WHY NJDOT IS GOING MODIFIED

By

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for
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Pavement Management and Technology Unit

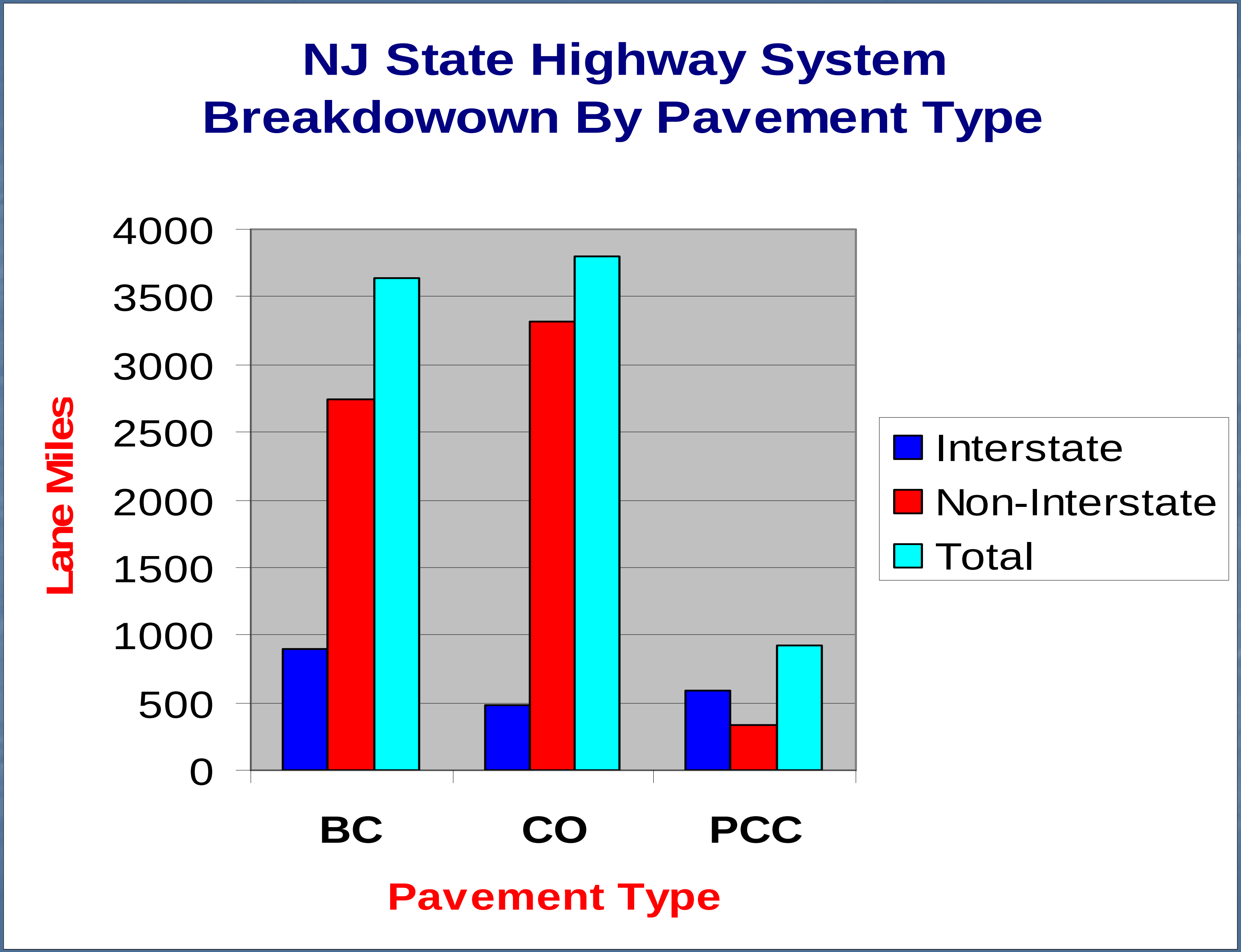
Design Services / Capital Program Management

NJ Facts and Figures

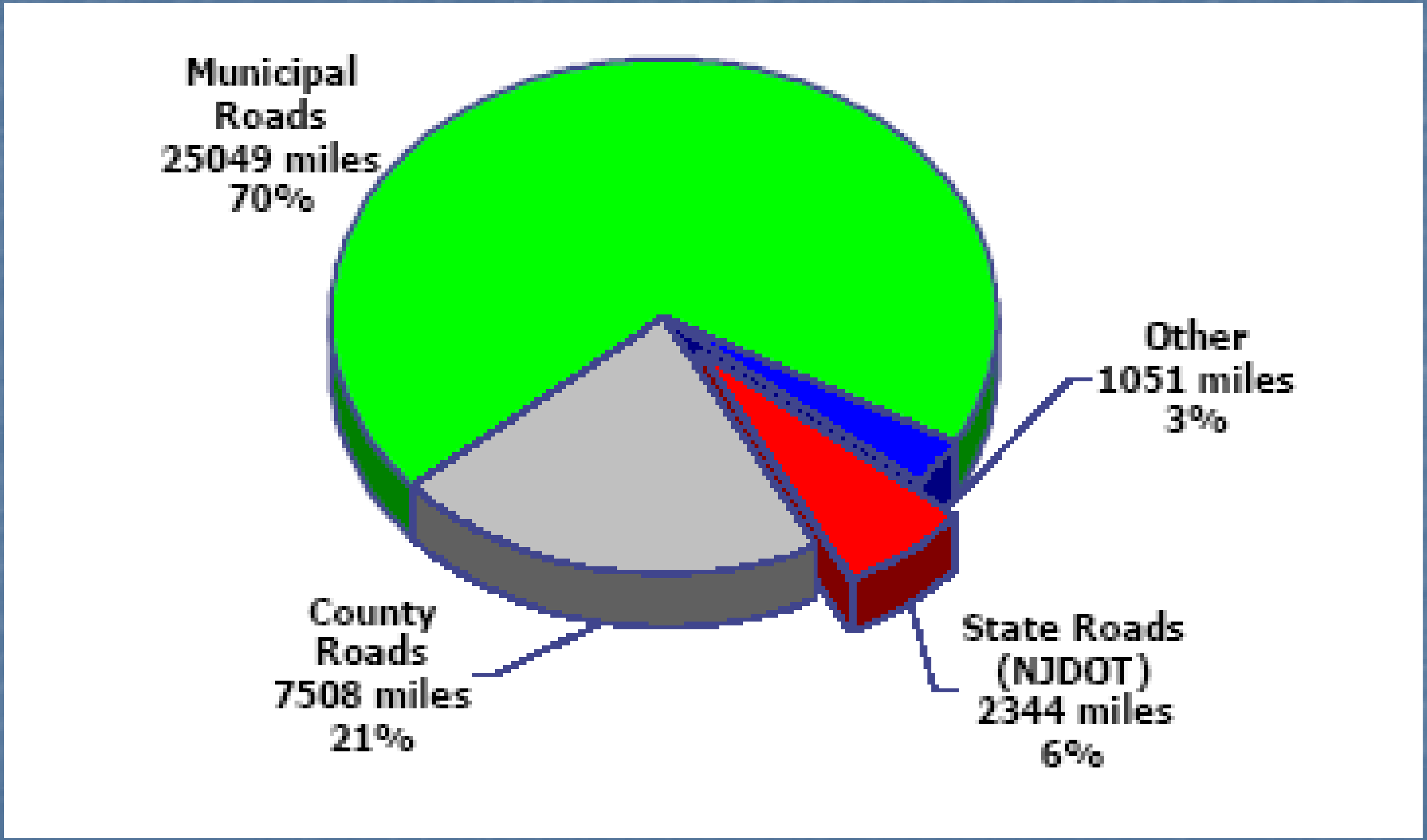
- Highest Population Density: 1134/Sq Mi
- 47th State in Size / 9th in Population
- Highest Urban Population: 90%
- All 21 Counties Classified as Metropolitan Areas
- Most Dense Highway & Rail System in US
- Car Thefts: Newark > NYC + LA Combined
- Second in Per Capita Income

NJ STATE HIGHWAY SYSTEM
LANE MILES

Road Class	Pavement Type			Total
	BC Bituminous Concrete	CO Composite	PCC Portland Cement Concrete	
Interstate	895	477	584	1956
Non-Interstate	2744	3322	334	6400
Total	3639	3799	918	8356


NJ State Highway System
Breakdowown By Pavement Type
4000
3500
3000
2500
2000
1500
1000
500
0
Lane Miles
BC
CO
PCC
Pavement Type
Interstate
Non-Interstate
Total

New Jersey Roadway System Breakdown By Centerline Miles



Two-thirds of all traffic is carried on state-owned roads

The Problem

Based on pavement structural analysis, 53 % of the NJ state highway system is deficient to carry design traffic loads

NJ Interstate Highway Pavement

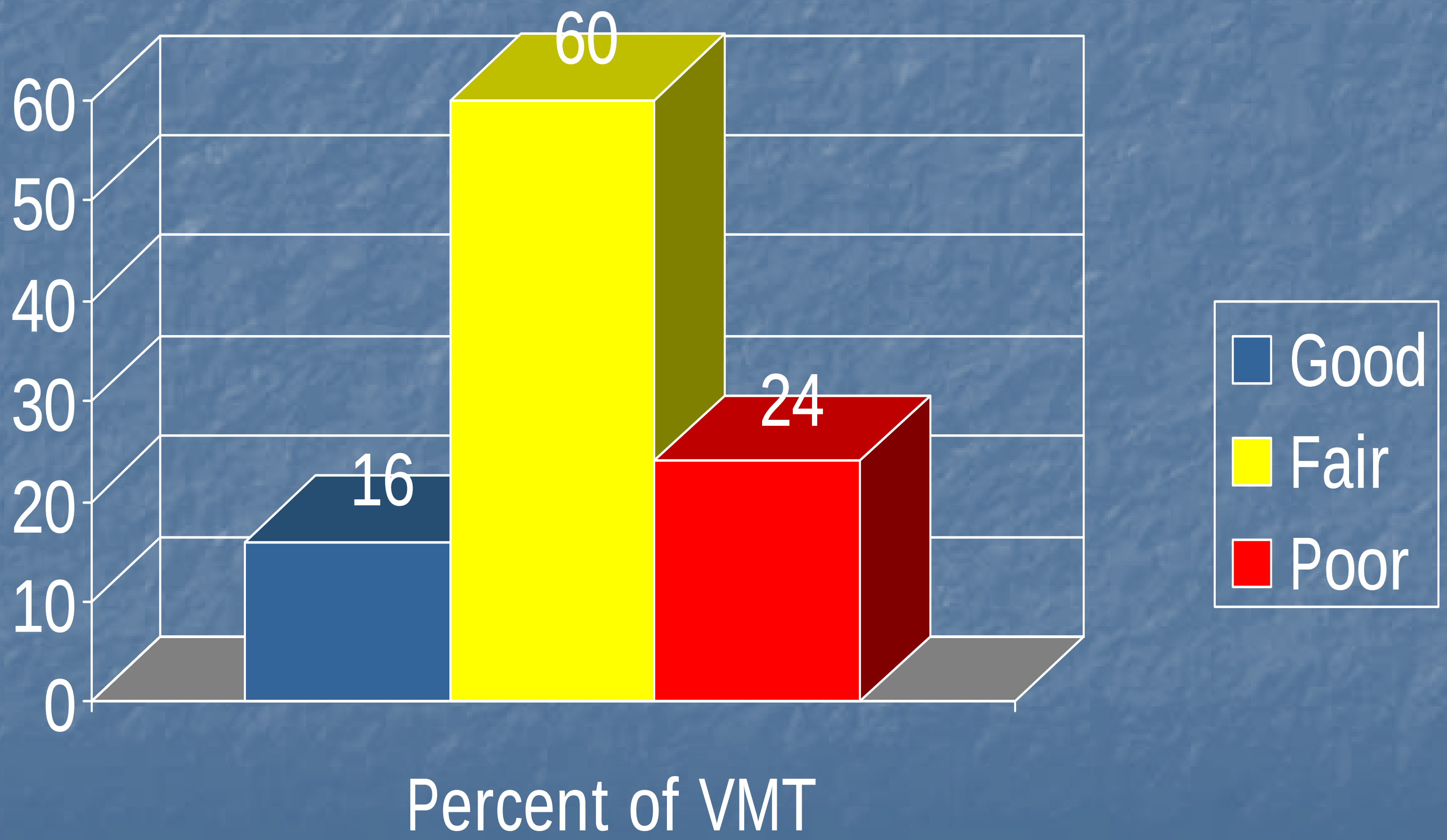
New Jersey's Interstate Pavements Rank 48th in the Nation **(Ref: Trip Report 2003)**

Chart 5. Five States With Highest Percentage of Interstate Pavements in Poor Condition, 2001

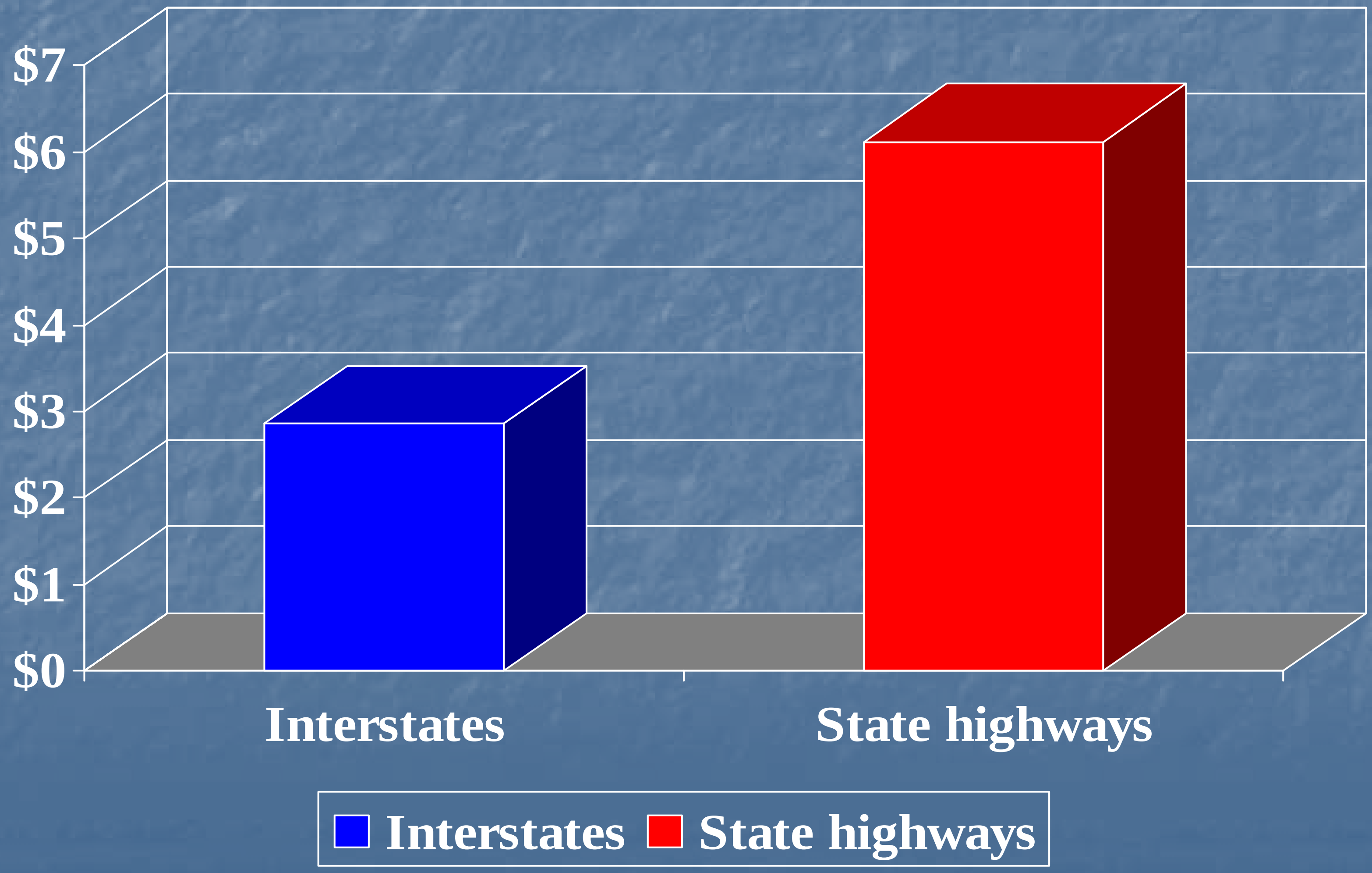
	PCT. POOR	MILES OF POOR	TOTAL MILES
Delaware	28%	11	39
Arkansas	28%	179	647
New Jersey	17%	70	418
California	14%	349	2,455
Michigan	13%	166	1,239

