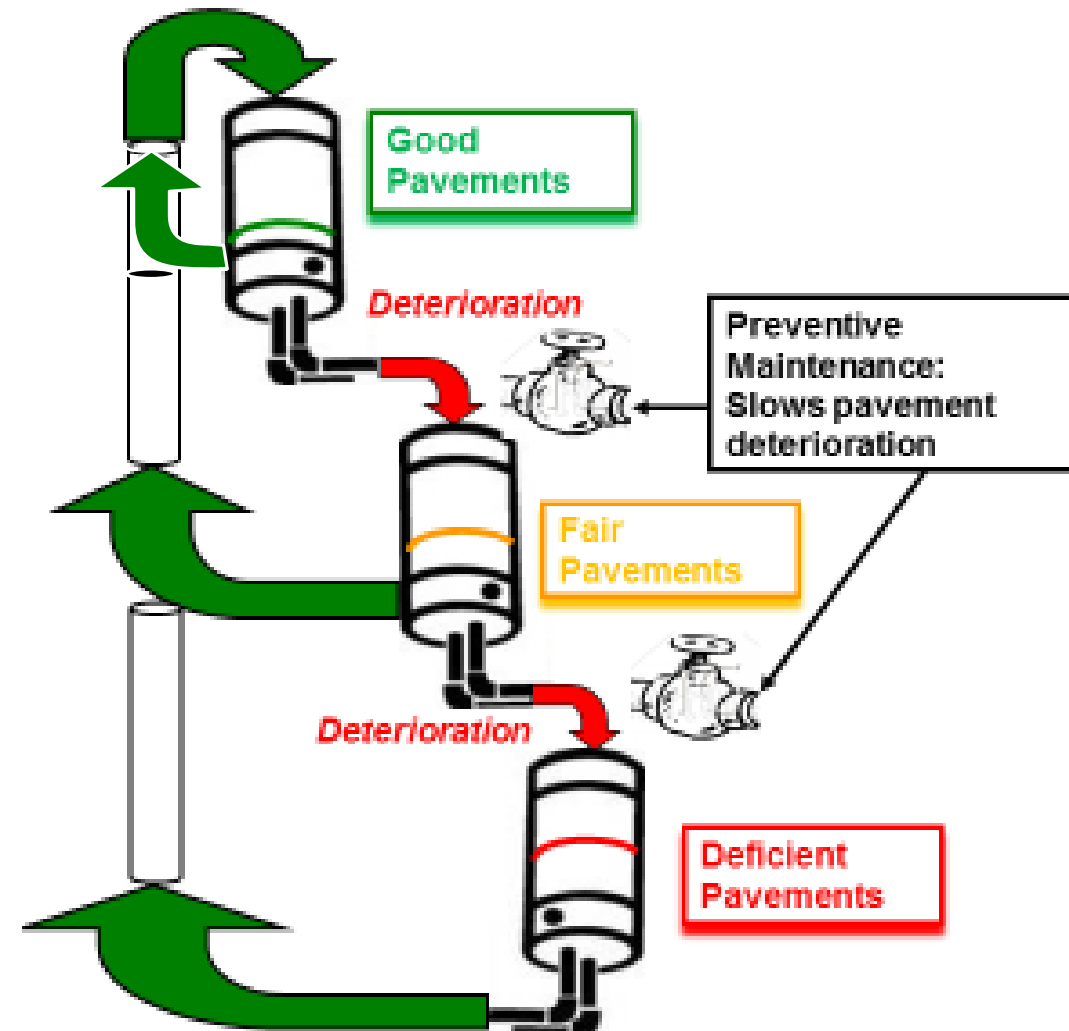
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## Pavement Preservation Methodology

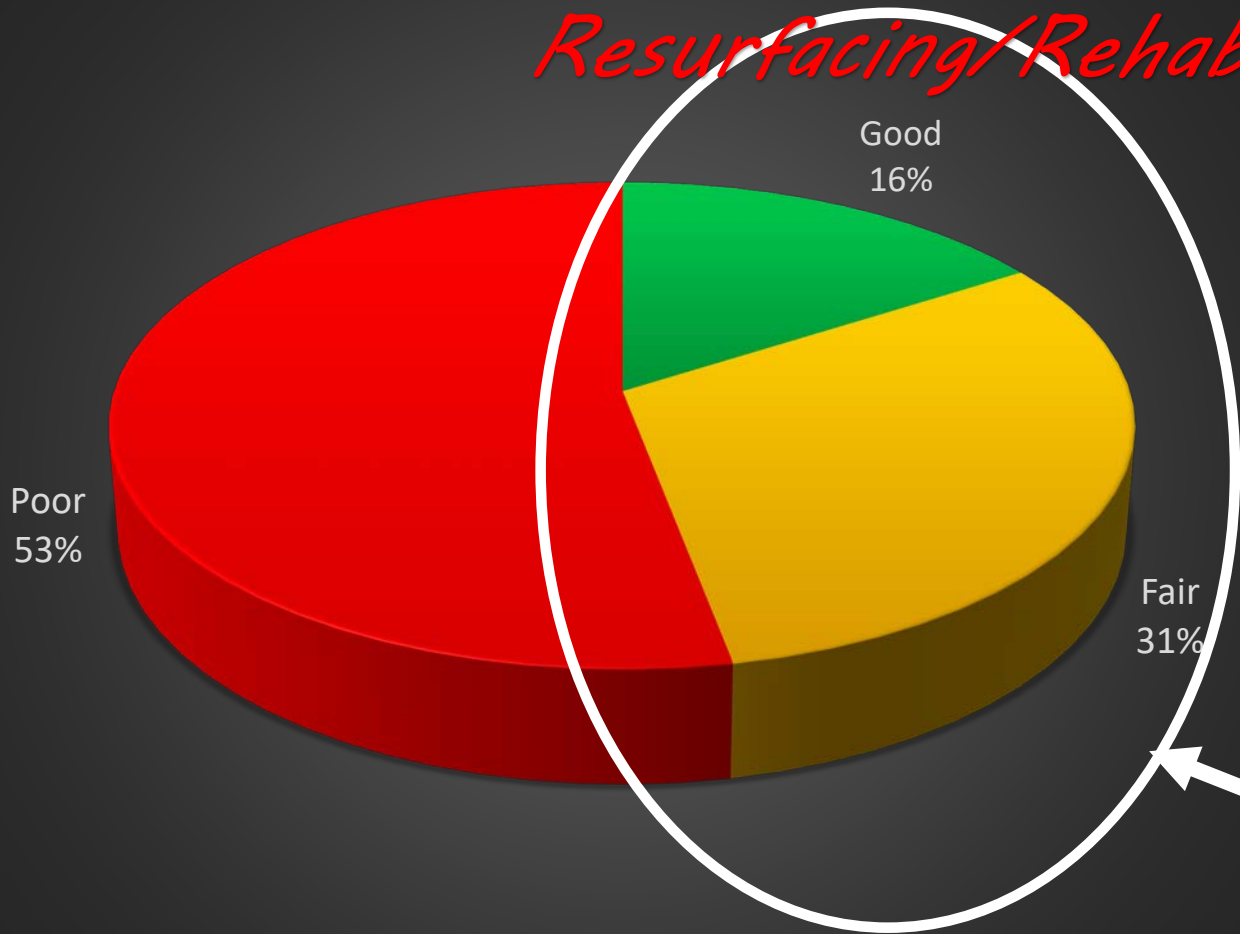
Preservation &  
Preventive  
Maintenance

Minor Rehab &  
Resurfacing

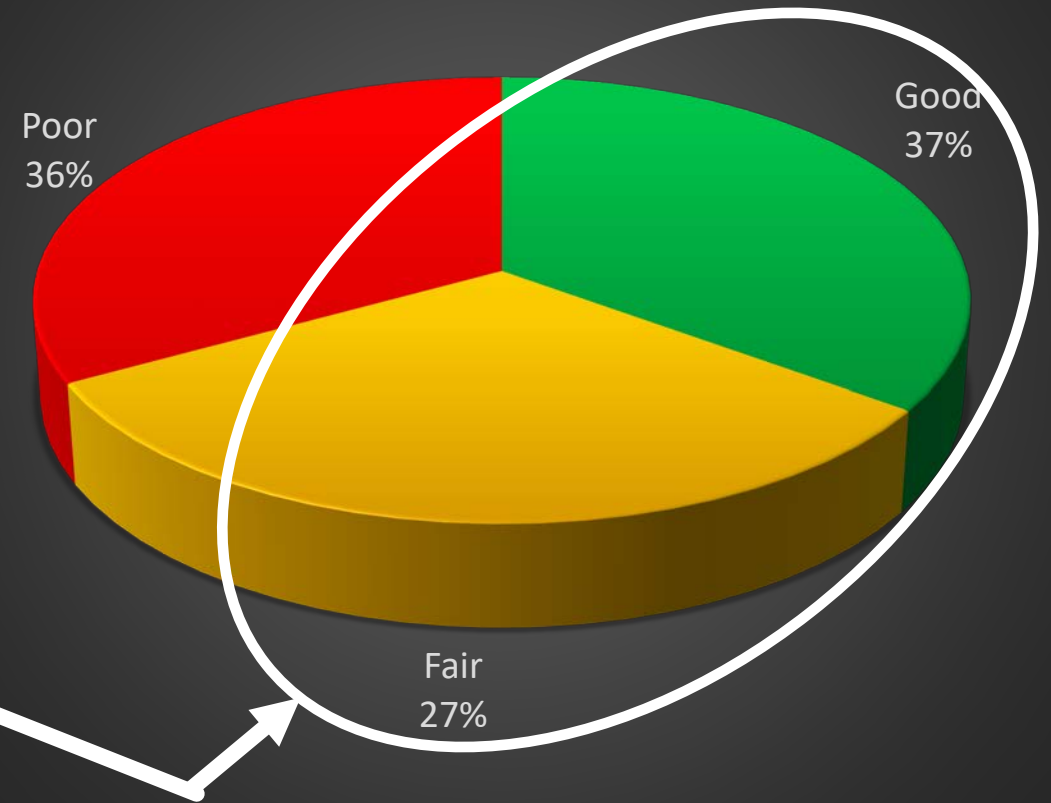
Major Rehab &  
Reconstruction



NJDOT Pavement Condition 2008



NJDOT Pavement Condition 2018



Good =  $IRI < 95$  and  $SDI \geq 3.5$

Poor =  $IRI > 170$  or  $SDI \leq 2.4$

Fair = Everything in between

	Design Traffic	Compaction Parameters			Typical Roadway Application
	ESAL ( $10^6$ )	$N_{ini}$	$N_{des}$	$N_{max}$	
Low Compaction "L" mixes	< 0.3	6	50	75	Local Roads
Medium Compaction "M" mixes	0.3 to < 3	7	75	115	Collector Road; Access Streets
High Compaction "H" mixes	3 to < 30	8	100	160	US Highways; Rural Interstates
Very High Compaction "V" mixes	$\geq 30$	9	125	205	US Interstates; Heavy, slow moving trucks

NJDOT

MODIFICATIONS TO HMA DESIGN



2) Compaction Level  
Low "L"  
Medium "M"

3) Binder Grade  
• PG 64-22  
• or PG 64E-22

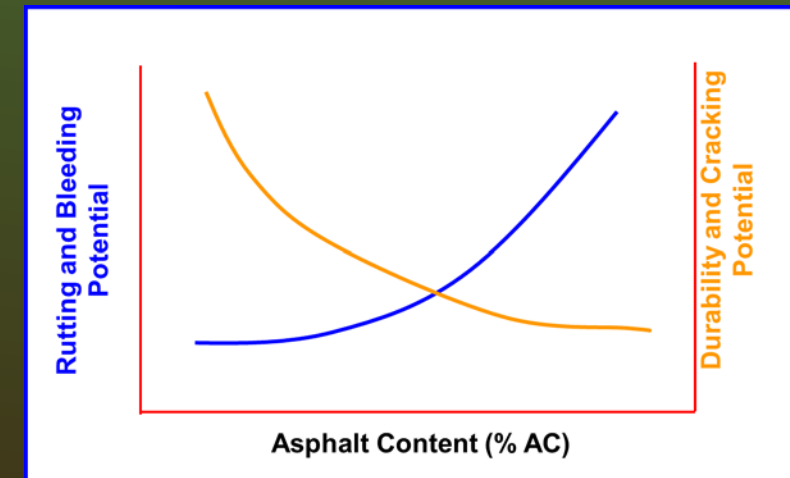
~~Superpave~~ HMA 12.5 M 64 Surface Course

```
graph TD; A[1) Nominal Maximum Aggregate Size (mm)  
• 4.75, 9.5, 12.5, 19 or 25] --> C((12.5)); B[2) Compaction Level  
Low "L"  
Medium "M"] --> D((M)); E[3) Binder Grade  
• PG 64-22  
• or PG 64E-22] --> F((64)); G[4) Location within the payment  
• Surface, Base or Intermediate] --> H((Surface Course)); C --- D --- F --- H
```

1) Nominal Maximum  
Aggregate Size (mm)  
• 4.75, 9.5, 12.5, 19  
or 25

4) Location within  
the payment  
• Surface, Base  
or Intermediate

- ▶ Volumetric mixture design  $\neq$  good performance
- ▶ Need End Result Performance Related Specifications
- ▶ **NEED “BALANCED” ASPHALT MIXTURES**
  - ▶ RUT RESISTANCE, FATIGUE RESISTANCE, REFLECTIVE CRACK RESISTANCE
  - ▶ PERFORMANCE CRITERIA SPECIFIED FOR MIX TYPE, LOCATION IN PAVEMENT, & PAVEMENT TYPE



# CURRENT PAVEMENT DESIGN - ASPHALT MIXTURE PERFORMANCE TESTING



**Example Run, Texas Section**

General Information

Design type: New Pavement

Pavement type: Flexible Pavement

Design life (years): 20

Base construction: W-1

Pavement construction: A-1b

Traffic opening: September 2014

Performance Criteria

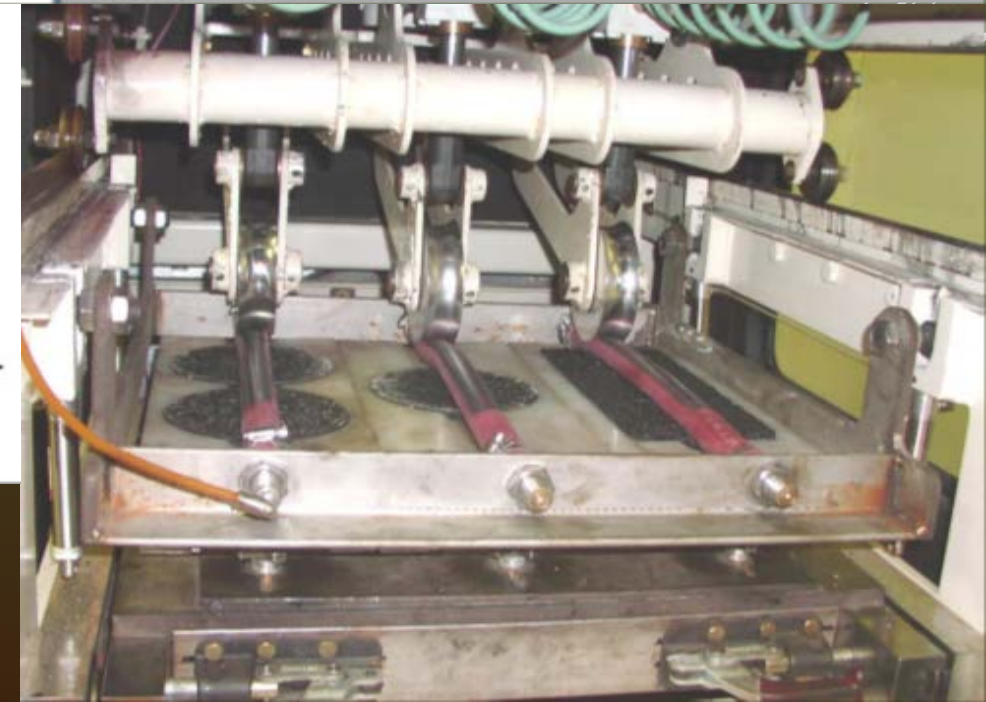
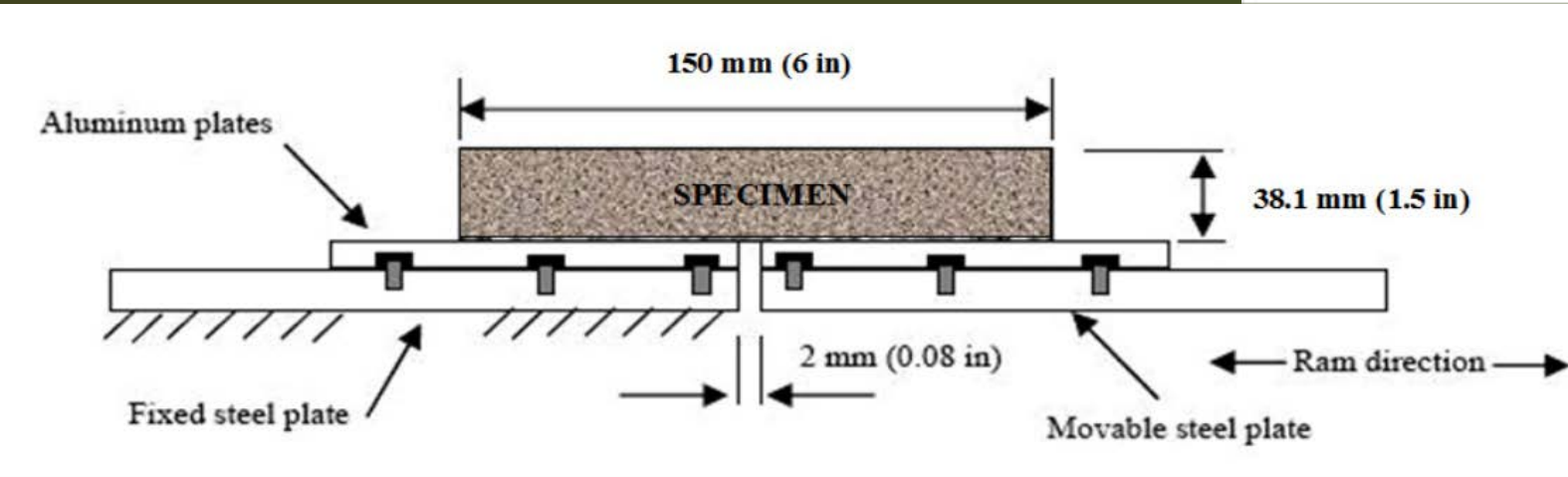
	Unit	Probability
Initial IRI (in./mi)	63	
Terminal IRI (in./mi)	150	90
AC top-down fatigue cracking (ft/mi)	2000	90
AC bottom-up fatigue cracking (percent)	10	90
AC thermal cracking (ft/mi)	1000	90
Permanent deformation - total pavement (in.)	0.5	90
Permanent deformation - AC only (in.)	0.4	90

Metadata

Display name/Identifier	Example Run, Texas Section
Description of object	
Approvers	
Date approved	2/15/2013 3:45 PM
Author	
Date created	2/15/2013 3:45 PM
County	
State	
Direction of travel	
From station (miles)	
To station (miles)	
Highway	
Permit Number	
User defined field 1	
User defined field 2	
User defined field 3	
Item Locked?	False

Display name/Identifier

Display name of object created/project for outputs and graphical interface.