Source: TRIP analysis of FHWA data

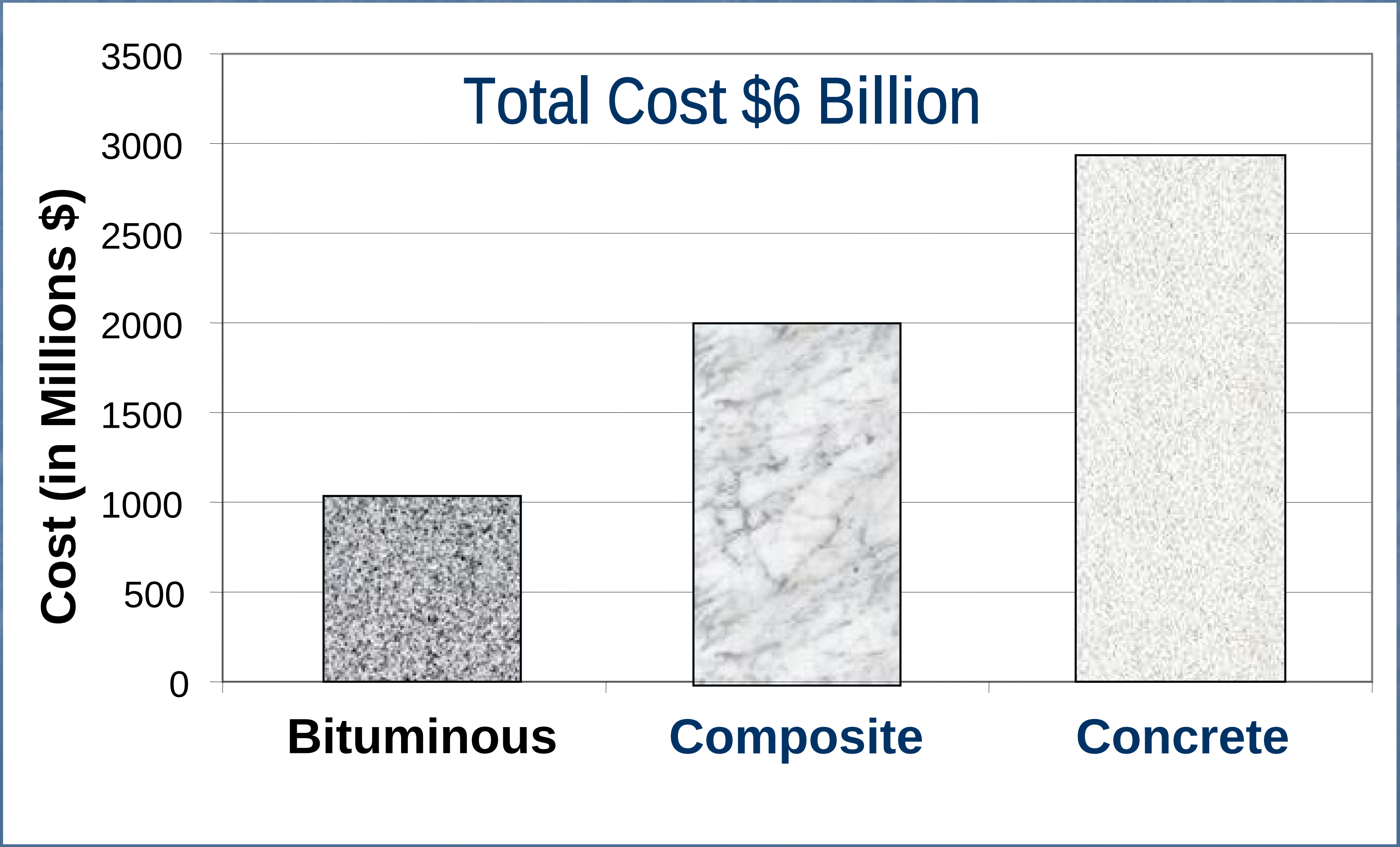
NJ STATE ROADWAY SYSTEM
IRI SMOOTHNESS RESULTS



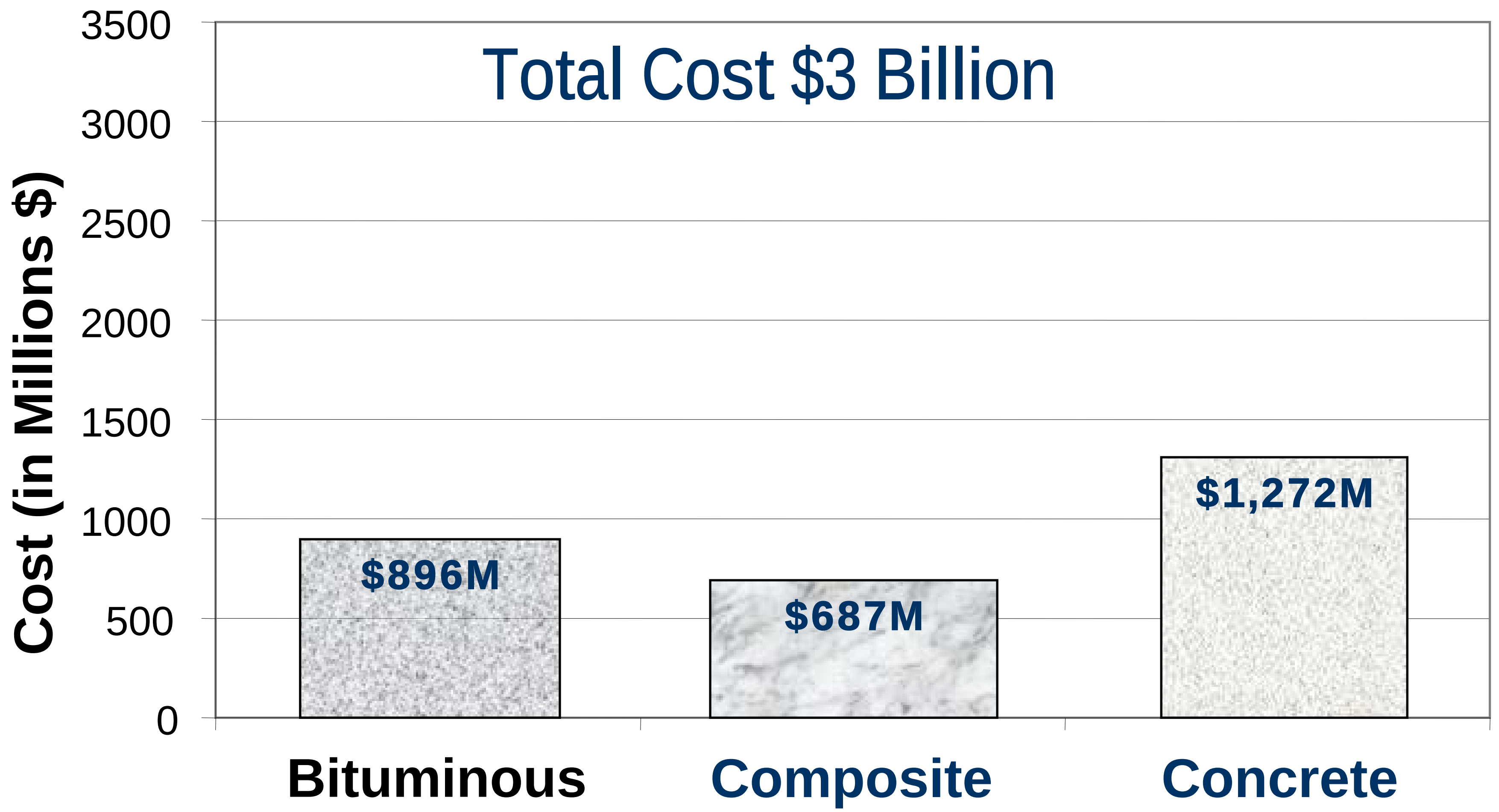
NJ 10 Year Pavement Needs Interstate and State Highways
(based upon FWD analysis)



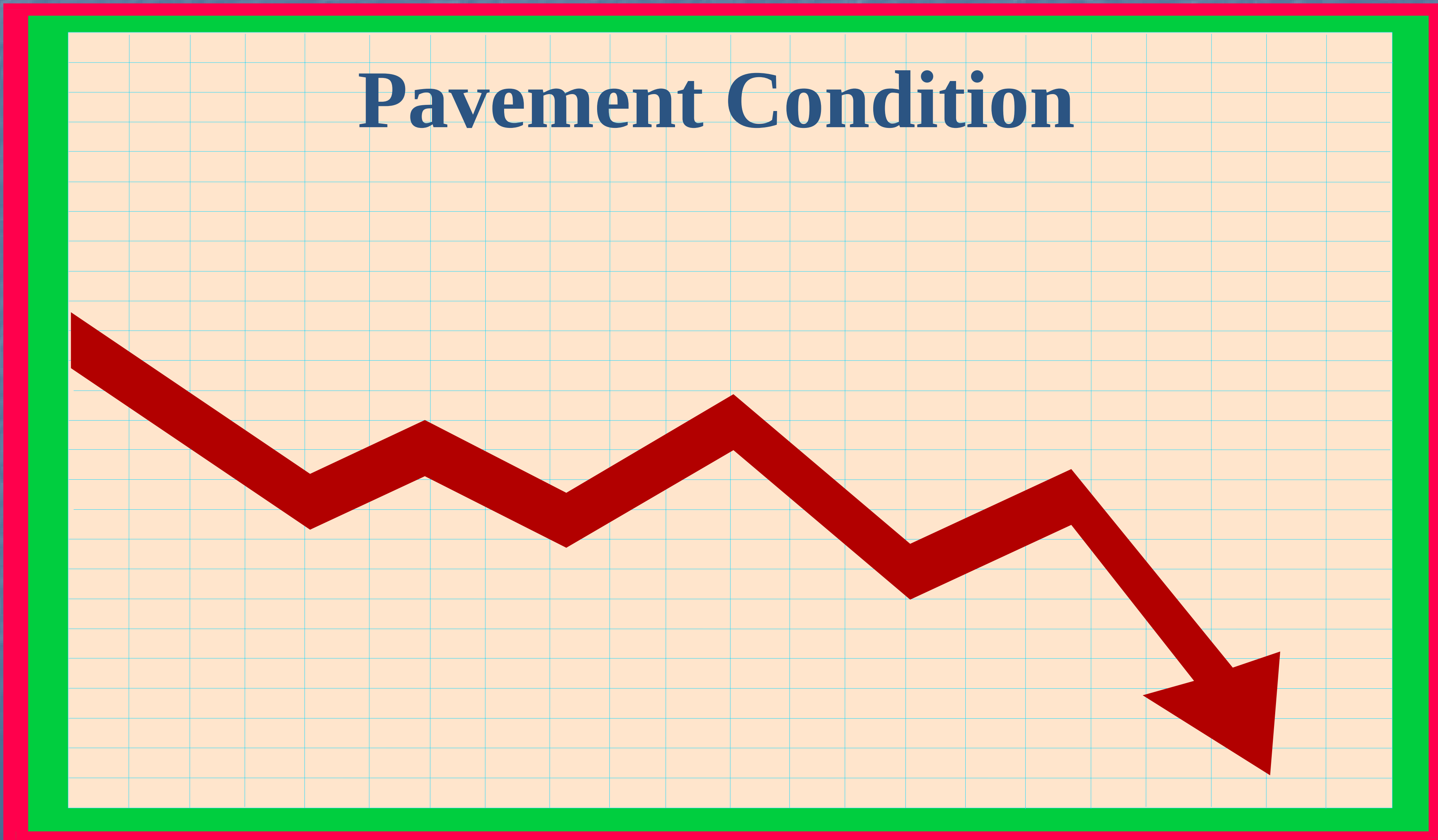
NJ State Highway Pavement Rehabilitation Needs



NJ Interstate Highway Pavement Rehabilitation Needs



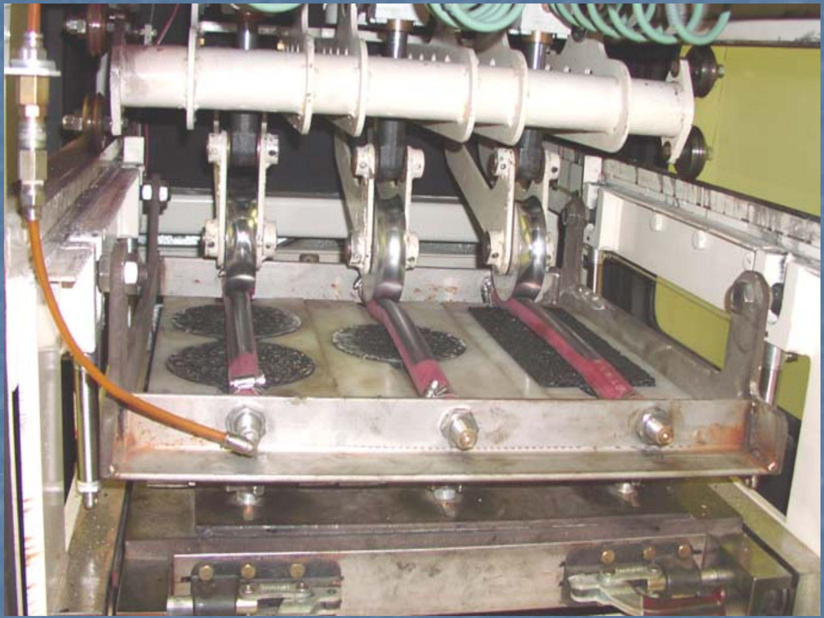
Business as usual will not work !



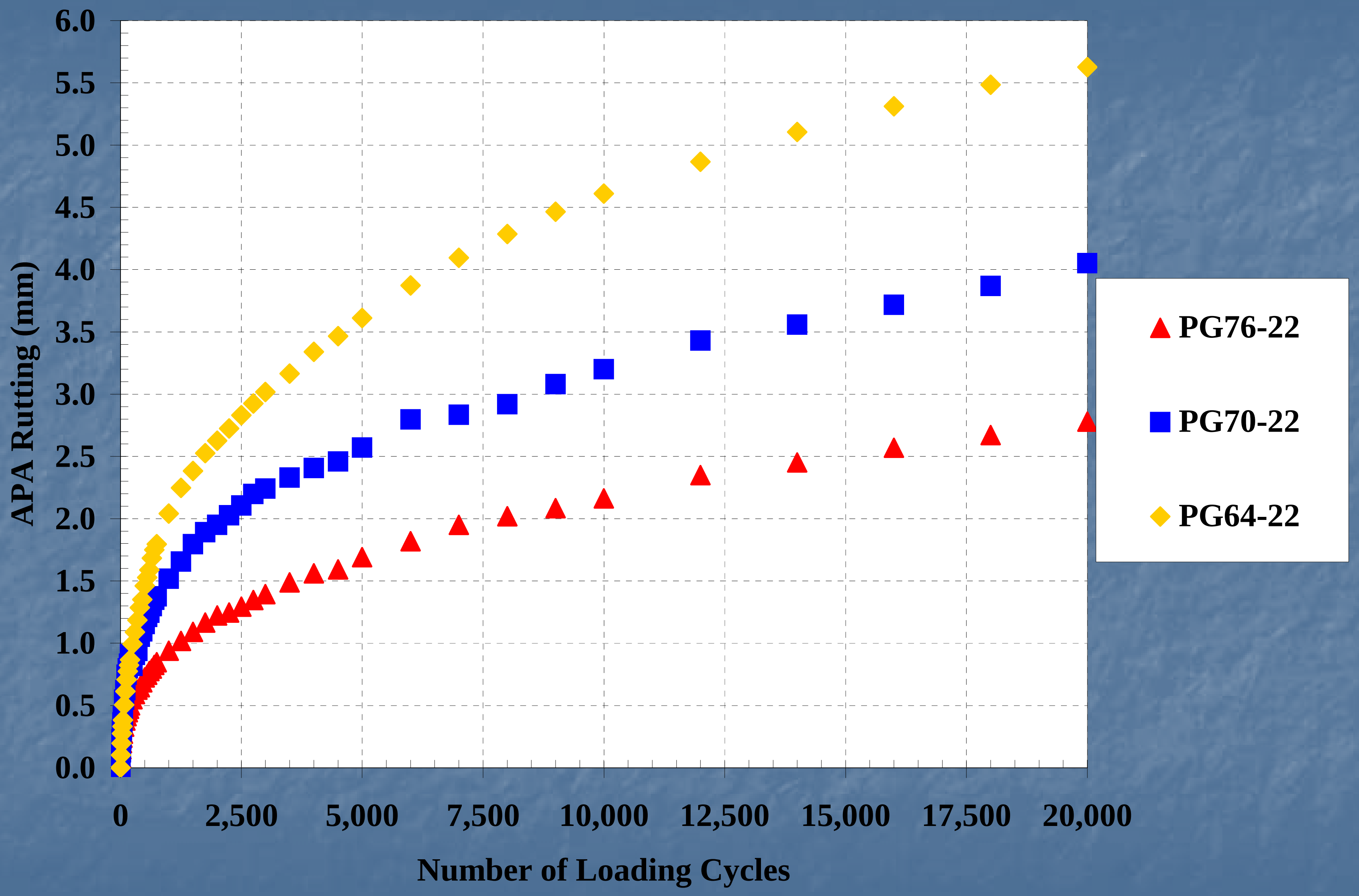
Why use polymer modified asphalt?

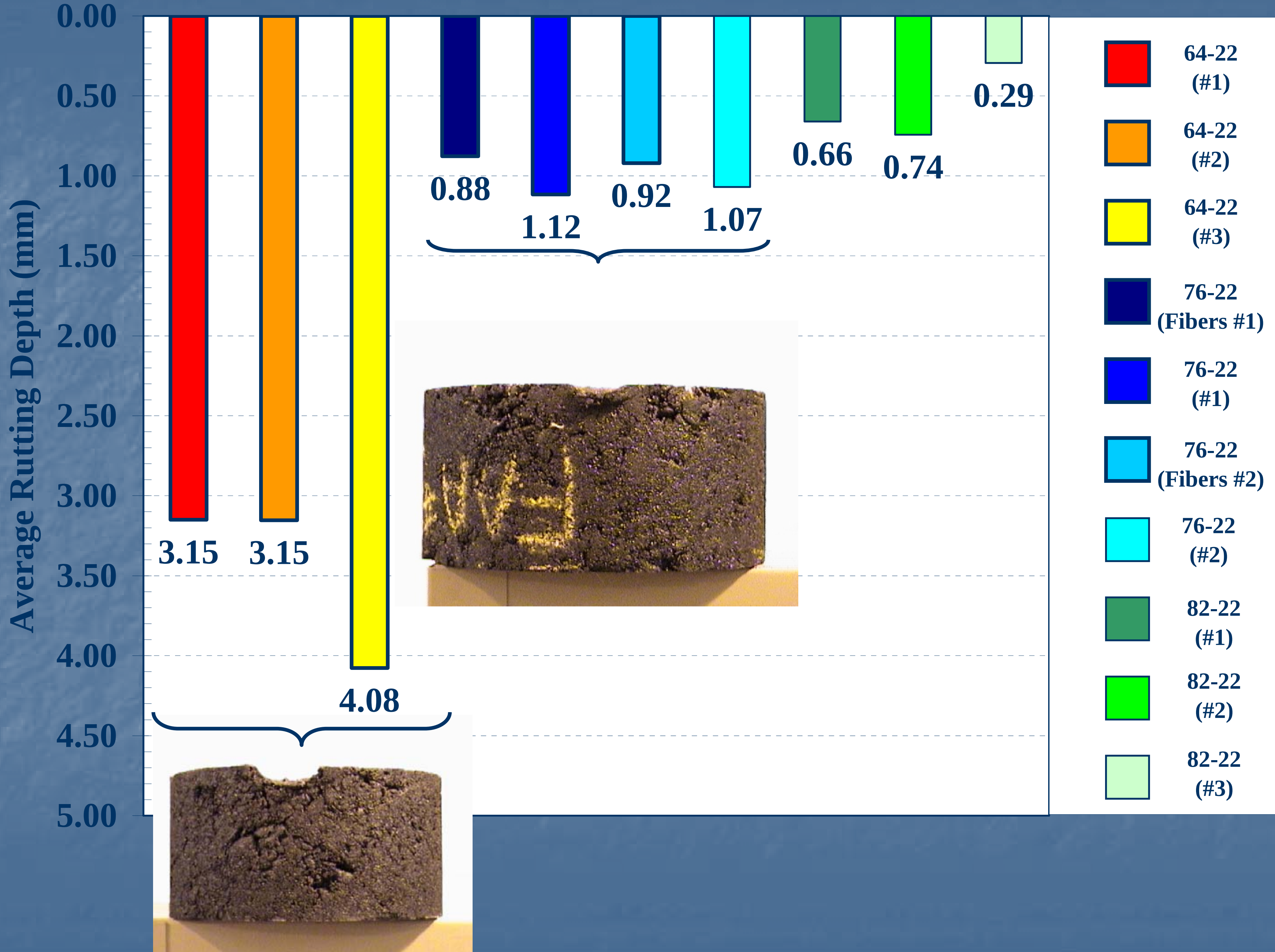
What we learned in the Rutgers lab

Asphalt Pavement Analyzer (APA)



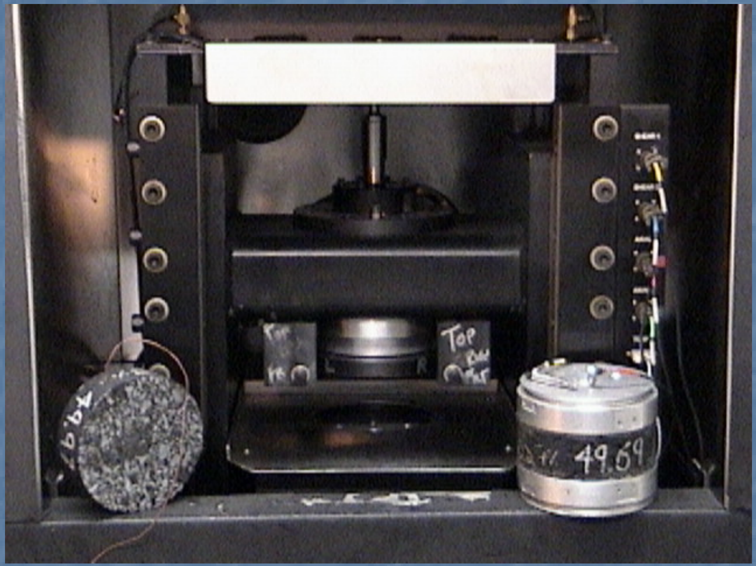
- *Moving wheel load (100 lbs) applied pressurized hose (100 psi) which lies on top of asphalt samples*
- *Tested at $64^{o}C$ for 8,000 loading cycles*

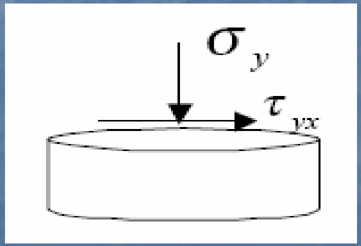

APA Rutting (mm)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2,500
5,000
7,500
10,000
12,500
15,000
17,500
20,000
Number of Loading Cycles
PG76-22
PG70-22
PG64-22

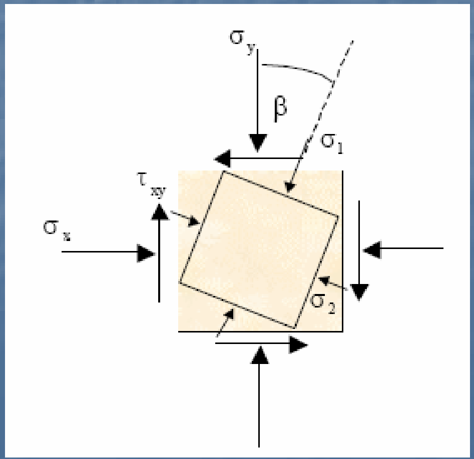

Average Rutting Depth (mm)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
3.15
3.15
4.08
0.88
1.12
0.92
1.07
0.66
0.74
0.29
64-22 (#1)
64-22 (#2)
64-22 (#3)
76-22 (Fibers #1)
76-22 (#1)
76-22 (Fibers #2)
76-22 (#2)
82-22 (#1)
82-22 (#2)
82-22 (#3)

Superpave Shear Tester (SST)

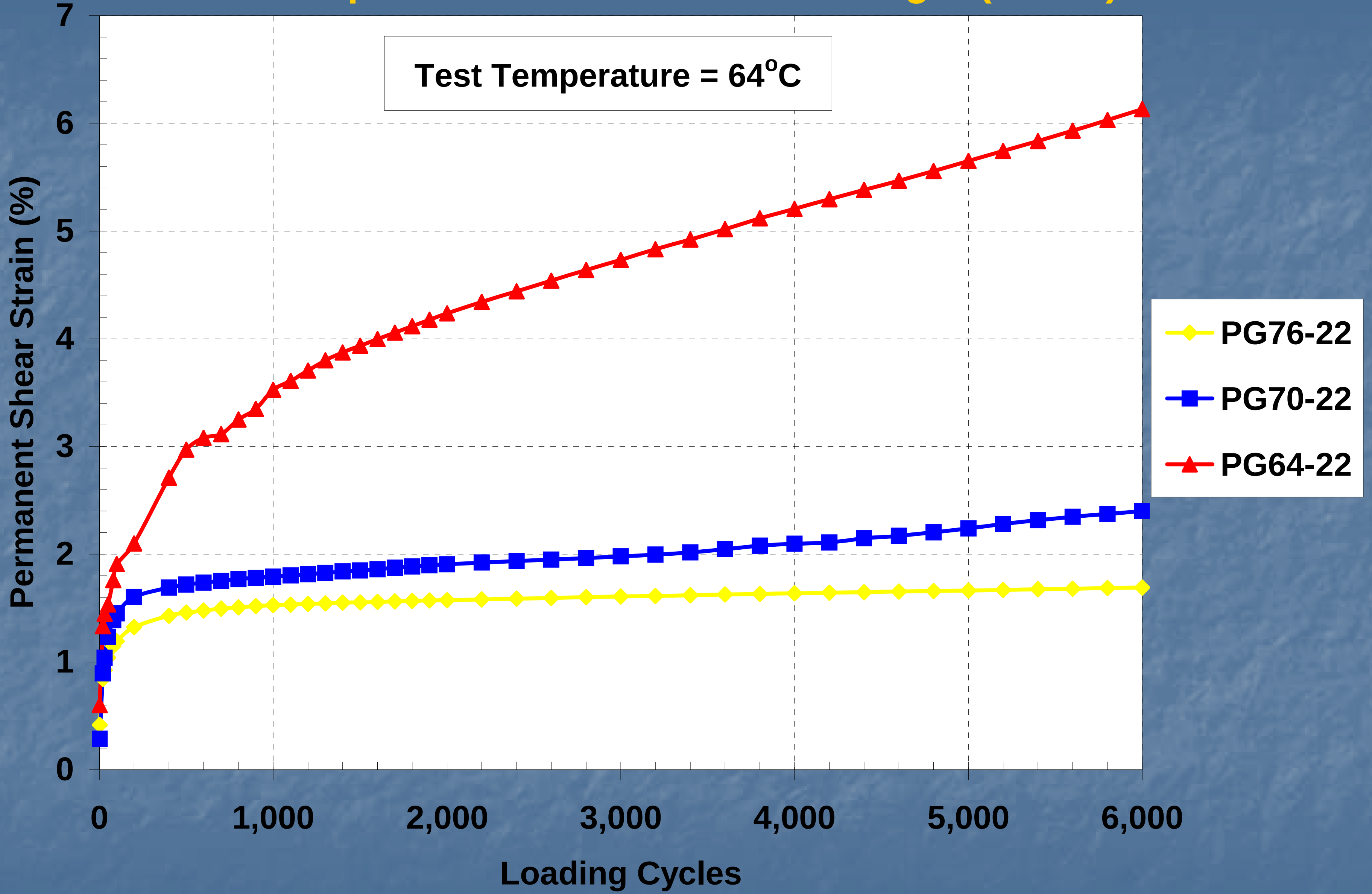
- Developed under the Strategic Highway Research Program (SHRP) for the performance evaluation of hot mix asphalt
- Provides an evaluation of the creep, stiffness and permanent deformation properties of hot mix asphalt at a wide range of temp.