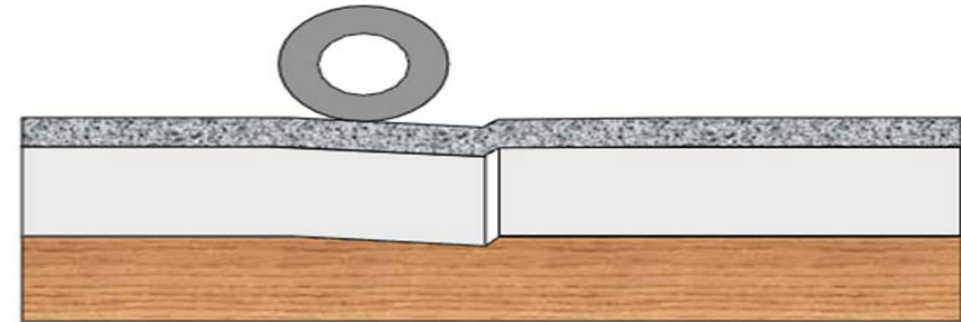


# PAVEMENT & ASPHALT MIX DESIGN





**“causes shear stresses in the overlay.”**

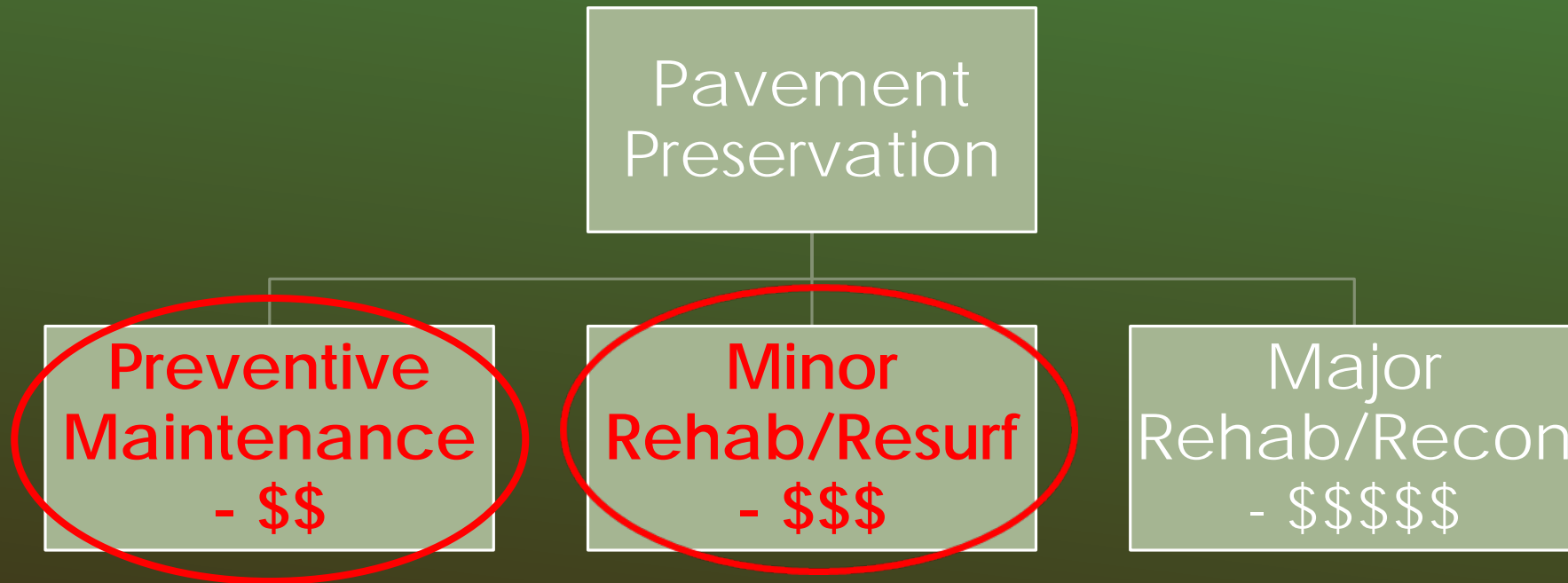


Mode 1: Vertical Shear Stress

PAVEMENT TYPE

Mixture Type	Avg. Performance in Overlay Tester (cycles to failure)	Average Cost per Ton (\$)	Cost Ratio of Mix Type vs HMA	Performance Ratio of Mix Type vs HMA	Benefit/Cost Ratio (Performance Ratio/Cost Ratio)
HMA	91	70	1.0	1.0	1.0
SMA	729	98	1.4	8.0	5.7
HPTO	3013	129	1.8	33.2	18.0
BRIC	3051	116	1.7	33.6	20.3

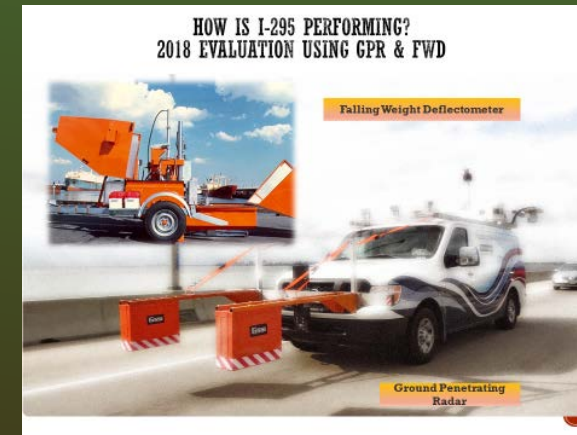
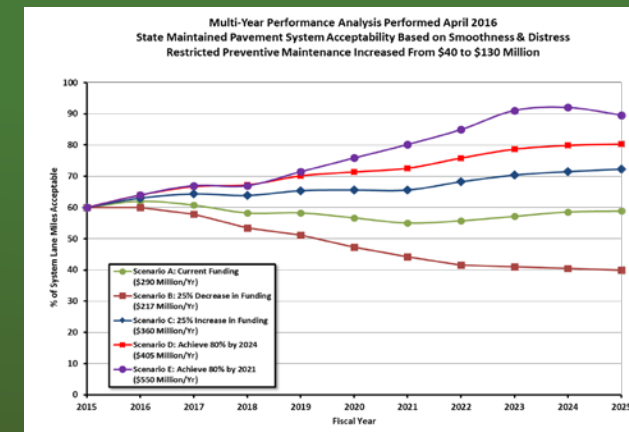
## PAVEMENT TYPE SELECTION



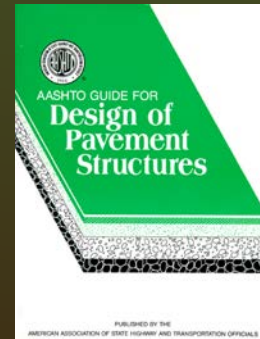
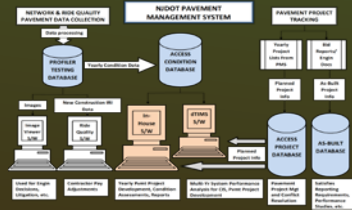
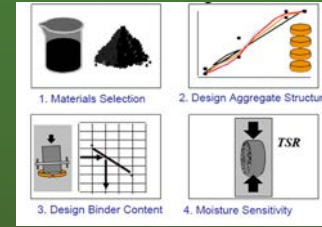
# NJDOT PAVEMENT PRESERVATION PROGRAM



- ▶ Pavement Type (Asphalt, Composite, Concrete)
- ▶ Future Equivalent Single Axle Loads (ESALs)
- ▶ Surface condition(SDI, IRI, Rutting, SN)
- ▶ Age and performance of last treatment
- ▶ Structural Requirements
- ▶ Life cycle cost analysis



# FACTORS AFFECTING PAVEMENT TYPE SELECTION



# PAVEMENT TYPE SELECTION

# PAVEMENT TYPE SELECTION - PREVENTIVE MAINTENANCE

Low to Medium Traffic Loading





## Cold applied system:

- ▶ Polymer modified asphalt emulsion (CQS-1hP)
  - ▶ SB, SBS, SBR or natural latex
- ▶ High quality aggregate
- ▶ Mineral filler
- ▶ Water
- ▶ Additives



# MICRO-SURFACING AND SLURRY SEAL

- ▶ Capable of being spread in variable cross-sections:
  - ▶ Wedges
  - ▶ Ruts
  - ▶ Longitudinal joints – micropaving joints
  - ▶ **Scratch or intermediate layer**
  - ▶ **Surface treatment**
- ▶ Typically applied at 20 lbs/SY aggregate + 0.35 gallons/SY PM asphalt emulsion



## MICRO-SURFACING AND SLURRY SEAL





MICROPAVING LONGITUDINAL JOINTS



- ▶ Benefits:
  - ▶ Maintains existing ride quality
  - ▶ Improves skid resistance
  - ▶ Seals out water
  - ▶ Renew road surface
  - ▶ Quick open to traffic
  - ▶ Minimal to zero rap
  - ▶ 50% of the cost to mill and pave



## MICRO-SURFACING AND SLURRY SEAL



- ▶ **Asphalt binder** application
  - ▶ 0.40 – 0.65 gallons/SY
  - ▶ Polymer modified asphalt
  - ▶ Crumb rubber modified
- ▶ **High quality aggregate** application immediately following the asphalt binder
  - ▶ 6.25 – 9.5 mm (1/4 - 3/8 inch) aggregate size
  - ▶ Clean and cubicle



# CHIP SEAL



Asphalt "Glue" + Stone "Chip"



Compaction "Seating"



CHIP SEAL



CHIP SEAL – VACUUM SWEEPING



- ▶ Benefits:
  - ▶ Maintains existing ride quality
  - ▶ Improves skid resistance
  - ▶ Seals out water
  - ▶ Renew road surface
  - ▶ Quick open to traffic
  - ▶ Minimal to zero rap
  - ▶ 50% of the cost to mill and pave



## CHIP SEAL

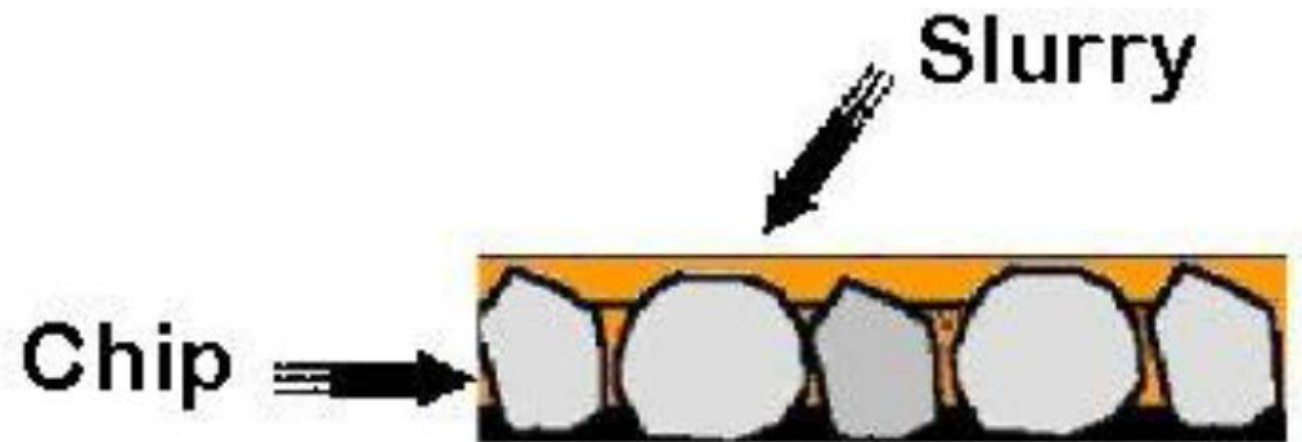
- ▶ Cape seal = slurry seal or microsurfacing over a chip seal