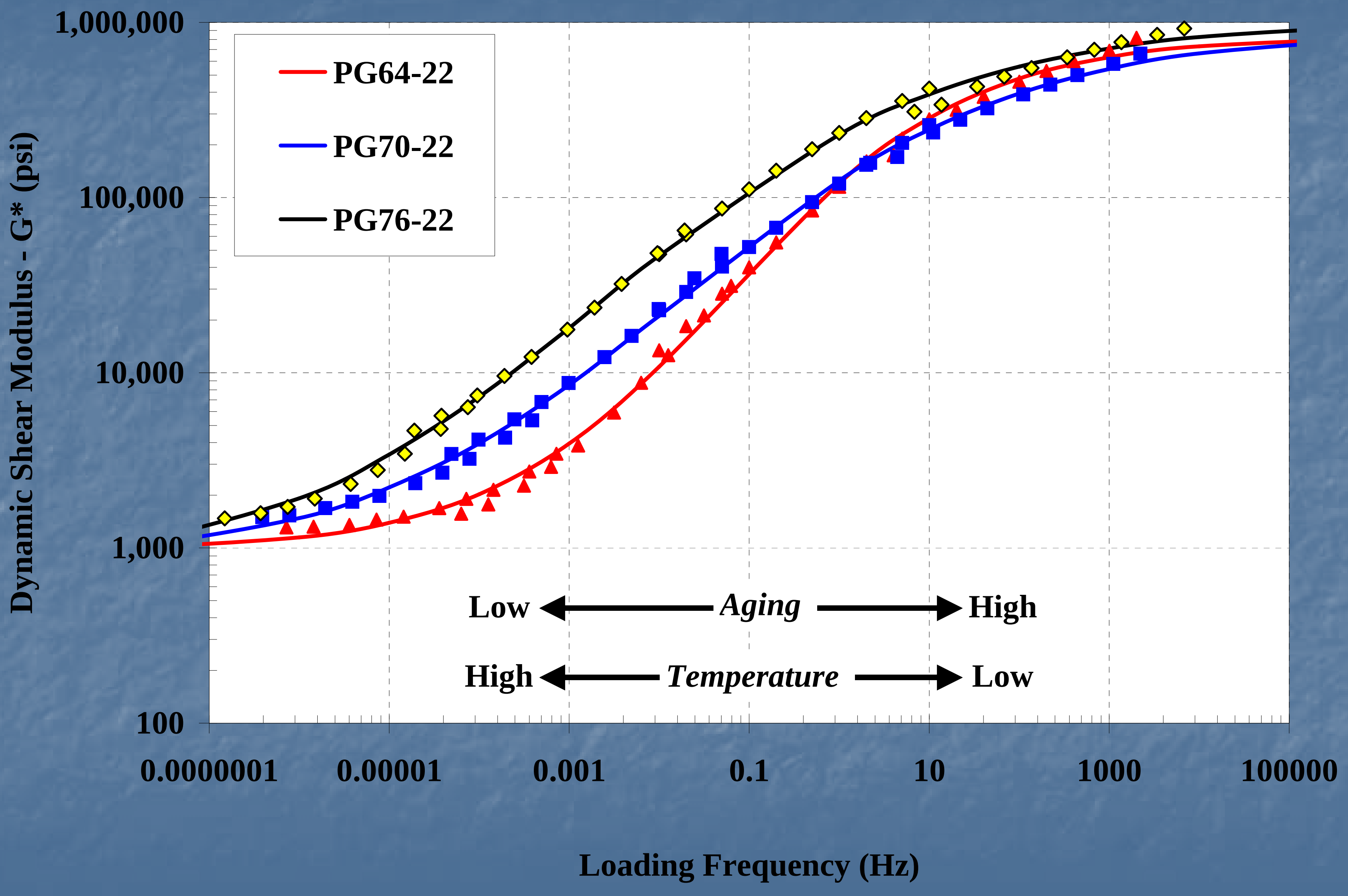




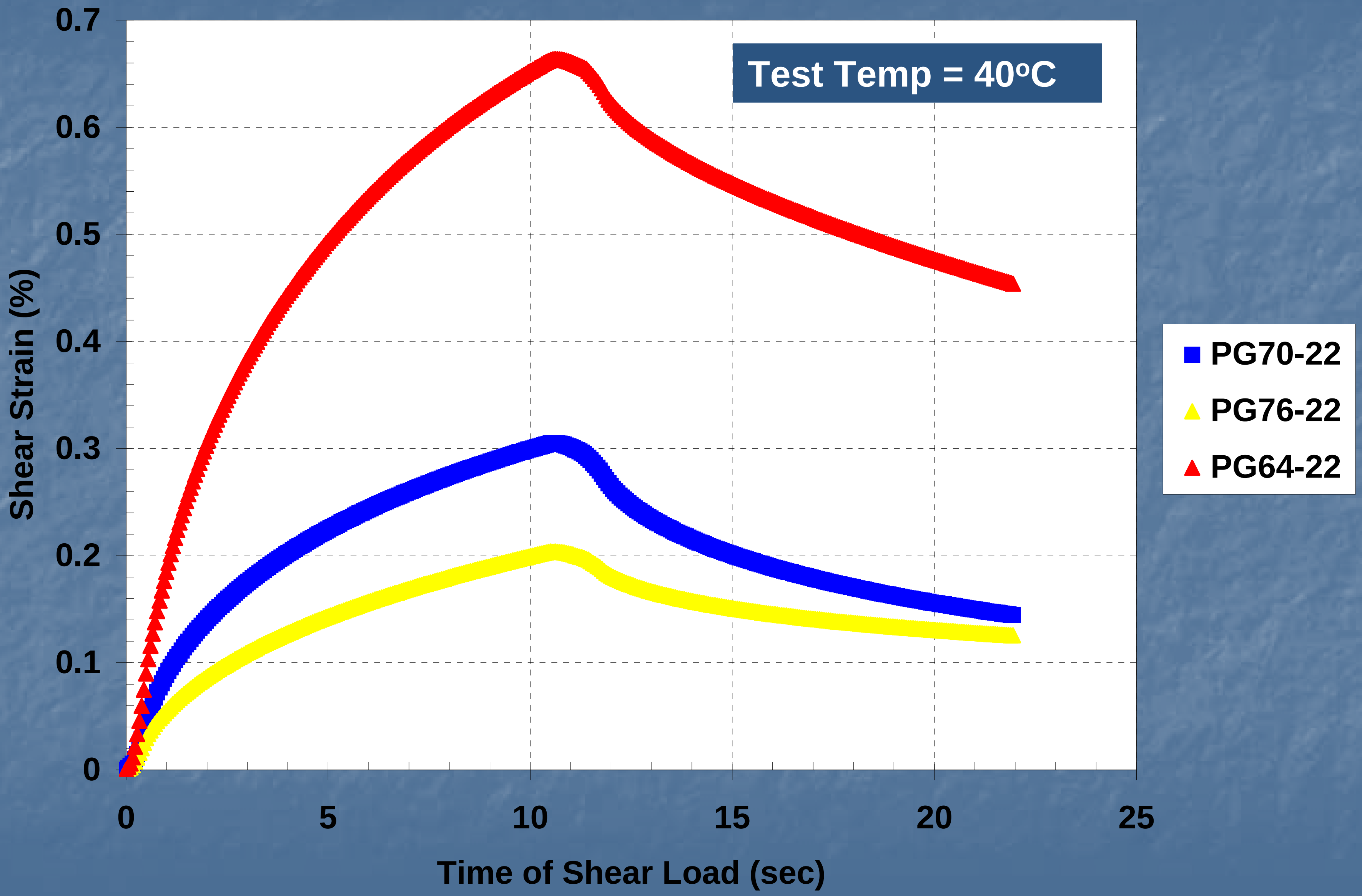
Repeated Shear at Constant Height (RSCH)



Frequency Sweep (Shear Stiffness) at Constant Height (FSCH)



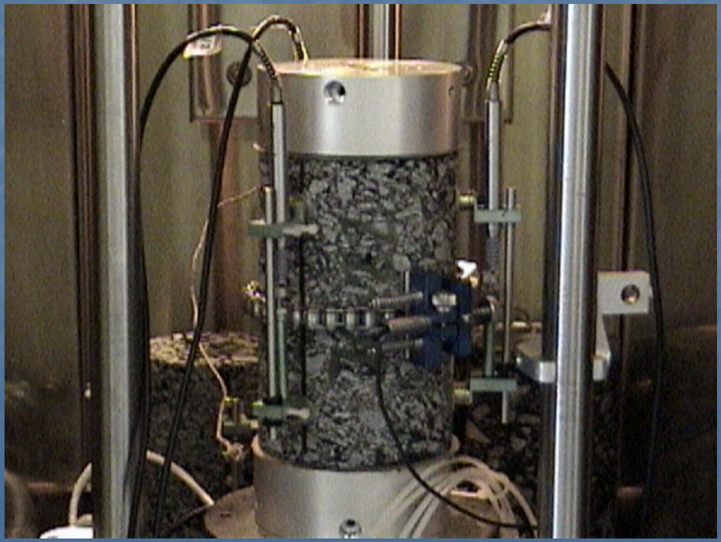
Simple Shear (Creep) at Constant Height (FSCH)

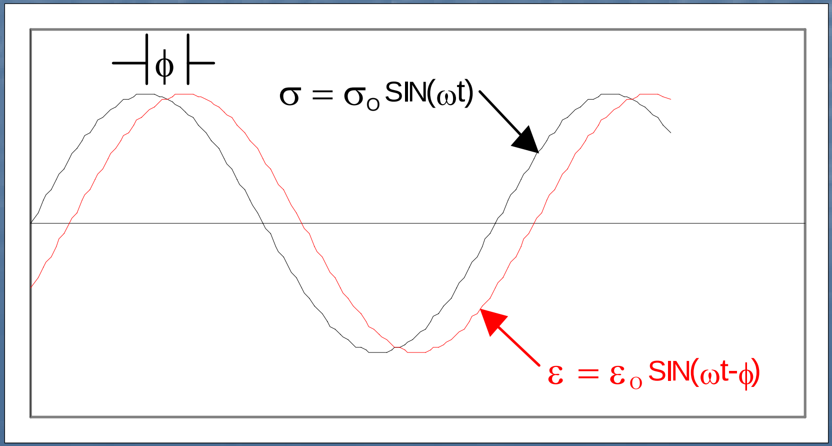


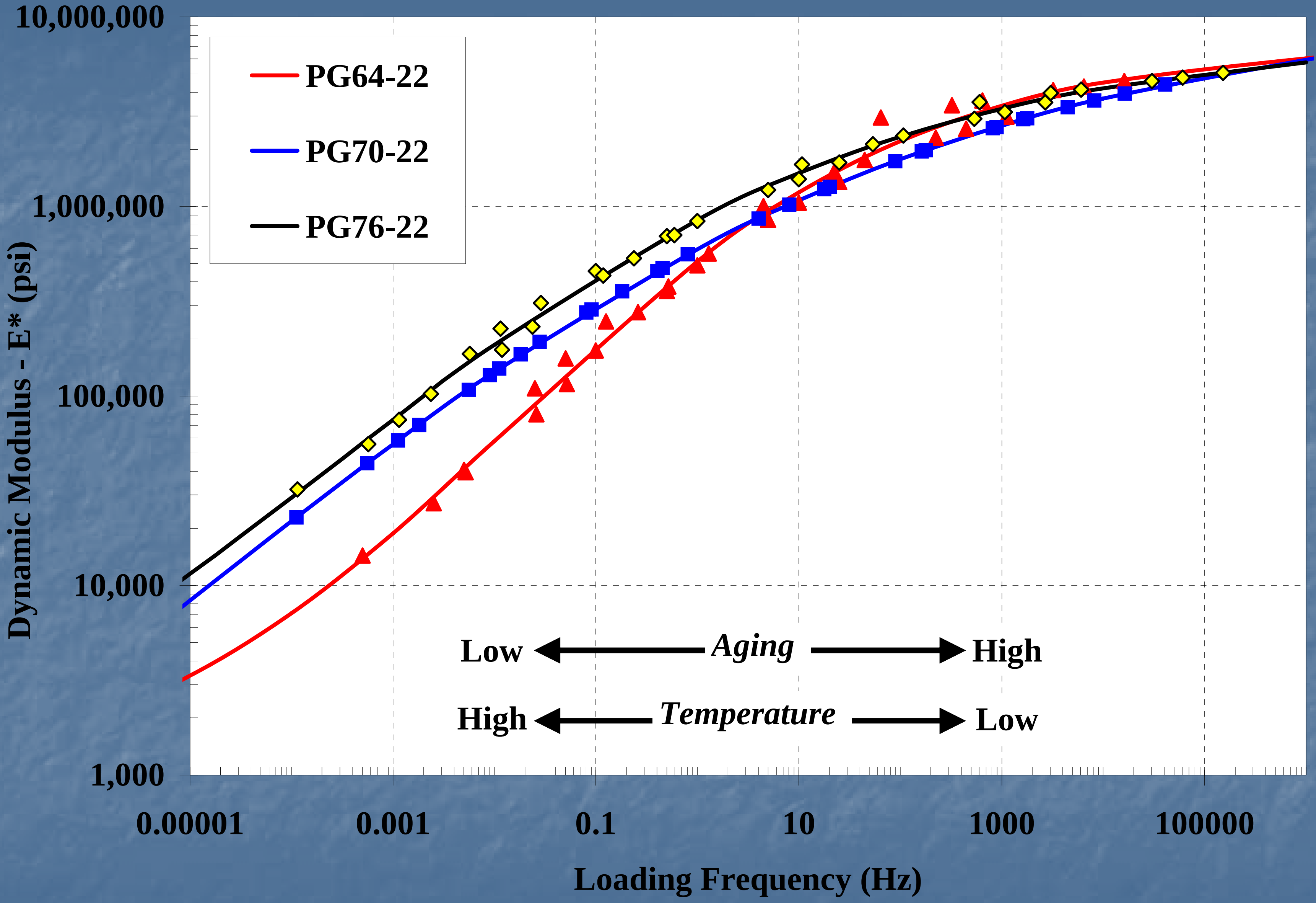
E* (Dynamic Modulus)

- Modified under current NCHRP research
- E* (dynamic modulus) defines the properties of a linear viscoelastic material subjected to sinusoidal loading
- Needed input for 2002 Mechanistic-Empirical Pavement Design Guide