- ▶ SHRP 2 R26

- ▶ Best performer



## CAPE SEAL





# PAVEMENT TYPE SELECTION - PREVENTIVE MAINTENANCE

Medium to High Traffic Loading





- ▶ “Work Horse” of preservation program
- ▶ Applicable for NJ highest ADT roadways
- ▶ 1 inch thick Surface Course
  - ▶ High quality 4.75mm NM Aggregate
  - ▶ Polymer modified asphalt binder PG 64-22E or better
  - ▶ Can be used for leveling when required in lifts 0.5 inch to 1.5 inch thick

## HIGH PERFORMANCE THIN OVERLAY (HPTO)



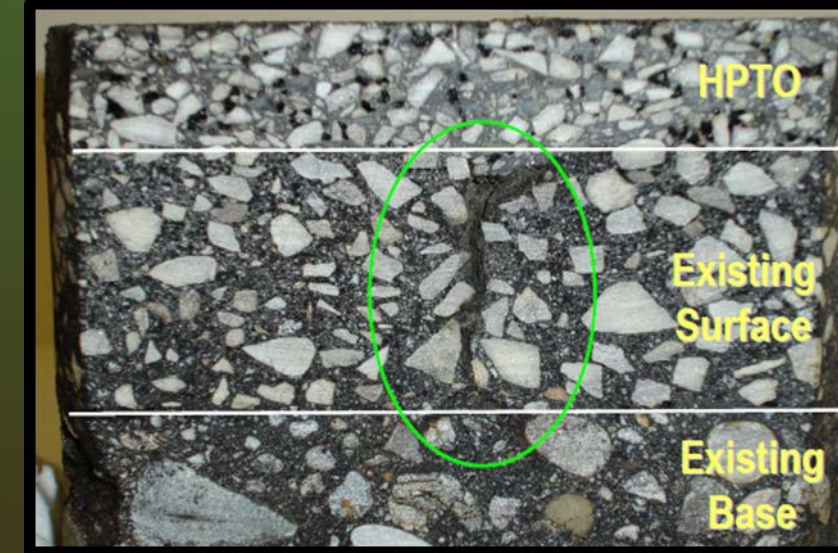
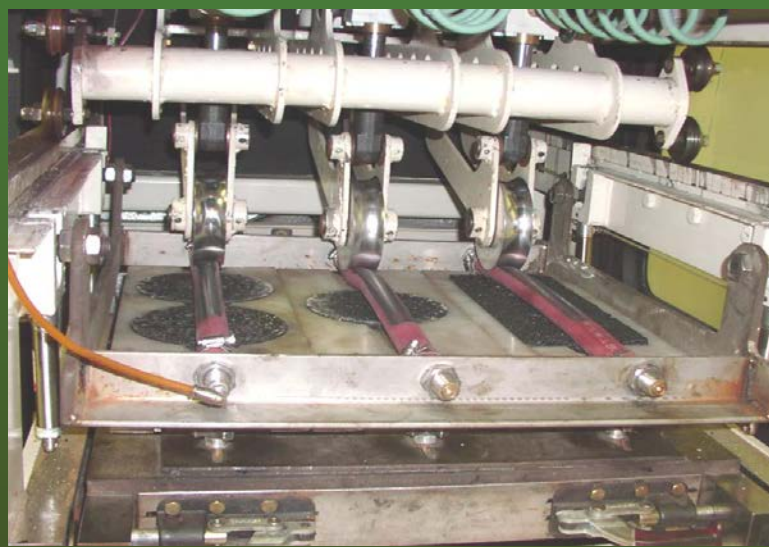
- ▶ HPTO must meet mixture performance requirements

- ▶ Texas Overlay Crack Tester

- ▶ Cycles > 600 in OT

- ▶ Asphalt Pavement Analyzer Rut Tester

- ▶ Rut < 4mm in APA



# WHAT IS HPTO?

**Table 902.08.03-1 Performance Testing Pay Adjustments for HPTO**

Test	Requirement	Test Result	PPA
APA @ 8,000 loading cycles, mm (AASHTO T 340)	5.0 maximum	$t \leq 5.0$	0
		$5.0 < t \leq 12.0$	$-50(t-5)/7$
		$t > 12.0$	-100 or Remove & Replace
Overlay Tester, cycles (NJDOT B-10)	600 minimum	$t \geq 600$	0
		$600 > t \geq 400$	$-(600-t)/4$
		$t < 400$	-100 or Remove & Replace



# HPTO PAY ADJUSTMENT

- ▶ Can improve ride quality (IRI) **significantly**
- ▶ Seals out water
- ▶ Renew road surface
- ▶ Quick open to traffic
- ▶ Minimal to zero RAP



## HPTO ADVANTAGES





- ▶ Placed with a conventional paver or ultra-thin paver
- ▶ Excellent life extension (12+ years) = durability
  - ▶ Mill 2" pave 2" w/ HMA = 8 years average life
- ▶ Low tire noise
- ▶ Improves skid resistance (SN = 50)
- ▶ Applicable to all roadways

## HPTO ADVANTAGES



- ▶ ¾ inch thick Thin Bonded Hot Mix Asphalt (HMA) Overlay
  - ▶ Like Novachip (but not proprietary)
- ▶ 4.9 – 6.0 % polymer modified (PG 64E-22) asphalt binder
- ▶ Volumetric Mix Design Requirements
- ▶ 9.5 mm nominal maximum size **high quality** aggregate
  - ▶ Gap/open graded HMA
  - ▶ Flakiness Index (cubicle aggregate)



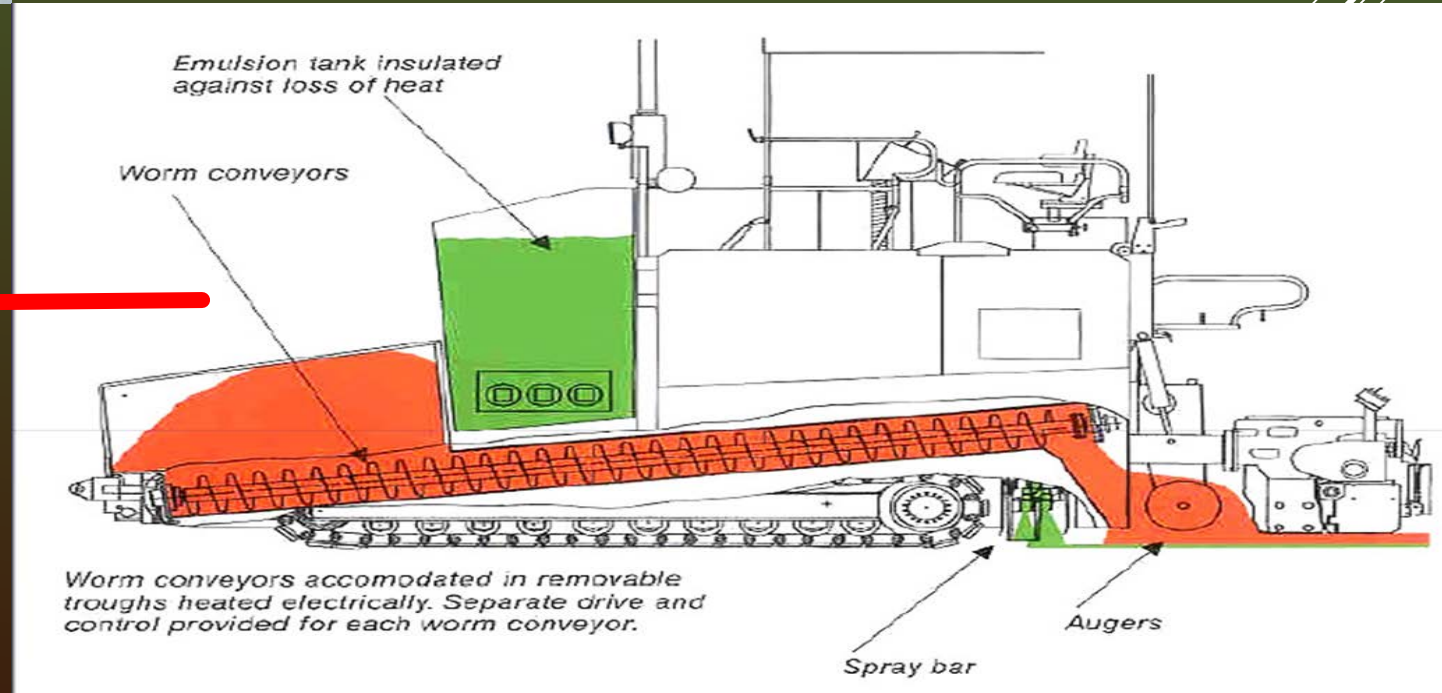
ULTRA-THIN FRICTION COURSE (UTFC)





- ▶ Constructed with ultra-thin paver
  - ▶ Spray paver
  - ▶ Self priming paver
- ▶ Polymer Modified Emulsified Asphalt Tack Coat
  - ▶ CRS – 1P

WHAT IS UTFC?



- ▶ Benefits:
  - ▶ Improvement in ride quality
  - ▶ Improves wet weather skid resistance/spray
  - ▶ Seals out water
  - ▶ Renew road surface
  - ▶ Quick open to traffic (300 feet!!)



# ULTRA-THIN FRICTION COURSE





- ▶ Benefits:
  - ▶ Minimal milling = minimal to zero rap
  - ▶ Placed with spray paver
    - ▶ Ensures superior bond with existing pavement
    - ▶ No tracking tack coat by HMA trucks!!
  - ▶ Great performance when designed and constructed properly (Rt.195 WB, 2000)

## ULTRA-THIN FRICTION COURSE





COMBINATION OF PREVENTIVE  
MAINTENANCE TREATMENTS

# PAVEMENT TYPE SELECTION - RESURFACING & MINOR REHAB

Flexible Pavements





HMA 9.5 M 64 Surface  
Course



HMA 12.5 M 64 Surface  
Course



LOW TO MEDIUM TRAFFIC  
- FLEXIBLE (HOT MIX ASPHALT)



HMA 9.5 M E Surface  
Course



HMA 12.5 M E Surface  
Course



MEDIUM TO HIGH TRAFFIC  
- FLEXIBLE

- ▶ Main Purpose – partner with industry to allow responsible increase % Reclaimed Asphalt Pavement (RAP) in HMA
  - ▶ Minimum 20% RAP in surface course (up from 15% max)
  - ▶ Minimum 30% RAP in intermediate & base course (up from 25% max)
- ▶ Mix design and plant produced HMA High RAP **must meet APA Rut & Overlay Crack test requirements**

**Table 902.11.03-2 Performance Testing Requirements for HMA HIGH RAP Design**

Test	Requirement			
	Surface Course		Intermediate Course	
	PG 64-22	PG 76-22	PG 64-22	PG 76-22
APA @ 8,000 loading cycles (AASHTO T 340)	< 7 mm	< 4 mm	< 7 mm	< 4 mm
Overlay Tester (NJDOT B-10)	> 150 cycles	> 175 cycles	> 100 cycles	> 125 cycles

# HOT MIX ASPHALT (HMA) HIGH RAP

Table 902.11.04-2 Performance Testing Pay Adjustments for HMA HIGH RAP					
	Surface Course		Intermediate Course		PPA
	PG 64-22	PG 76-22	PG 64-22	PG 76-22	
APA @ 8,000 loading cycles, mm (AASHTO T 340)	$t \leq 7$ $7 < t < 10$ $t \geq 10$	$t \leq 4$ $4 < t < 7$ $t \geq 7$	$t \leq 7$ $7 < t < 10$ $t \geq 10$	$t \leq 4$ $4 < t < 7$ $t \geq 7$	0 - 1 - 5
Overlay Tester, cycles (NJDOT B-10)	$t \geq 150$ $150 > t > 100$ $t \leq 100$	$t \geq 175$ $175 > t > 125$ $t \leq 125$	$t \geq 100$ $100 > t > 75$ $t \leq 75$	$t \geq 125$ $125 > t > 90$ $t \leq 90$	0 - 1 - 5

HOT MIX ASPHALT (HMA) HIGH RAP





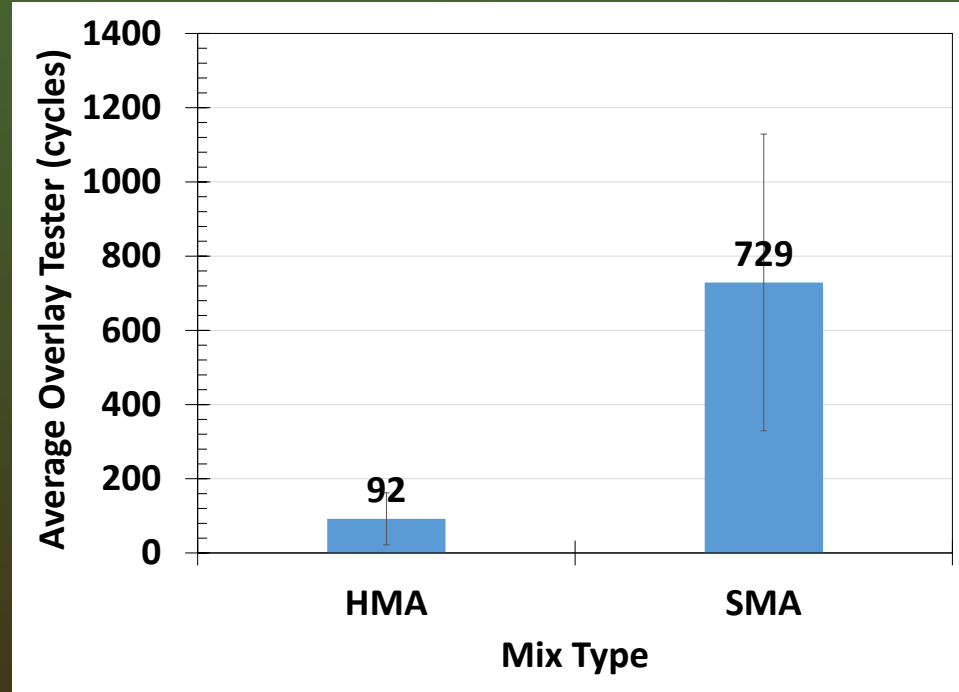
# SMA 12.5mm Surface Course



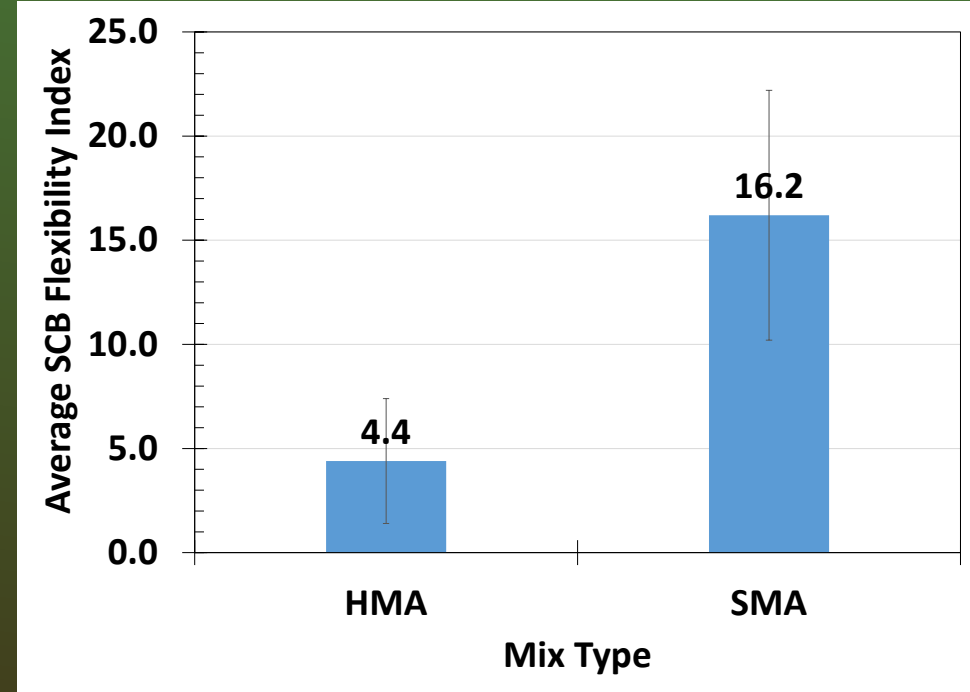
HIGH TRAFFIC  
- FLEXIBLE



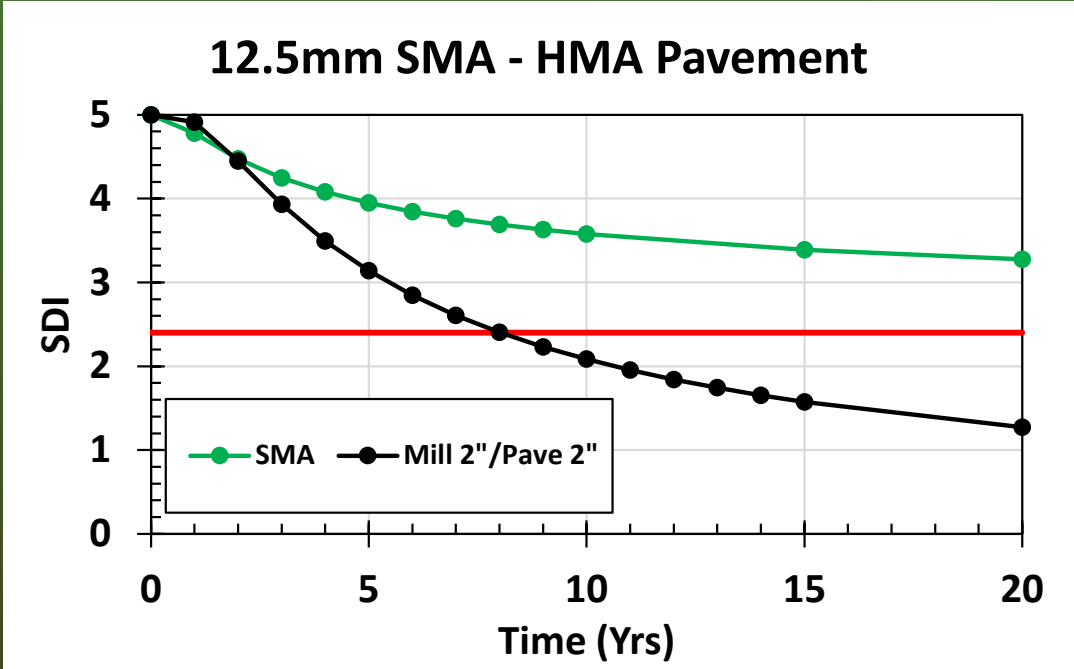
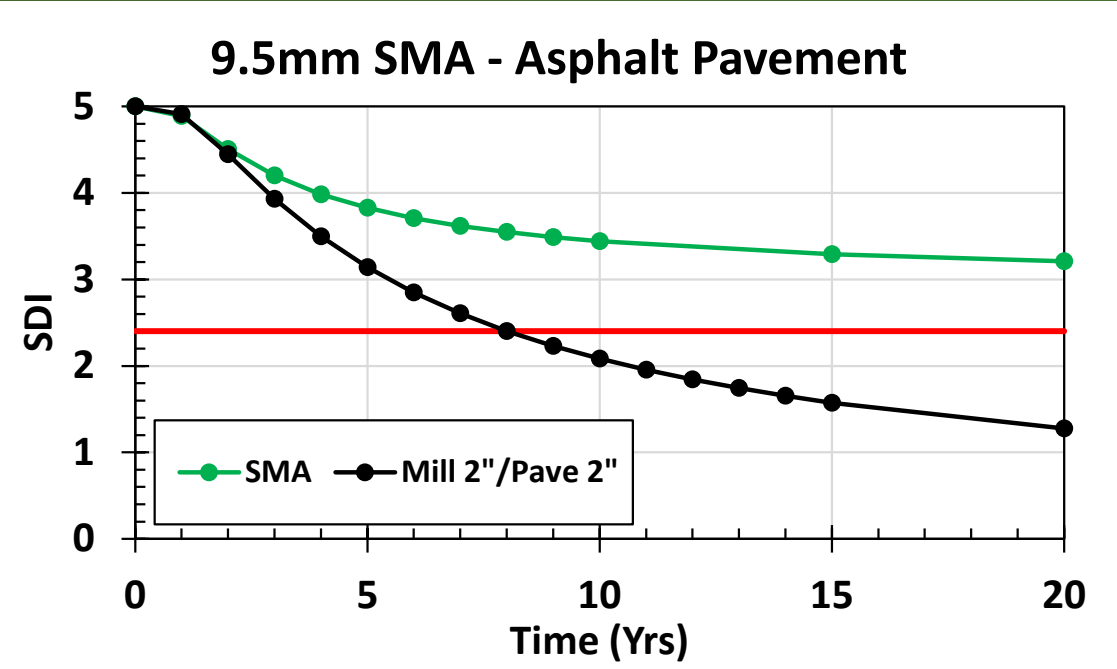
## Texas Overlay Crack Test