$$|E^*| = \frac{\sigma_o}{\varepsilon_o}$$



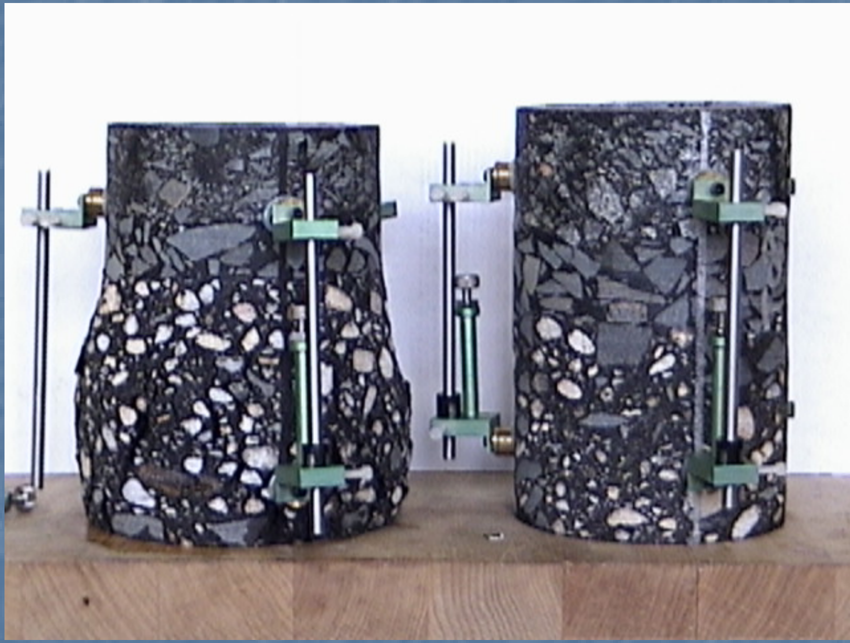


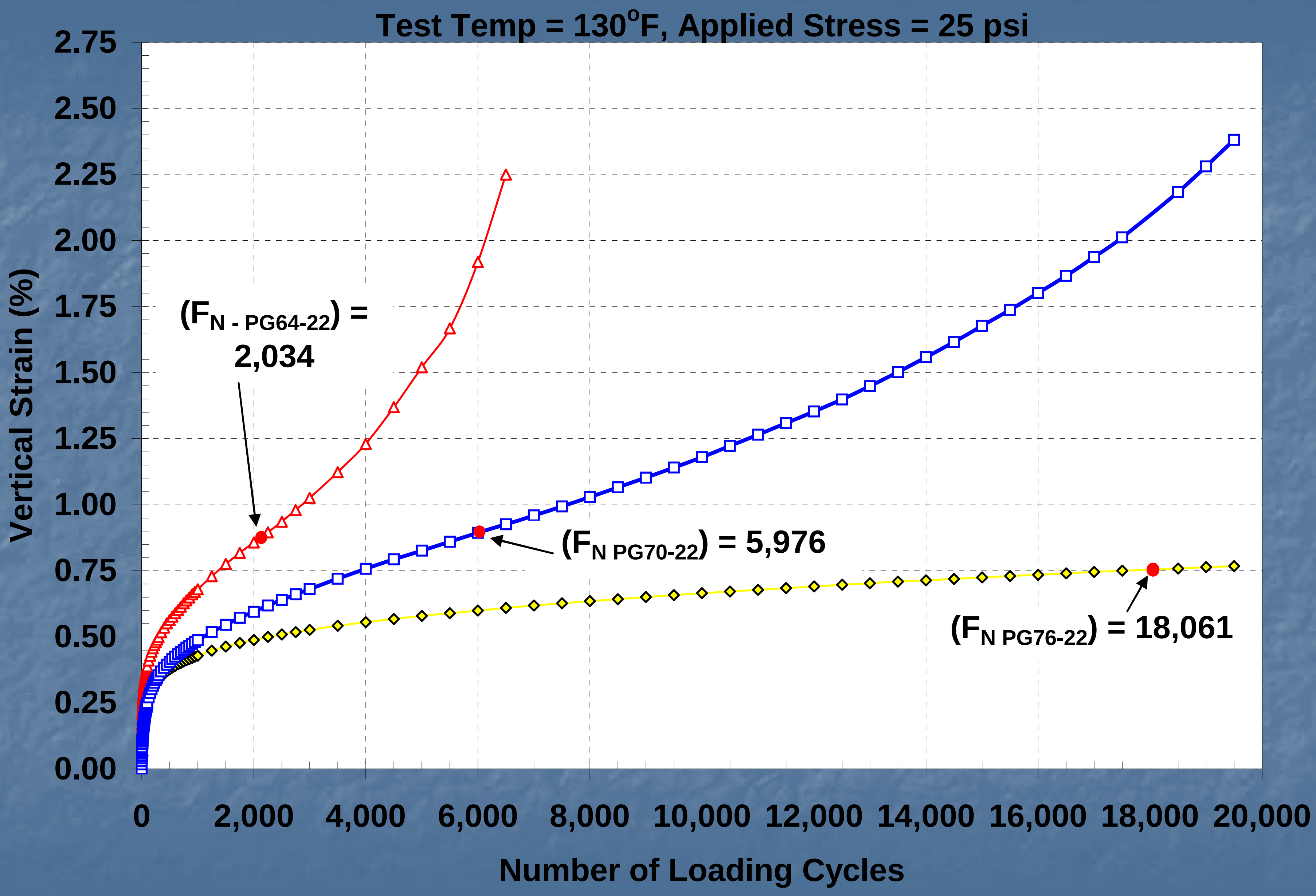


10,000,000
1,000,000
100,000
10,000
1,000
Dynamic Modulus - E* (psi)
PG64-22
PG70-22
PG76-22
Low
Aging
High
High
Temperature
Low
0.00001
0.001
0.1
10
1000
100000
Loading Frequency (Hz)

Simple Performance Test (SPT)

- Identical test set-up as dynamic modulus
- Consists of applying either a cyclic load or creep load and determine the time for tertiary flow (failure)
  - Typical test times
    - 3 hours per sample or until failure
  - Cyclic testing provides calibration parameters for rutting in 2002 Mechanistic-Empirical Pavement Design Guide

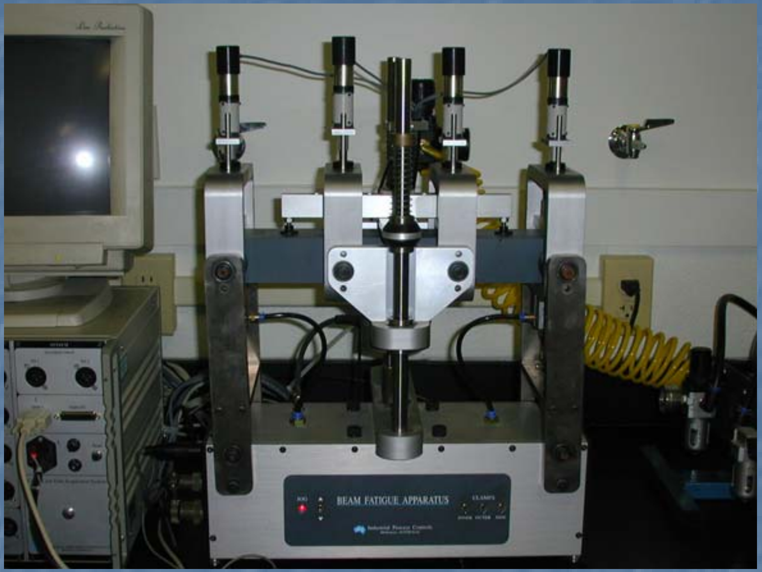


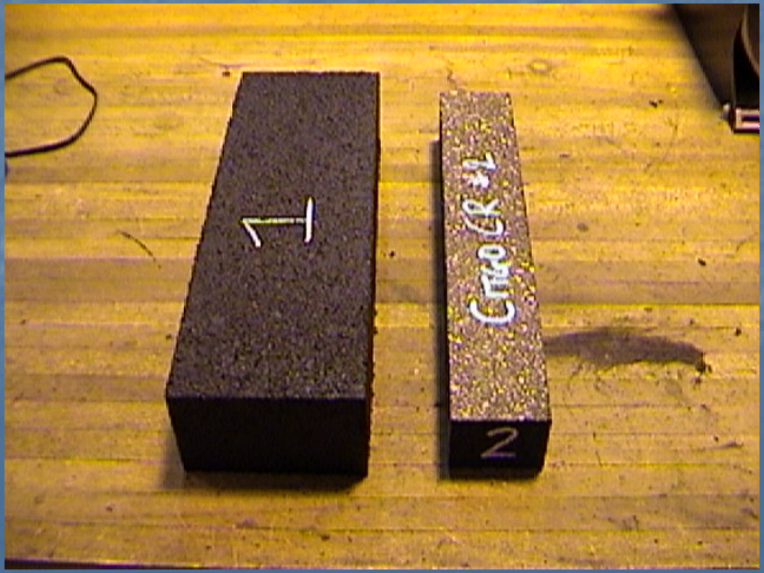


Test Temp = 130°F, Applied Stress = 25 psi
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Vertical Strain (%)
(FN - PG64-22) =
2,034
(FN PG70-22) = 5,976
(FN PG76-22) = 18,061
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
Number of Loading Cycles

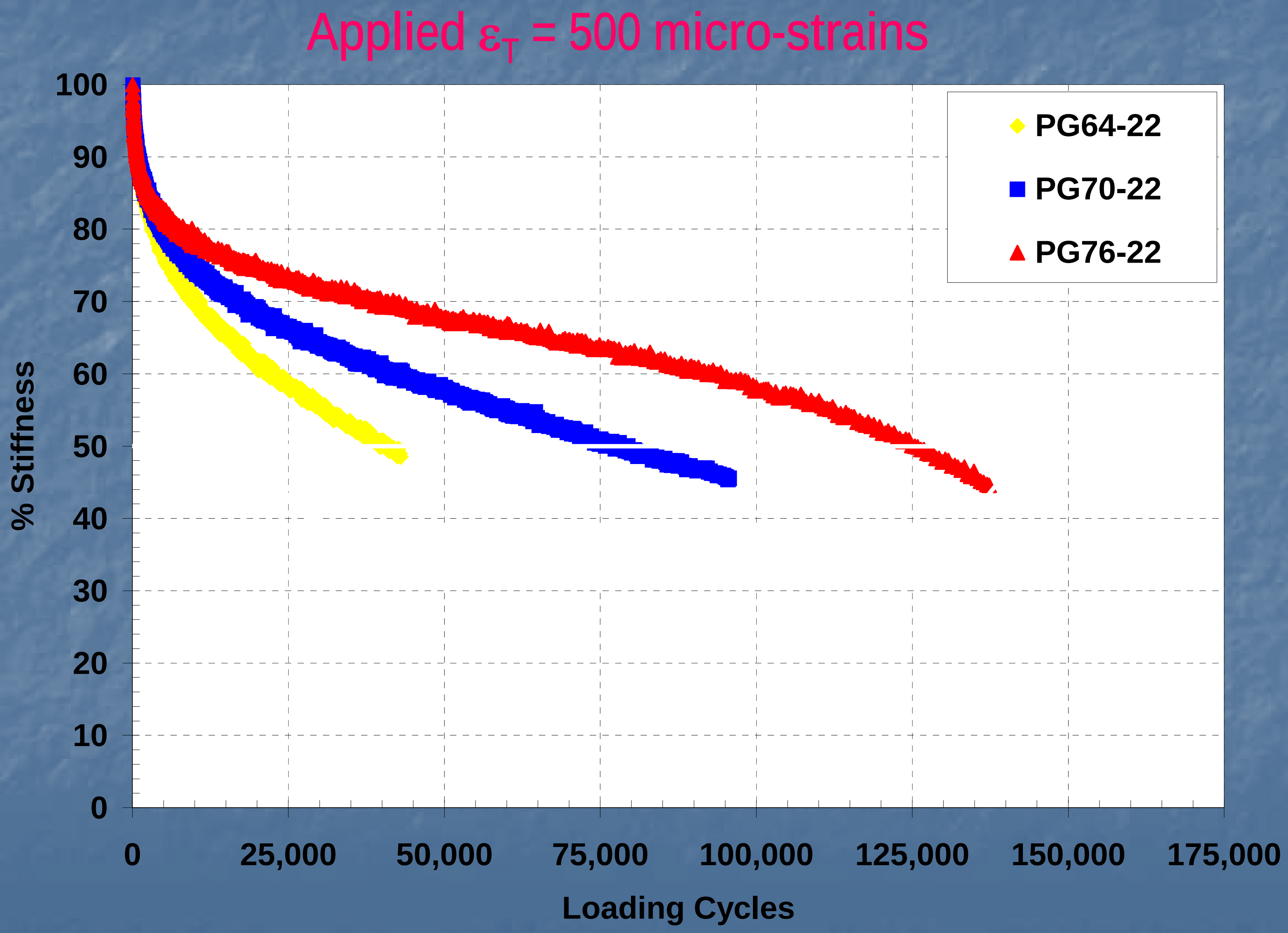
Flexural Beam Fatigue Device

- Evaluate the fatigue properties of HMA compacted beam samples
- Test under variety of stress and strain conditions, as well as temperature
- Parameters used to calibrate models in AASHTO M-E Design Guide





Example of Fatigue Results

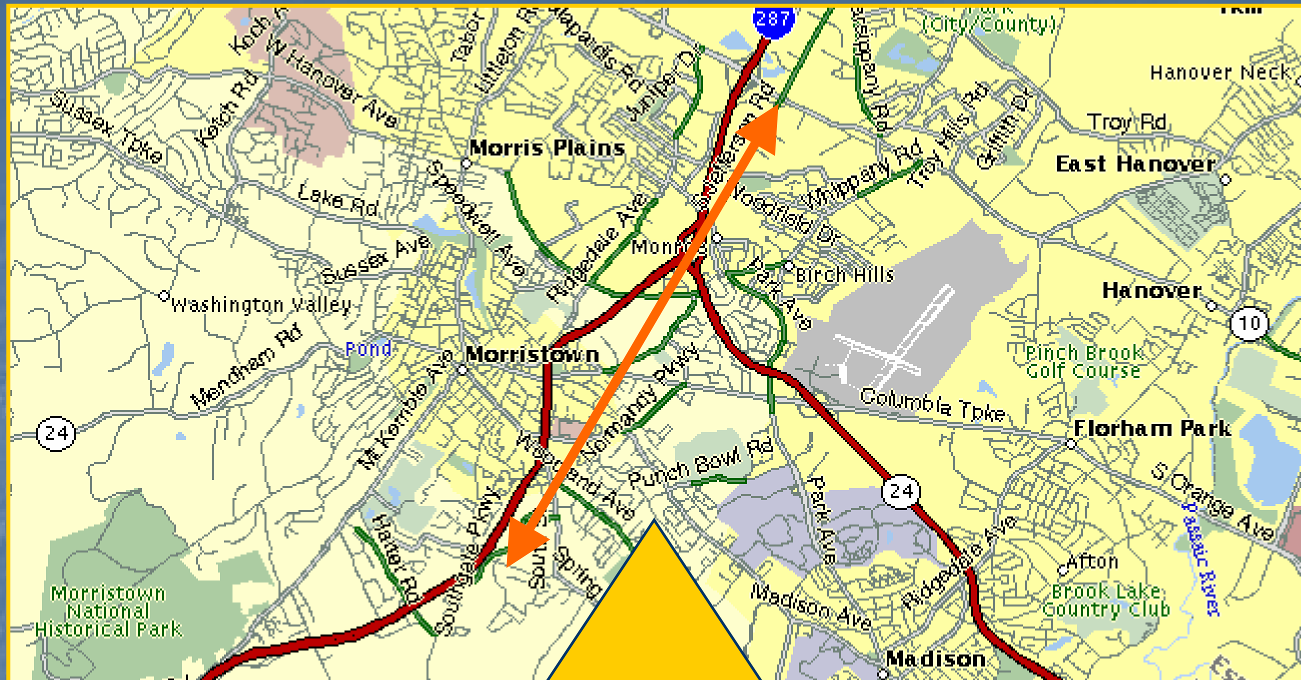


Where NJDOT has used Polymer Modified Hot Mix Asphalt

- Case Histories- major success stories
  - Route I-287 Morris County
  - Route I-78 Somerset County
  - Route I-295 Camden & Burlington

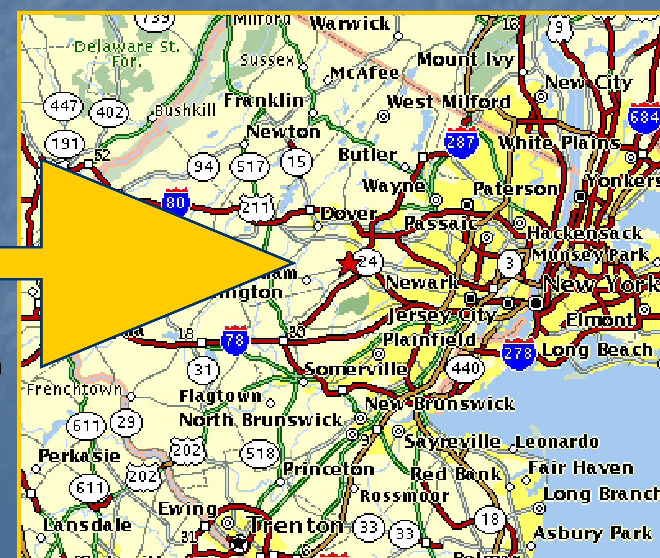
Rt. I-287 MP 35.5 - 38.8

- North/South highway that provides a western bypass around NY City
- 3 major east/west highways intersect at this location: Rt. I-80, Rt.10 and Rt. 24
- Restricted roadway geometry: urban location in the town of Morristown
- 24,000 trucks/day (2 way)
- First Major Polymer Project for NJDOT



Project Location

- Initial construction 1968
- Rehab design 1993



Rt. I-287 Project Objective

- Construct a HOV lanes to coincide with the opening of I-287 to the north
- Rehabilitate pavement structure with minimal impact to roadway profile
- Provide a long life, rut resistant pavement
- Maintain existing number of travel lanes during all peak traffic hours

Rt. I-287 Pavement History

- Existing Pavement Composition
  - 3” HMA Surface Course
  - 7” HMA Base Course [stone mix]
  - 8” Crushed Stone Base [dense graded]
  - 10” Subbase [graded sand]
- No rehabilitation up to this point

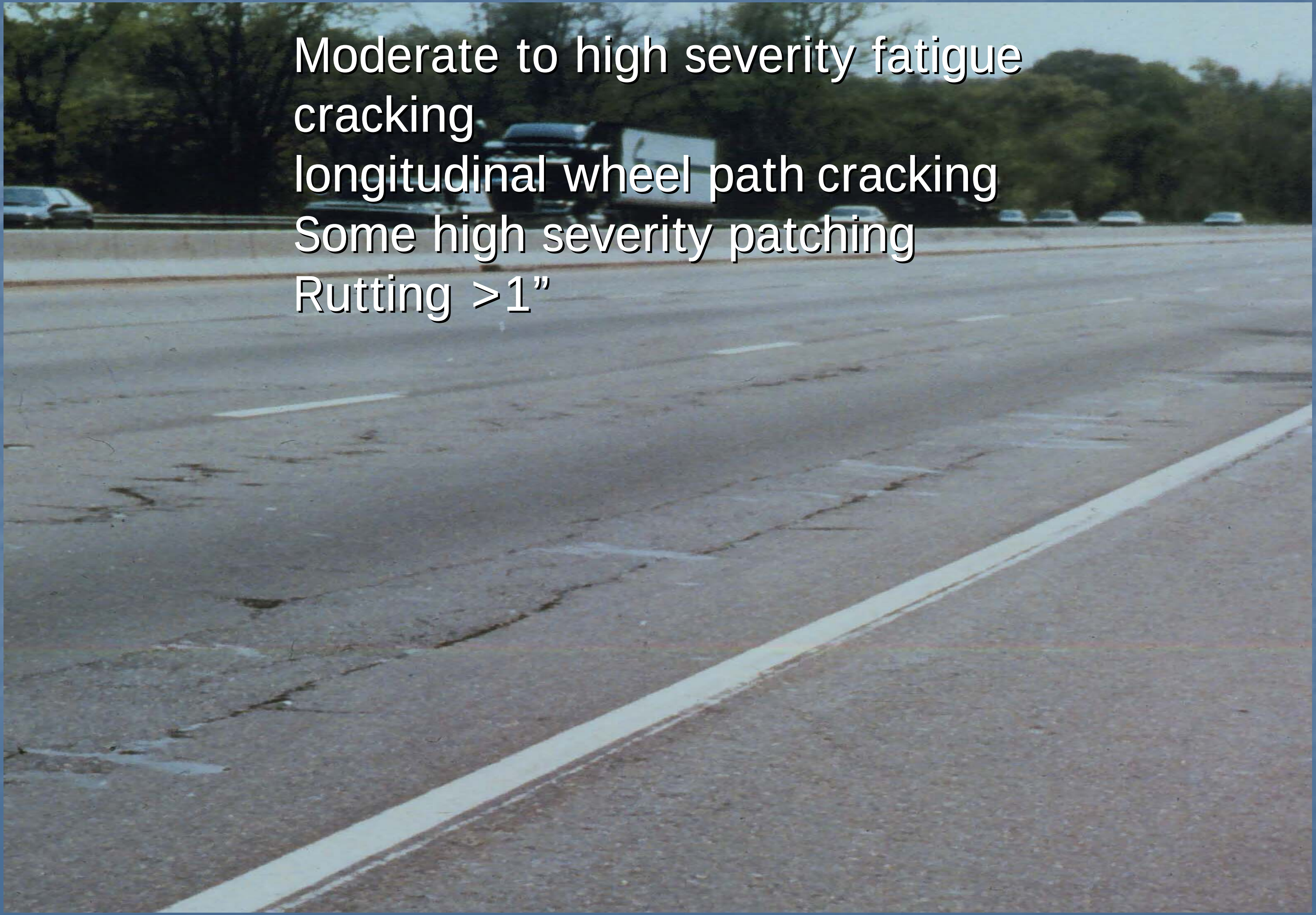
Rt. I-287 Design Data

- Design Data
  - 1993 ADT_2 = 110,190
  - 2013 ADT_2 = 170,830
  - 22% Total Trucks, 9% Heavy Trucks
  - 20 year ESALs = 50,000,000+
  - Slow/standing loads due to periodic traffic congestion

Rt. I-287 Design Data

- Pavement age 26 years
- Subgrade soil: silty sand
- Frost penetration 36 inches
- 75,000 tons HMA surface mix (polymer)
- 225,000 tons HMA base mix (AC-20)

Rt. I-287 Surface Appearance



Rt. I-287 Pavement Coring

- Initial indications were that cracks penetrated through all bound layers
- Coring results
  - Cracks originated at surface with majority stopping at the base layer (3” depth)
  - Materials testing
    - 25 Pavement cores

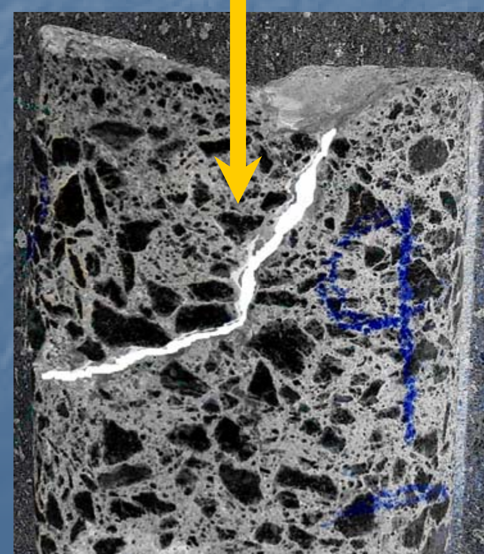
Penetration and Air Voids

REC. PEN	VOIDS
16	5.5%
40	4.9%
22	6.8%
25	9.3%

Example of Surface Cracking

PHOTOGRAPH
OF CORE

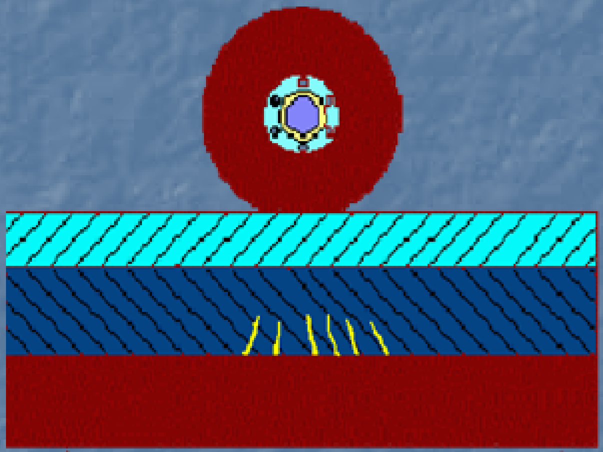
CRACK



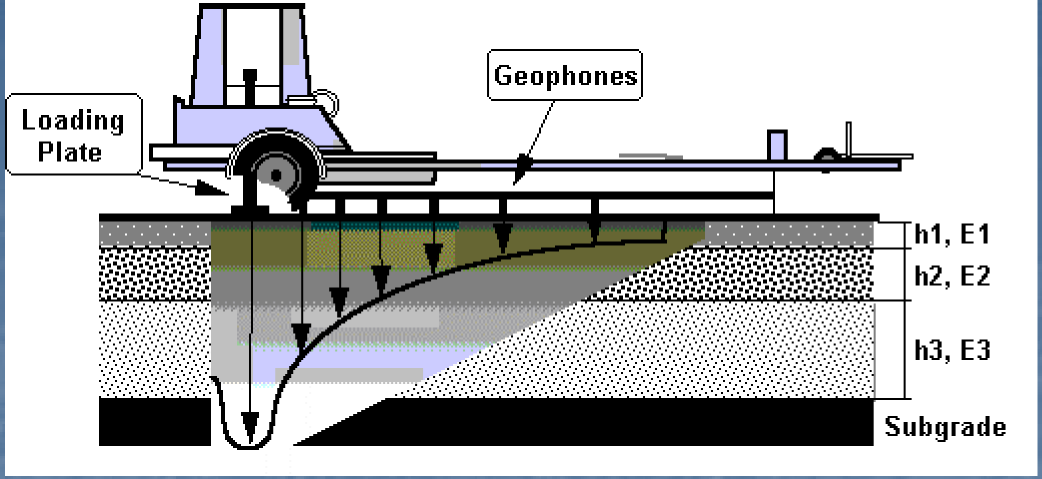
NEGATIVE
ENCHANCED
IMAGE

Pavement Models

- Classical Pavement Design
  - Fatigue Cracks Start at bottom
  - Pavement rutting controlled by sub-grade strain
- On Site
  - Extensively cracked pavement
  - Cracks restricted to top 3 inches
  - No cracks through entire layer



Typically cracks assumed to start here!



- FWD testing
  - Pavement structure generally good, slow lane S_n = 5.7
  - Deflection testing after milling S_n = 4.5
  - After resurfacing S_n = 7.6
- FWD and core analysis suggests that after removing distressed surface layers a structurally sound base will remain

Rt. I-287 1996 Pavement Rehabilitation

- Mill 3” depth (removes most cracks)
- Overlay
  - 2” HMA surface course polymer modified
  - 2” minimum HMA base course [stone mix]
  - Test area with 1200 tons of NJ’s first Superpave mix
  - Minimal modification needed to convert existing mixture to meet 12.5 mm Superpave requirements

Project Summary

- Adequate service life achieved with only a relatively thin mill and overlay
- Existing structural capacity 7,000,000 ESALs
- Rehabilitated structural capacity 69,000,000 ESALs
- Superpave mix not much different than NJDOT's current "I-4 HD" mix

I-287 Current Condition

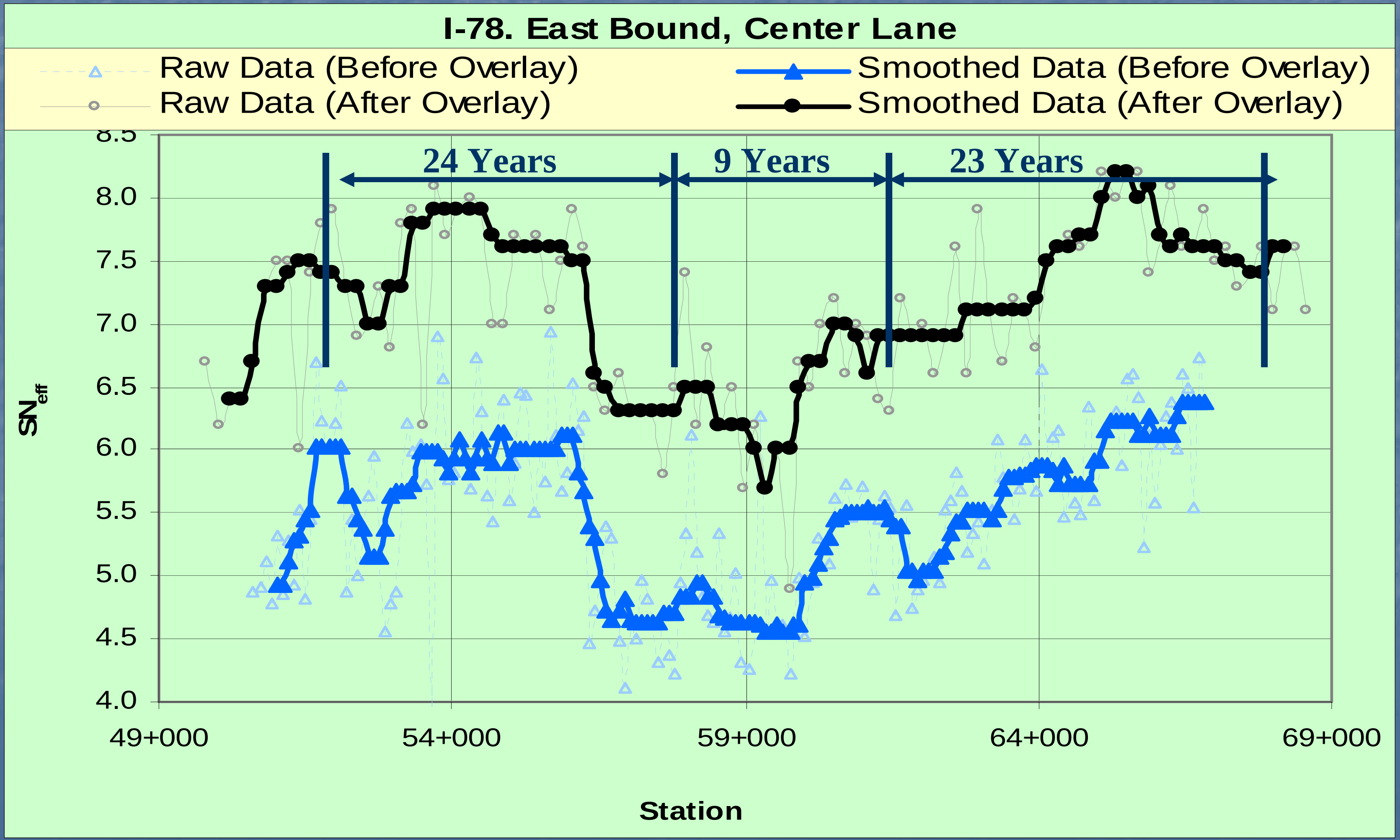
Route I-78 MP 30.5 - 42.7 History

- Constructed in 1970 (dead end)
- 6”-7” Hot Mix Asphalt
- 9”-13” crushed stone base (Research)
- 12”-14” granular subbase
- Resurfaced in 1986 (mill 2”, resurface 6”)
  - Recycled a poor quality aggregate
- Raveling investigation (visual survey & coring): Jan 98
- Core recovery: 1.5”-12” HMA

Route I-78 EB MP 30.5- 42.7

- Initial design: mill 2” pave 4” as interim repair
- 2” Superpave 12.5 mm PG 76-22 Surface Course
- 2” Superpave 19 mm PG 76-22 Intermediate
- FWD added to construction contract
- Incorporation of FWD:
  - Elastic modulus of HMA (E_{AC})
  - Subgrade resilient modulus (M_R)
  - Effective structural number (SN_{eff})
  - SN_{eff} profile of project
- I-78 WB Resurfaced 1999

FWD Results
Pavement Evaluation
Route 78 EB
MP 30.5 to MP 42.7



Route I-78 Conclusion

- 12 mile segment that was assumed to need complete reconstruction successfully rehabilitated with mill and pave
- Both EB & WB projects currently in excellent condition
- Recommended for crack sealing in 2004 to seal longitudinal “cold” joints

Route 295
MP 32 to 41

- **9 miles (PCC)**
- **3 lanes and 1 shoulder in each direction**
- **NDT performed:**
  - **Fwd**
  - **DCP**
  - **PSPA (bridges)**
  - **Pachometer**
  - **Half-cell**

Rt. I-295 Typical Pavement Distress in Southern Segment

- Project bid fall 2002, spring 03 start
- $57,638,305.80 low bid
- 262,000 tons PG 76-22 HMA
- 352,000 tons PG 64-22 HMA (95,000T ASOG)
- 446,099 SY of Subgrade Geotextile
- 168,077 LF of Underdrains
- Reconstruct, Rubblization & CPR + 5” HMA

2002 Mechanistic-Empirical Pavement Design Guide

- Distress Simulations (Rutting & Alligator Cracking)
  - New Jersey climate
  - AADT = 80,000
  - 33% trucks
    - 23% light trucks
    - 10% heavy trucks

Route 295 Rehabilitation
NB & SB MP 32.0 to MP 41.0
Camden and Burlington Counties

- Existing Pavement Section:
  - three 12-ft pccp lanes each direction
    - 9-in pcc slab on 12-in subbase
    - Constructed 1961-1964
  - 12-ft HMA outside shoulders
  - 3 to 5-ft wide inside shoulder

Route 295 PCCP DATA

- MP 32 to 37 “fair to poor” Surface Distress Index (SDI)
  - Average Crack Density 227 cracks/mile
- MP 37 to 41 “good” SDI
  - Average Crack Density 18 cracks/mile