## SCB Flexibility Index



WHY SMA?  
LAB PERFORMANCE



WHY SMA? – FLEXIBLE PAVEMENT  
FIELD PERFORMANCE



# PAVEMENT TYPE SELECTION - RESURFACING & MINOR REHAB

Composite Paver



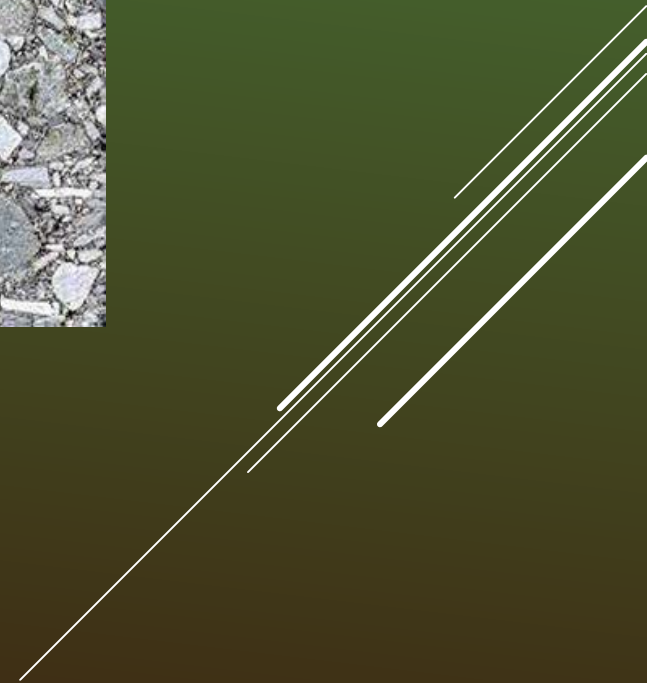
HMA 9.5 M E Surface  
Course



HMA 12.5 M E Surface  
Course



LOW TO MEDIUM TRAFFIC  
- COMPOSITE





HMA 9.5 M E  
Intermediate Course



HMA 12.5 M E  
Intermediate Course



LOW TO MEDIUM TRAFFIC  
- COMPOSITE

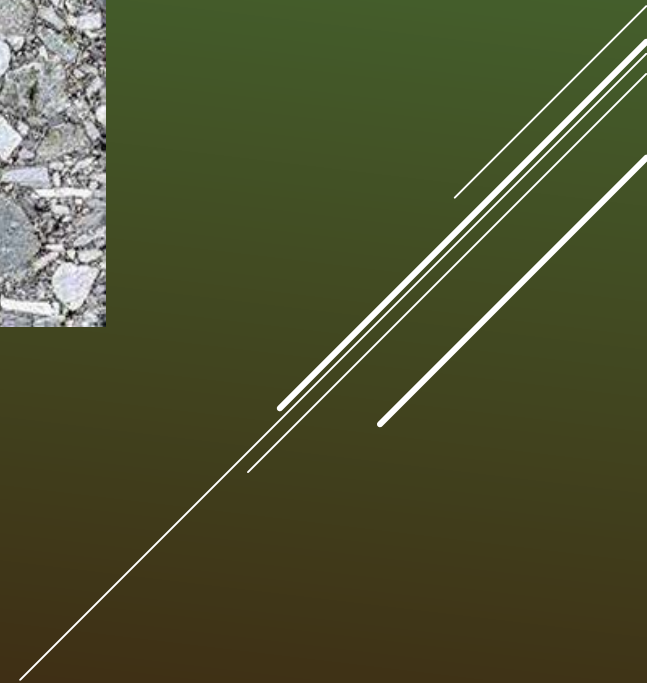




Table 902.11.04-2 Performance Testing Pay Adjustments for HMA HIGH RAP					
	Surface Course		Intermediate Course		PPA
	PG 64-22	PG 76-22	PG 64-22	PG 76-22	
APA @ 8,000 loading cycles, mm (AASHTO T 340)	$t \leq 7$ $7 < t < 10$ $t \geq 10$	$t \leq 4$ $4 < t < 7$ $t \geq 7$	$t \leq 7$ $7 < t < 10$ $t \geq 10$	$t \leq 4$ $4 < t < 7$ $t \geq 7$	0 - 1 - 5
Overlay Tester, cycles (NJDOT B-10)	$t \geq 150$ $150 > t > 100$ $t \leq 100$	$t \geq 175$ $175 > t > 125$ $t \leq 125$	$t \geq 100$ $100 > t > 75$ $t \leq 75$	$t \geq 125$ $125 > t > 90$ $t \leq 90$	0 - 1 - 5