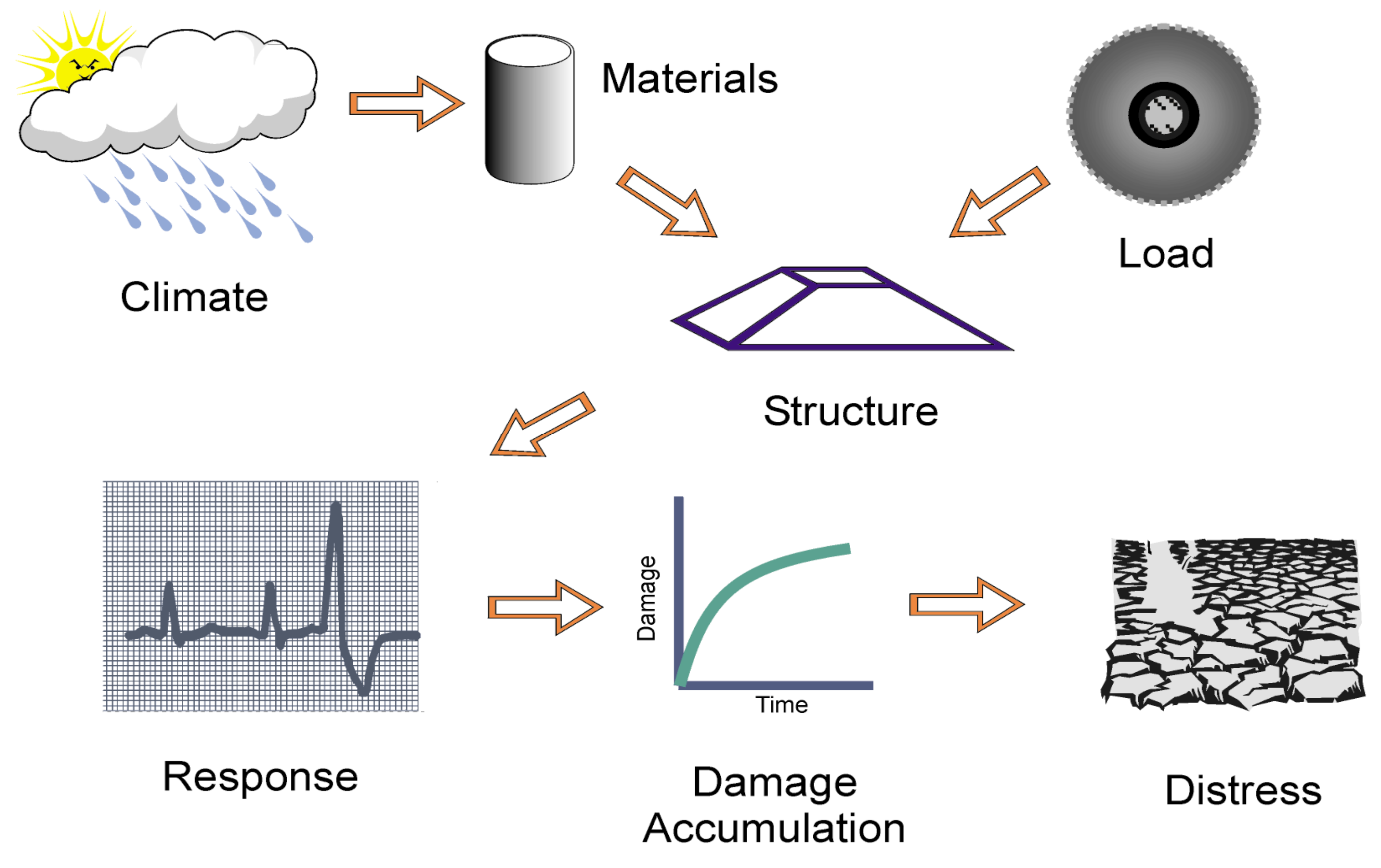
Pavement Design Criteria

- Maintain All Travel Lanes During Rehab
- Maximize Recycling of Existing Materials
- Rapid Reconstruction and Long Life
- Perpetual Pavement
- Lowest Life-Cycle Cost & Easy Maintenance
- Improve Surface Characteristics
- 33% Total Trucks, 10% Heavy Trucks
- 46 Million ESALs, 90,000+ ADT

Route 295 Pavement Evaluation

- FWD at Transverse Joints & Mid-Slab
- Visual Condition Survey
- Pavement Cores
- DCP Testing of Unbound Pavement Layers
- Compressive Strength on 20 pccp cores
- Hollow Stem Auger Borings
- Sieve Analysis & Atterberg Limits

AASHTO 200X Design Guide
(Mechanistic-Empirical)



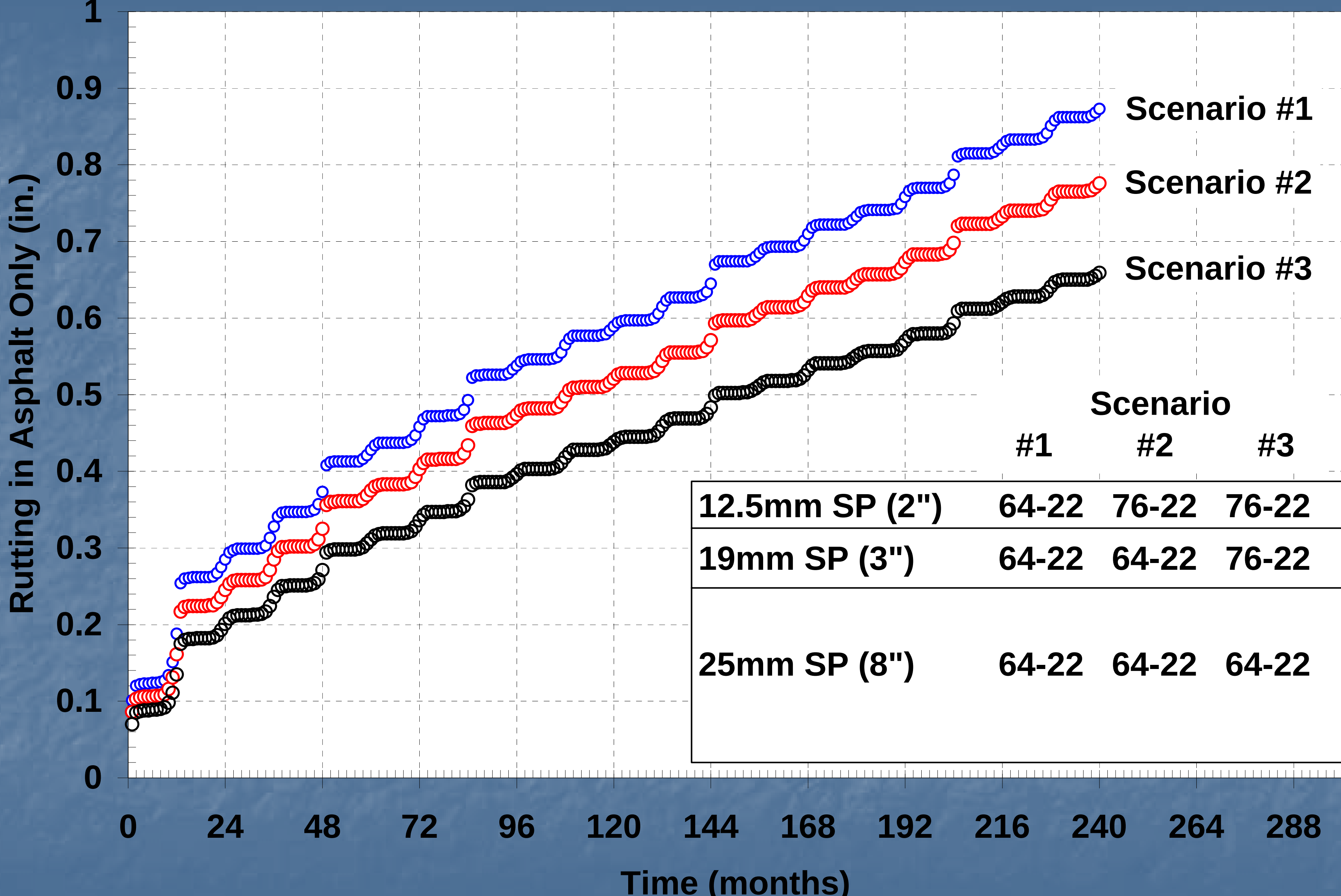
2002 Mechanistic-Empirical Pavement Design Guide

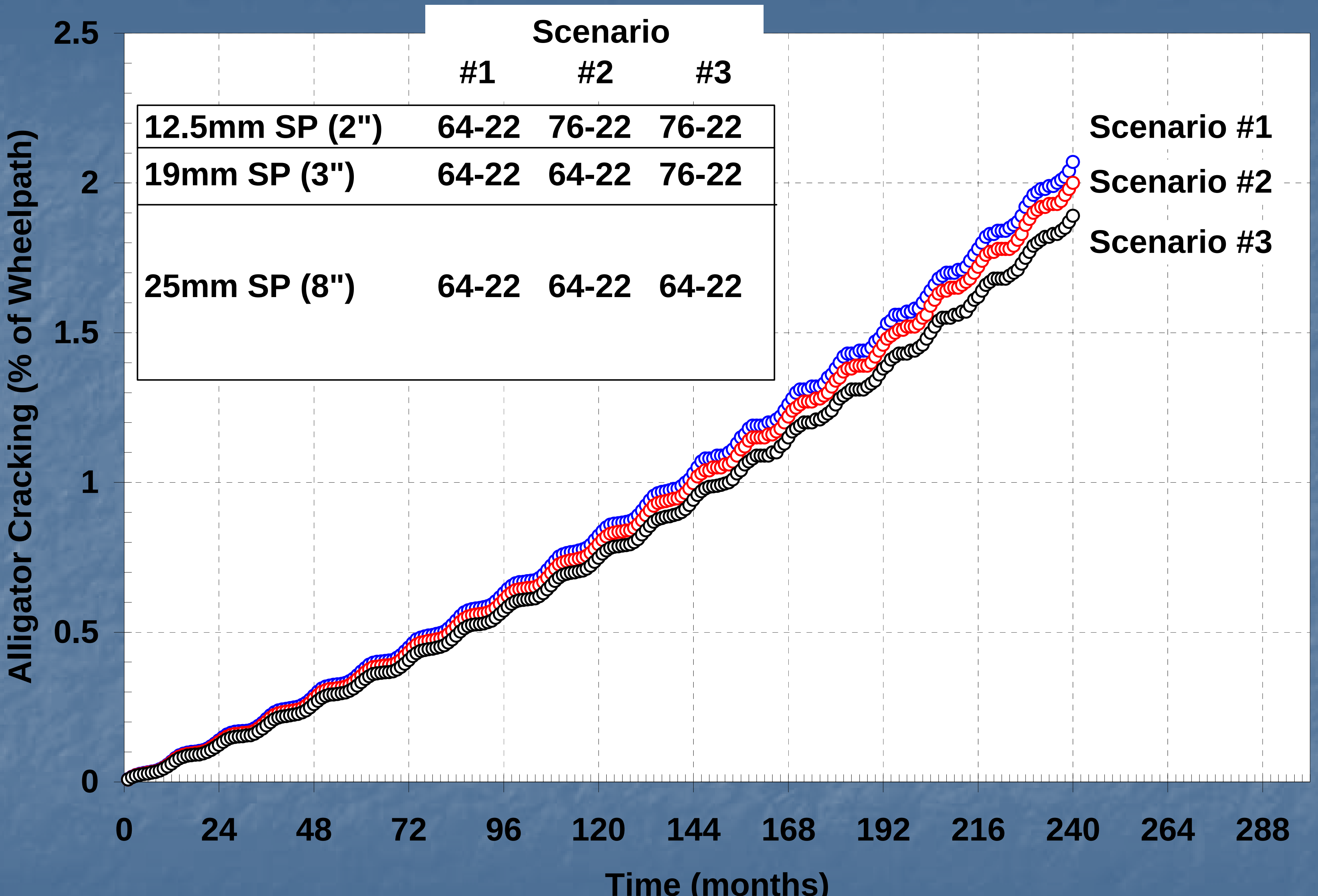
12.5mm Superpave HMA (2”)
19mm Superpave HMA (3”)
25mm Superpave HMA (8”)
ASOG (4”)
DGA (8”)

Subgrade (A-6)

Route 295 Reconstruction

- 2-in Superpave HMA 12.5V76 Surface
- 3-in Superpave HMA 19V76 Intermediate
- 8-in Superpave HMA 25H64 Base
- 4-in Asphalt Stabilized Drainage Layer
- 8-in Dense Graded Aggregate Base
- Geotextile for stabilization/separation


Rutting in Asphalt Only (in.)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
24
48
72
96
120
144
168
192
216
240
264
288
Time (months)
Scenario #1
Scenario #2
Scenario #3
Scenario
#1
#2
#3
12.5mm SP (2") 64-22 76-22 76-22
19mm SP (3") 64-22 64-22 76-22
25mm SP (8") 64-22 64-22 64-22


Scenario
#1
#2
#3
12.5mm SP (2") 64-22 76-22 76-22
19mm SP (3") 64-22 64-22 76-22
25mm SP (8") 64-22 64-22 64-22
Scenario #1
Scenario #2
Scenario #3
Alligator Cracking (% of Wheelpath)
2.5
2
1.5
1
0.5
0
0
24
48
72
96
120
144
168
192
216
240
264
288
Time (months)


ANTIGO

Pavement Design Selection

- Reconstruct MP 32.0-33.61 and 34.45-37.0
- Rubblization MP 33.61 to MP 34.45
- CPR and 5”+ Overlay MP 37 to MP 41
- Install Longitudinal Edge Drains
- VE Proposal Doubles Rubblization

Route 295 Bottom Rich Analysis

- Increase binder 0.5% by wt. in bottom lift
  - Increases project cost $200,000 (128,000 T)
  - Increases Fatigue Life 104%

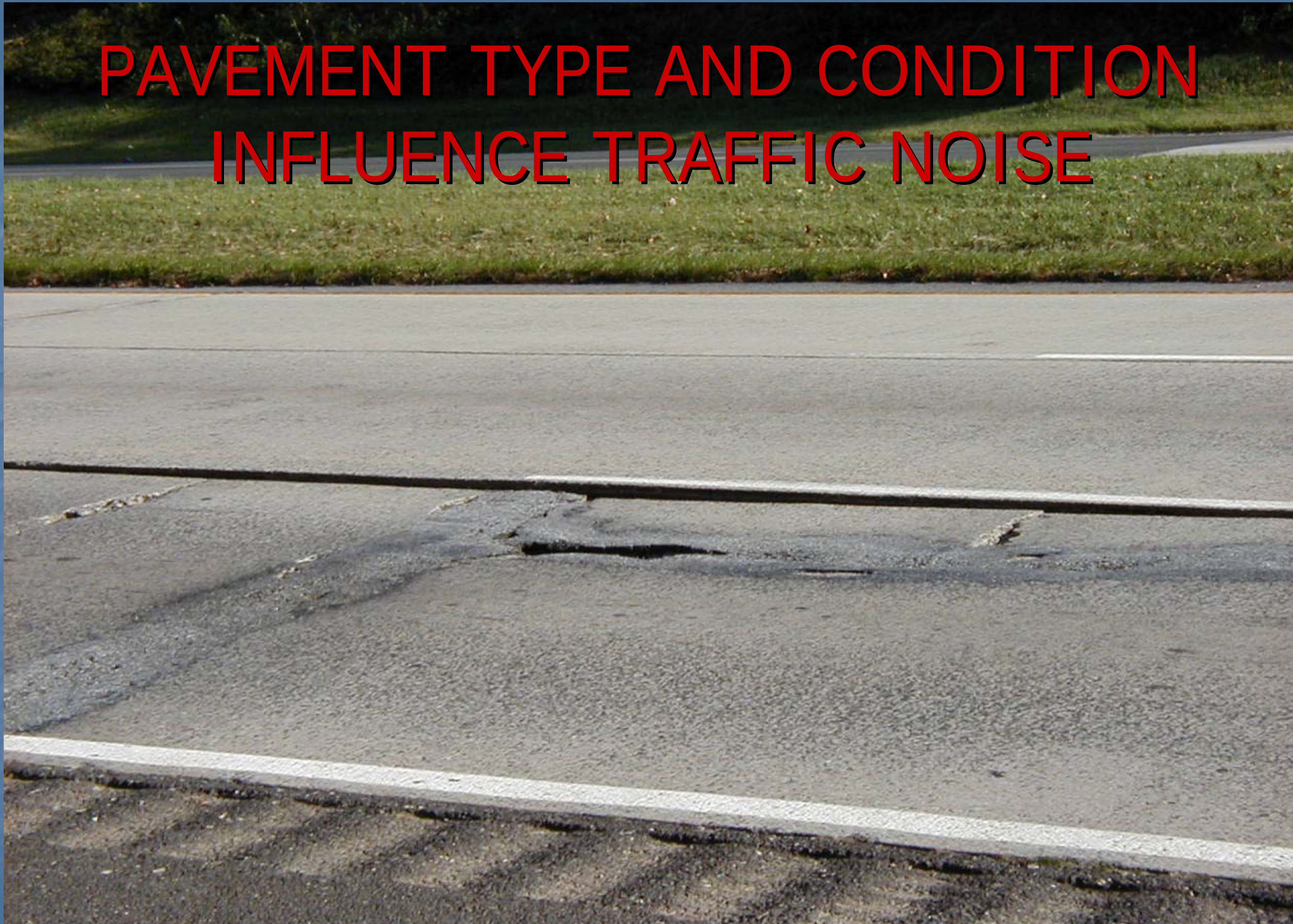
    or

  - Decreases Required HMA Thickness 2-in
  - Rutgers APA Test to Evaluate Material
    - Visual Check for Bleeding
    - Rutting Potential