HOT MIX ASPHALT (HMA) HIGH RAP

LOW TO MEDIUM TRAFFIC  
- COMPOSITE

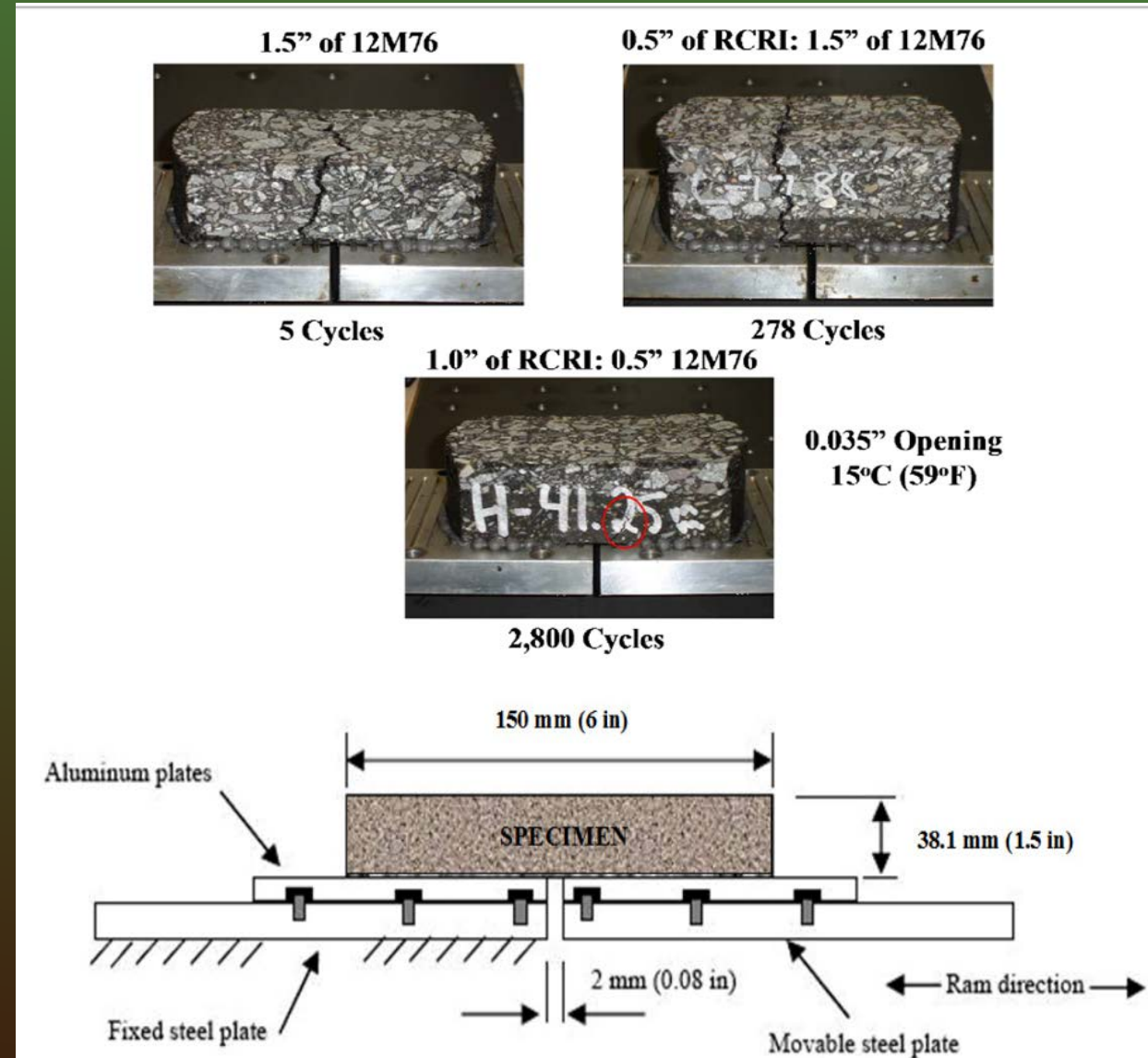


## SMA 12.5mm Surface Course

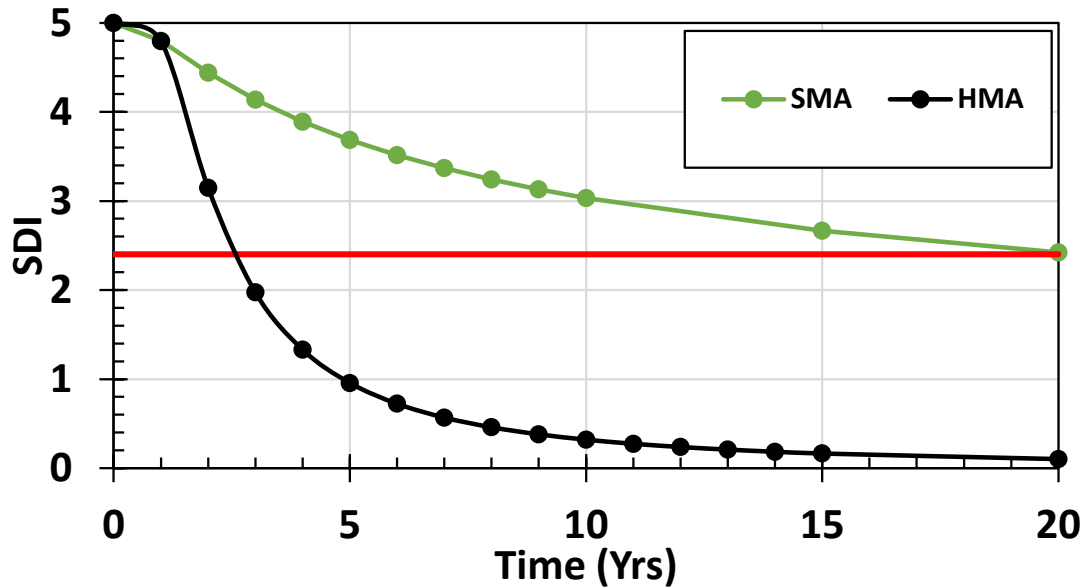


MEDIUM TO HIGH TRAFFIC  
- COMPOSITE

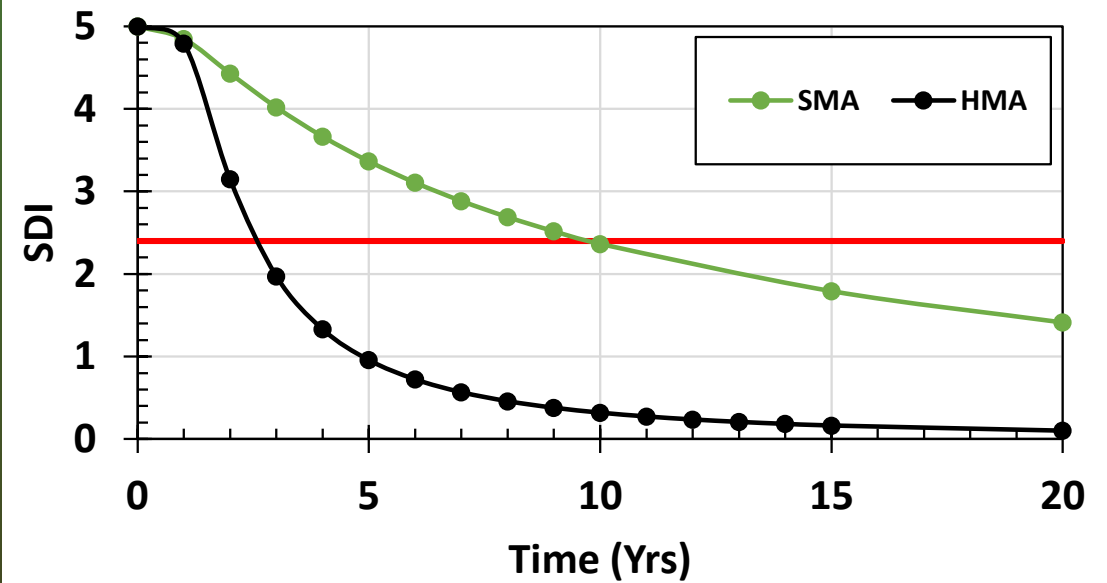
## Binder Rich Intermediate Course



9.5mm SMA - PCC Pavement



12.5mm SMA - PCC Pavement



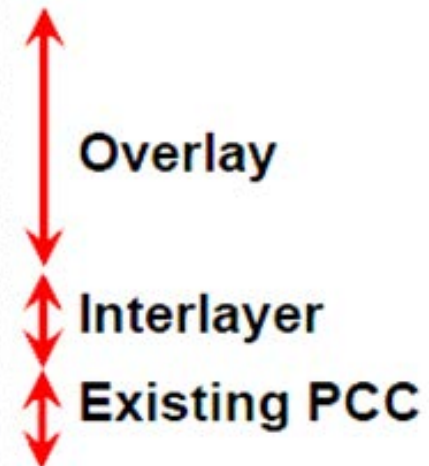
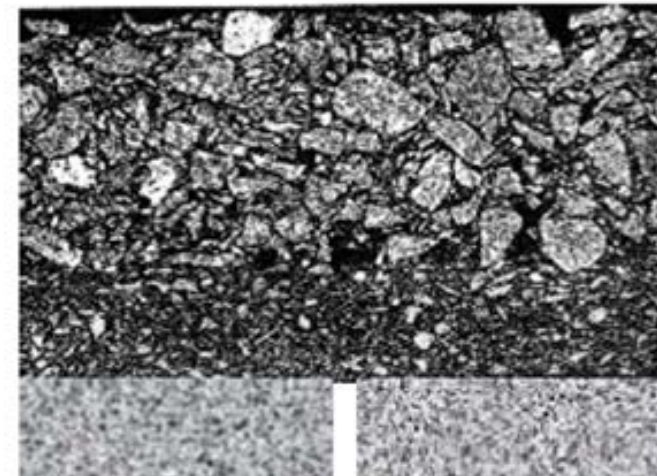
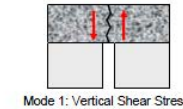
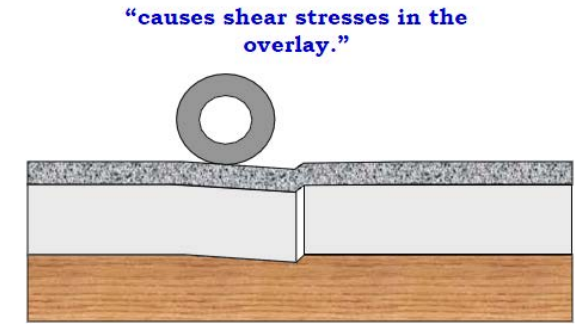
WHY SMA? – COMPOSITE PAVEMENT  
FIELD PERFORMANCE



# BINDER RICH INTERMEDIATE COURSE (BRIC)

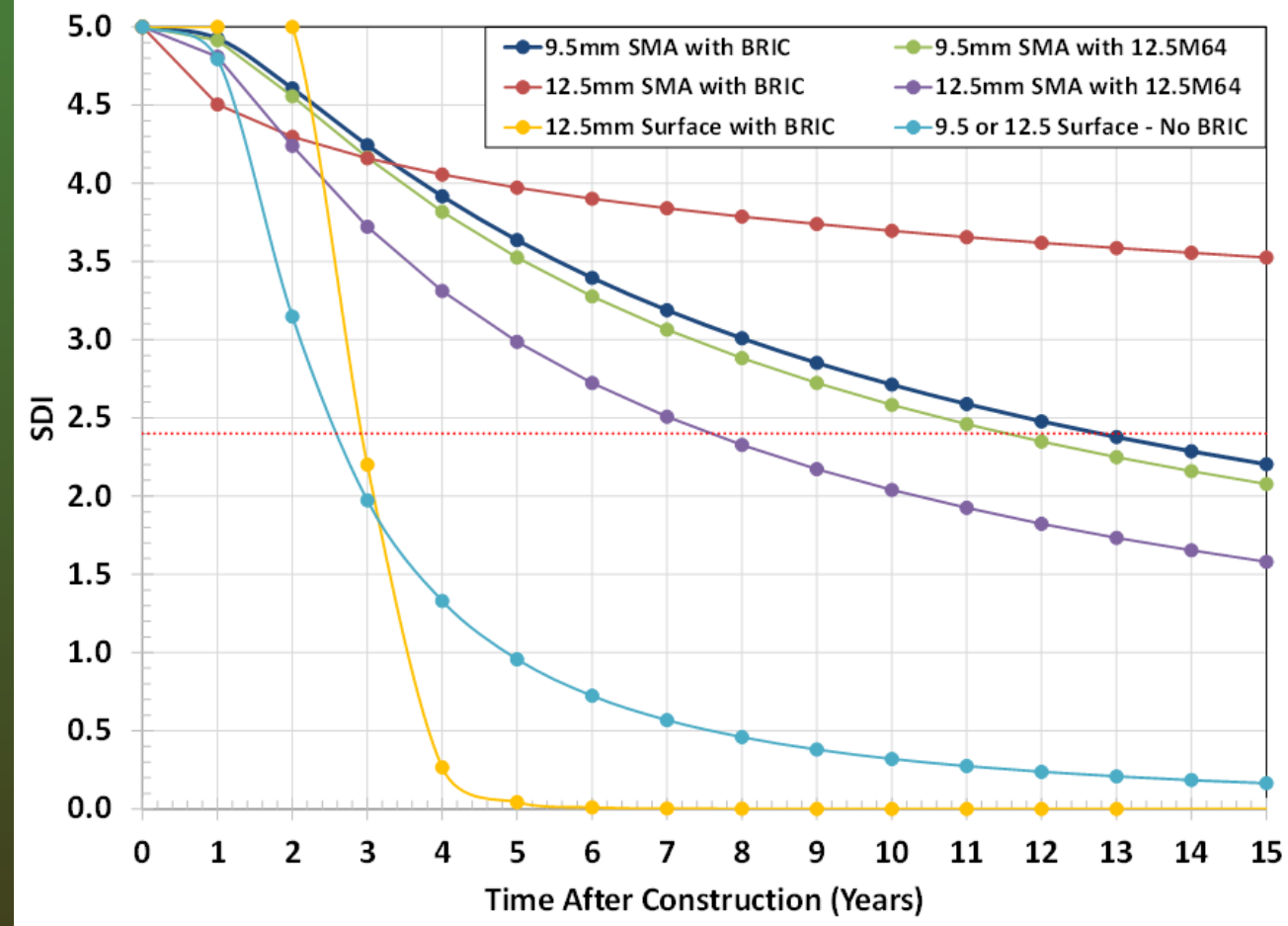
- ▶ Main Purpose – 1" Thick Reflective Crack Relief Interlayer (RCRI)
- ▶ 4.75mm Superpave + APA Rut Test + Overlay Crack Test
- ▶ 7.4% min. polymer modified binder (PG 70-28)
- ▶ 3.5% Air Voids at 50 Gyrations
- ▶ 0-6% air voids for QA
- ▶ APA Rut < 6mm (7mm) at 8000 cycles
- ▶ Overlay Test > 700 (650) cycles

## MEDIUM TO HIGH TRAFFIC - COMPOSITE



## BINDER RICH INTERMEDIATE COURSE (BRIC)

- ▶ Rutgers performed analysis of NJDOT Pavement Management data
- ▶ BRIC improves projected life, but largely influenced by surface course material
- ▶ 2" Stone Matrix Asphalt (SMA) over 1" BRIC provides 10 years more life than dense graded asphalt mixtures



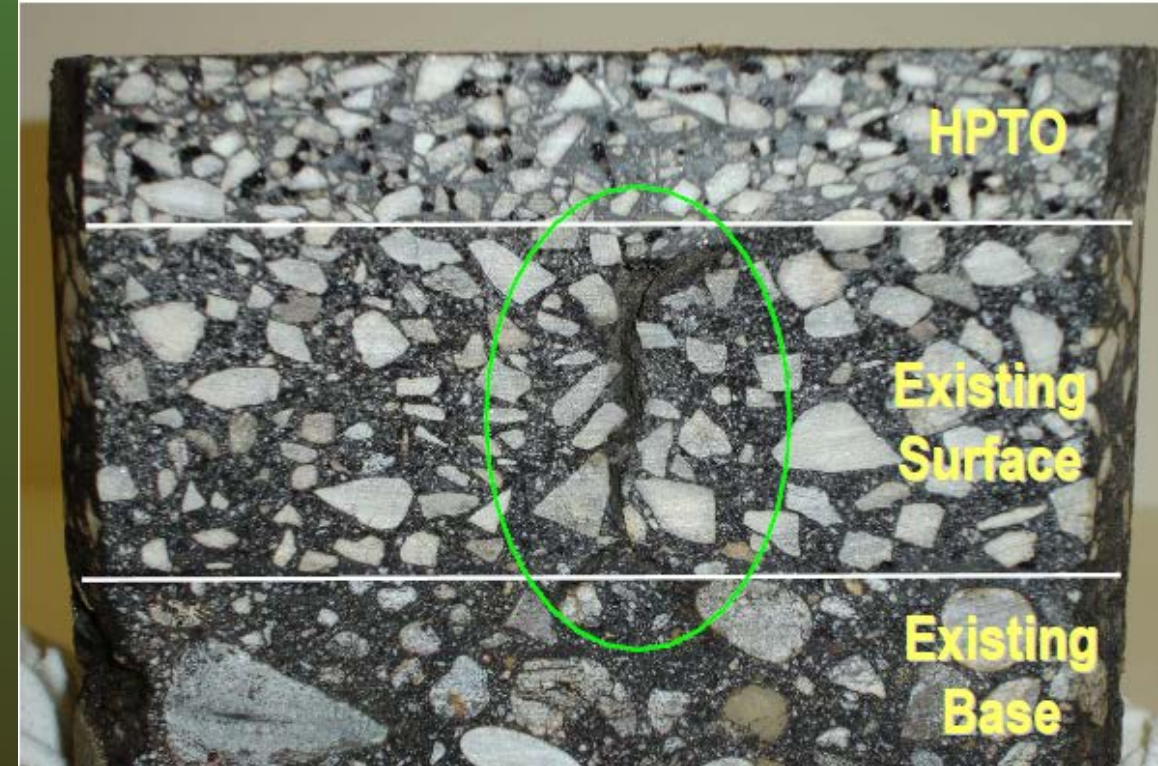
MEDIUM TO HIGH TRAFFIC  
- COMPOSITE

# HIGH PERFORMANCE THIN OVERLAY (HPTO)

- ▶ Main Purpose – used as a rut-resistant and durable thin lift mix for maintenance/pavement preservation
  - ▶ Superior leveling course
  - ▶ Overlay for bridge decks
  - ▶ Superior surface course for inlays
    - ▶ Composite pavement
- ▶ Appropriate on high or low volume roads

MEDIUM TO HIGH TRAFFIC  
- COMPOSITE

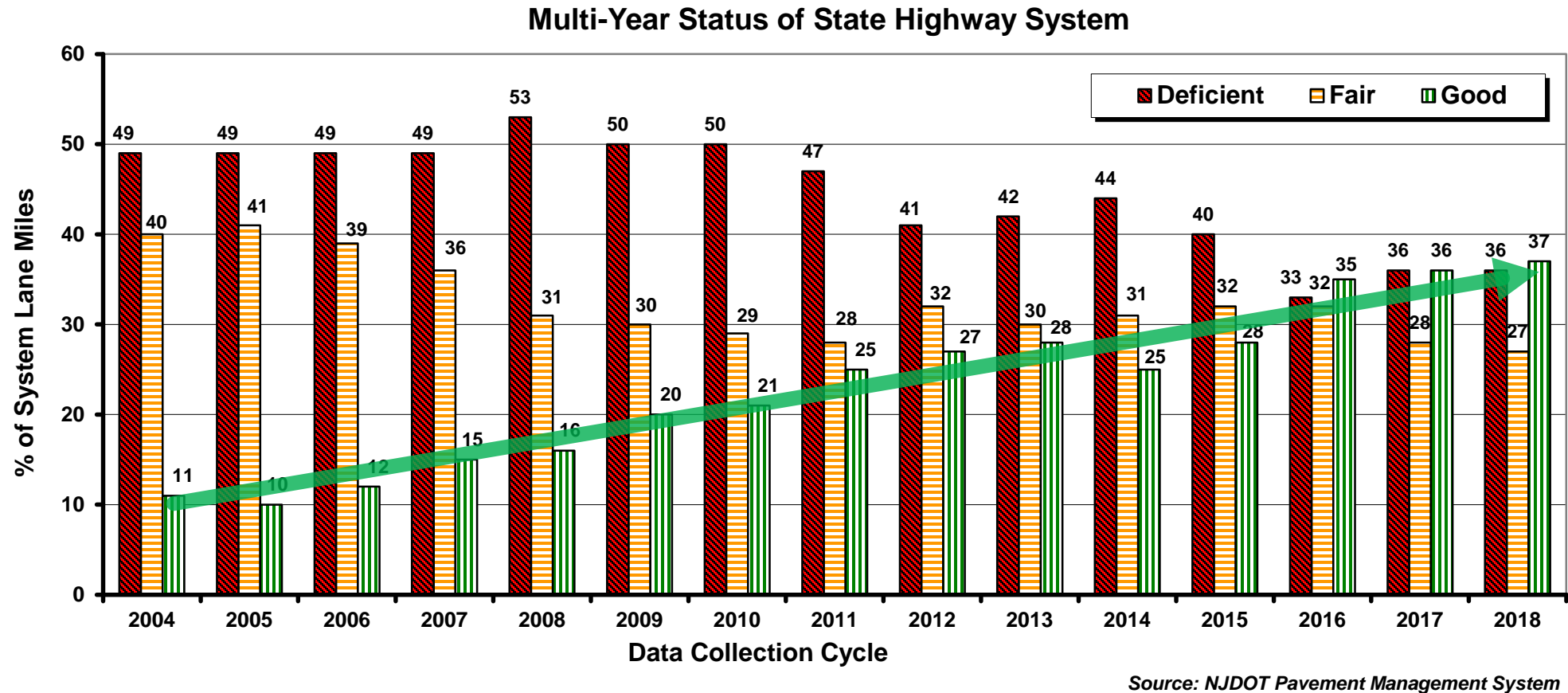
## Direct Overlay – No Milling



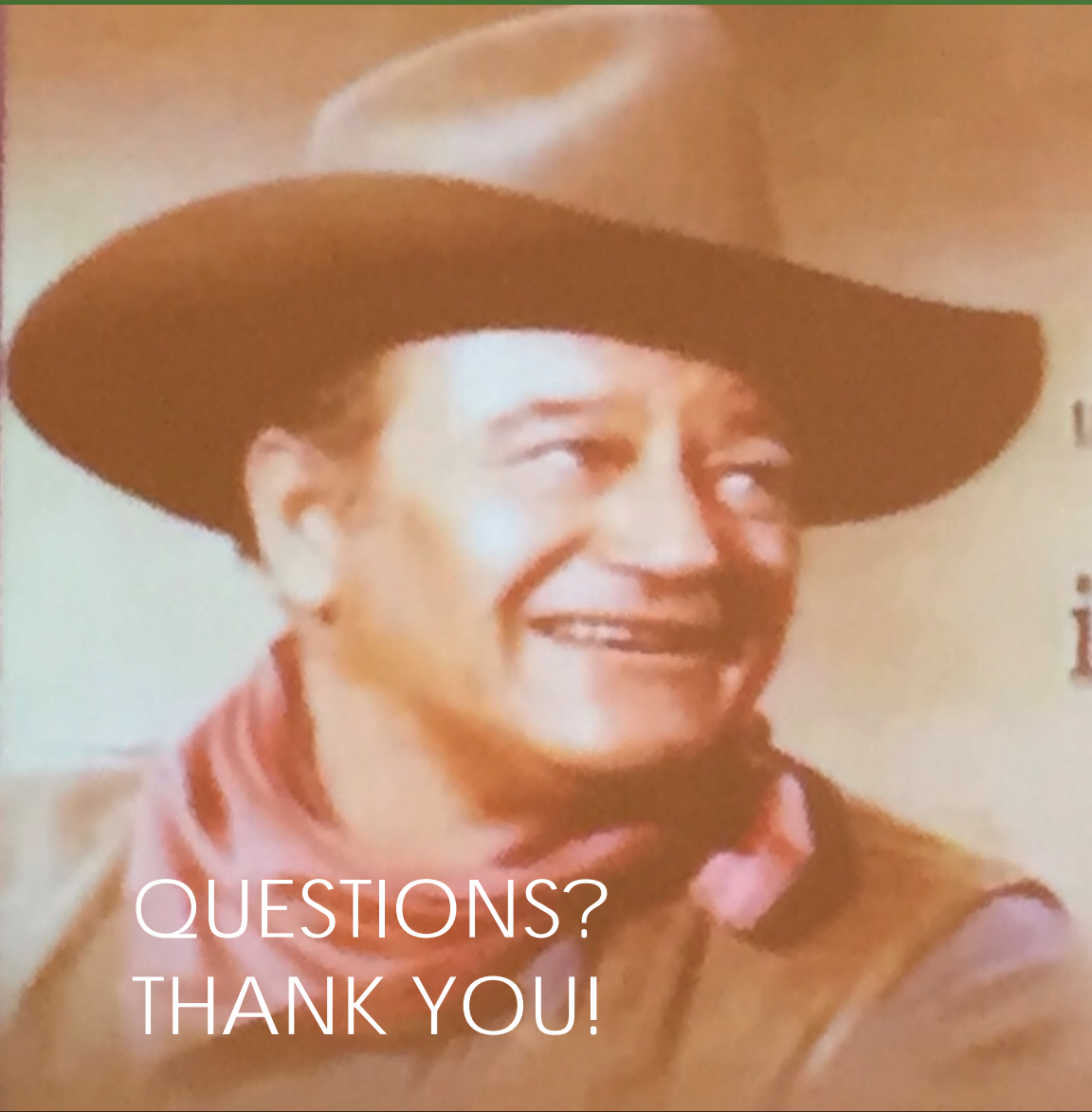




PAVEMENT TYPE SELECTION  
- RIGHT TOOLS FOR THE JOB!



PAVEMENT TYPE SELECTION  
- IT MAKES A DIFFERENCE!



"Life is hard;  
it's harder if you're stupid."

*John Wayne*

QUESTIONS?  
THANK YOU!

Robert Blight

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# What is coming is better than what is gone.

QUESTIONS?  
THANK YOU!

Robert Blight

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