2005 Interstate Projects

- Route 295 NB & SB
- MP 60.4 to 67.8
- Structural Overlay
- 4” mill, 6-7” resurface
- Travel lanes polymer
- IRI Ride Spec
- SMA in substandard horizontal curves

- Route 195 WB
- MP 5.3 to 9.0
- Structural Overlay
- 3” mill, 7” resurface
- Travel lanes polymer
- First NJDOT Project to use IRI Spec


PAVEMENT TYPE AND CONDITION
INFLUENCE TRAFFIC NOISE

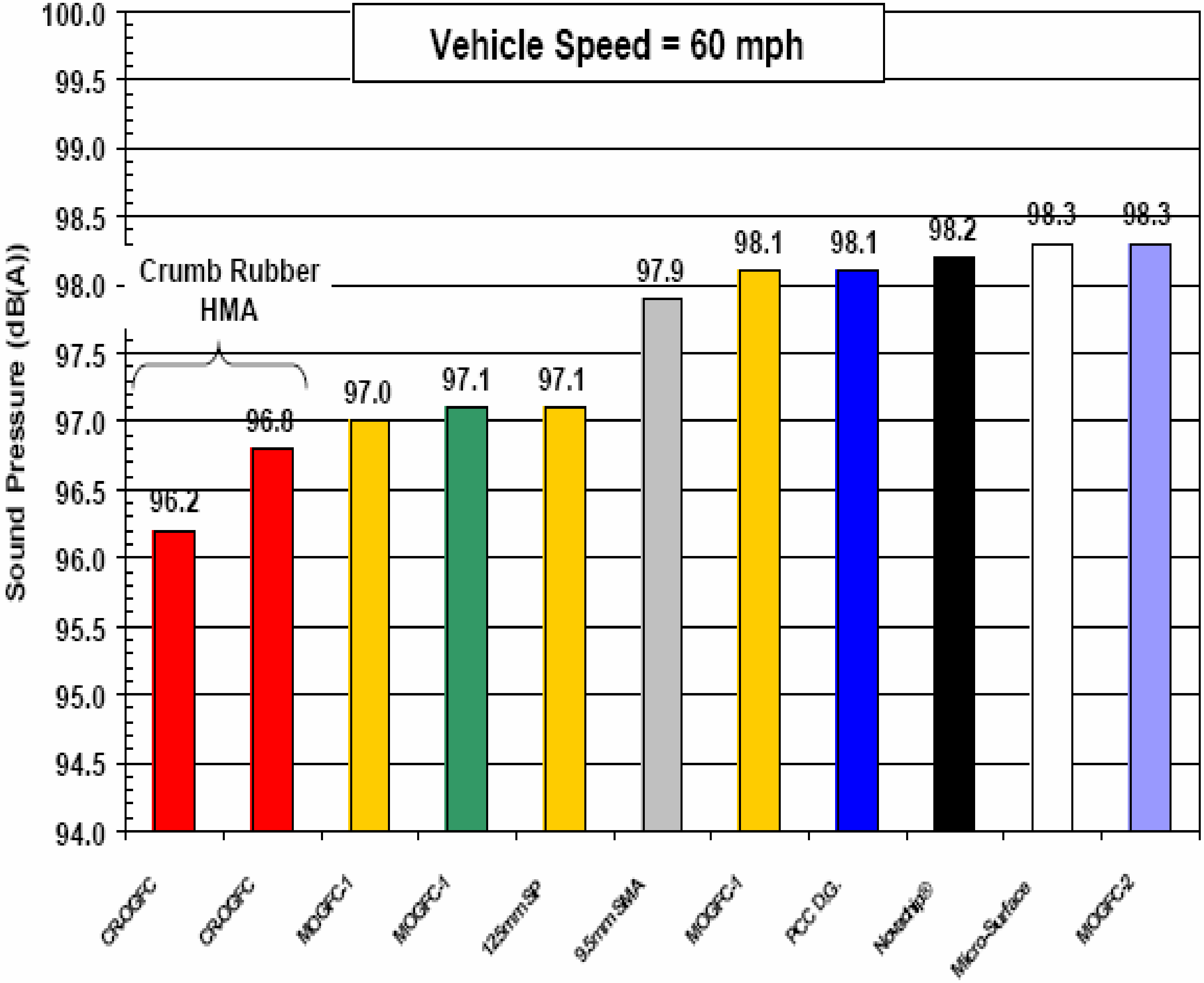


Figure 9 – The 10 (Out of 42) Quietest Pavement Surfaces Tested in New Jersey

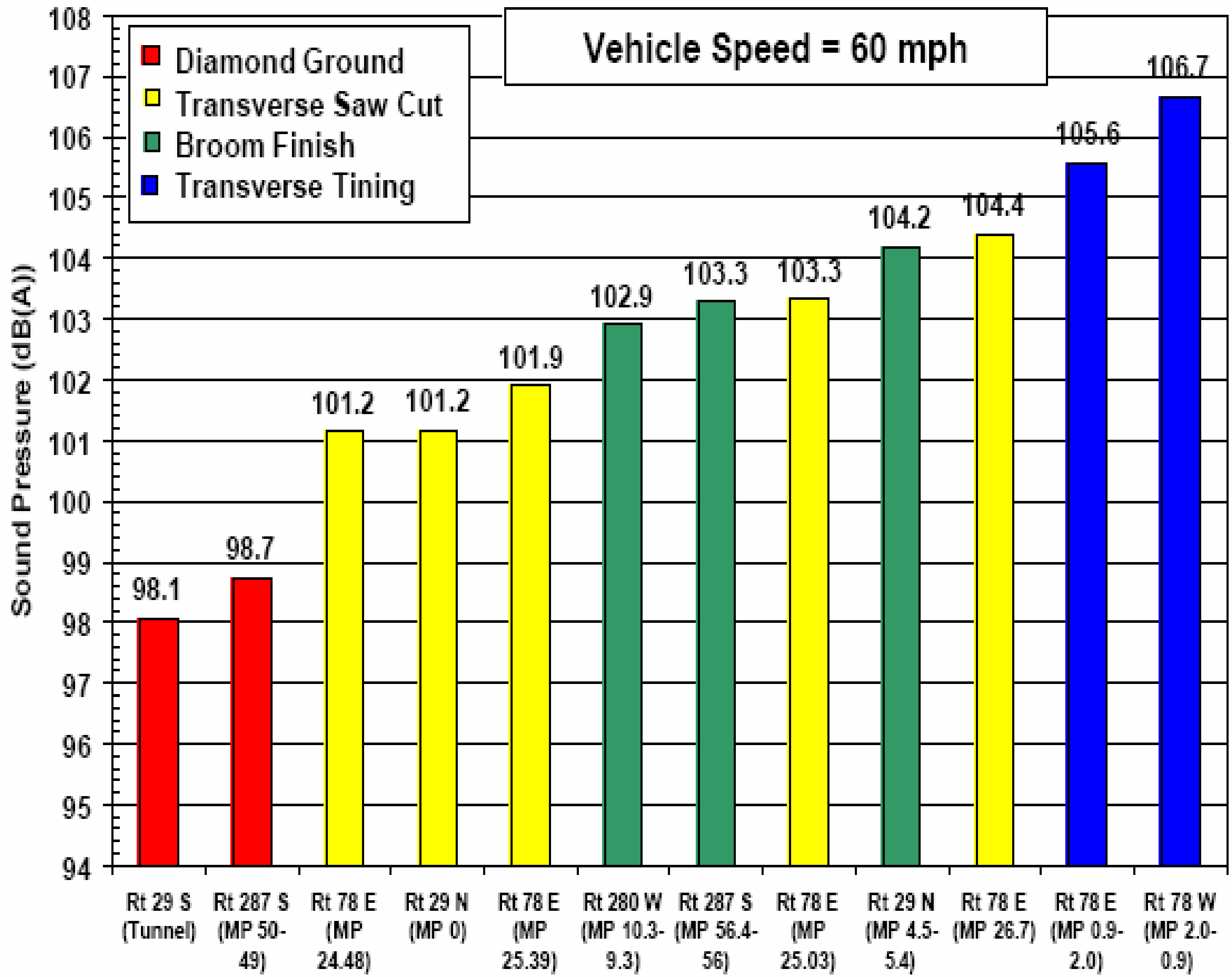
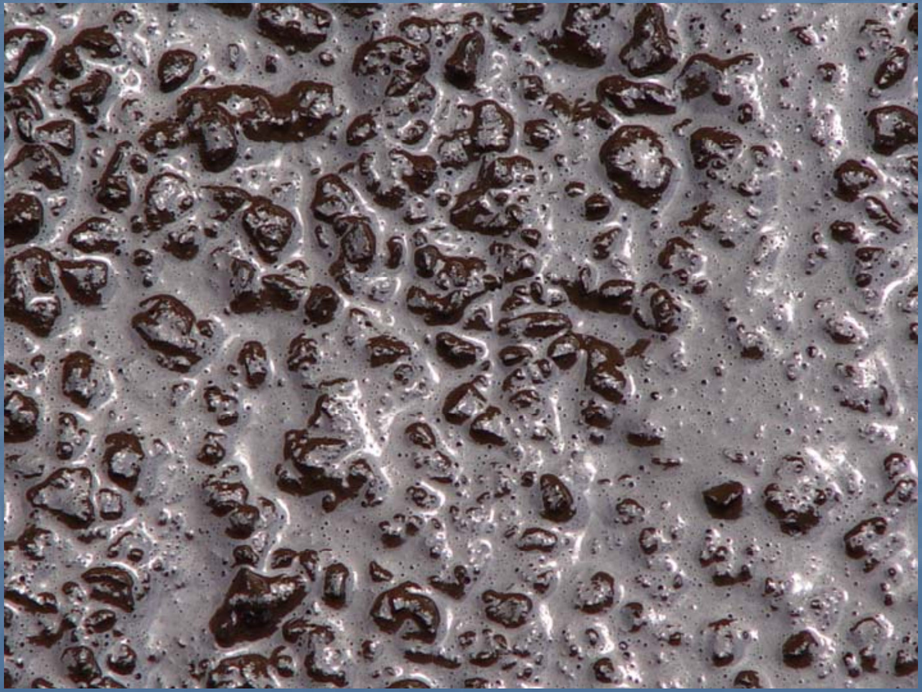


Figure 8 – Comparison of Tire/Pavement Related Noise for PCC Pavements

MOGFC-2 Route I-195 EB

Microsurfacing Route 29 (Preventive Maintenance)

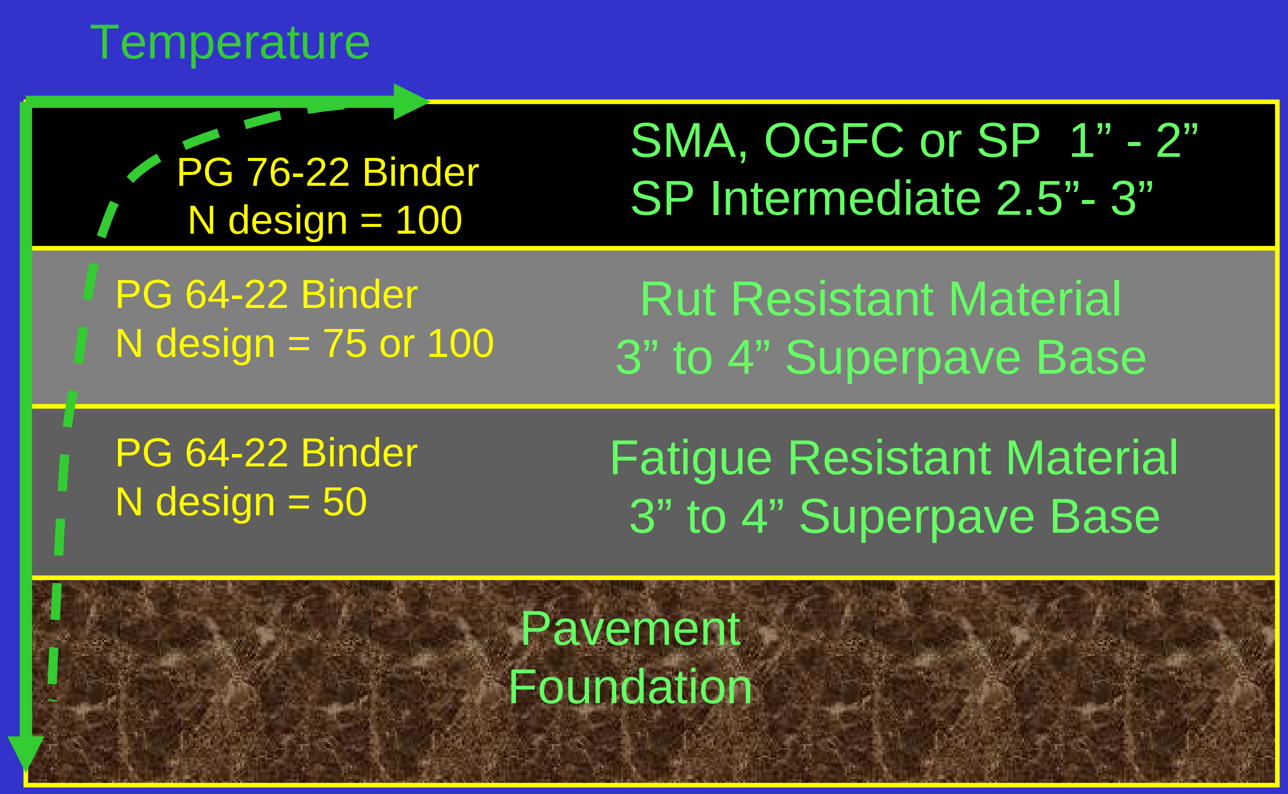


NOVACHIP Rt 195 WB

ULTRA-THIN FRICTION COURSE

NOVACHIP Macro-Texture

NJDOT Perpetual Pavement



Impact of Temperature Gradient on Asphalt Grade.

Thank You…