Development of Long Life Overlays for Existing Pavement Infrastructure Projects in New Jersey

Northeast Asphalt User/Producer Group Meeting

October 18, 2001

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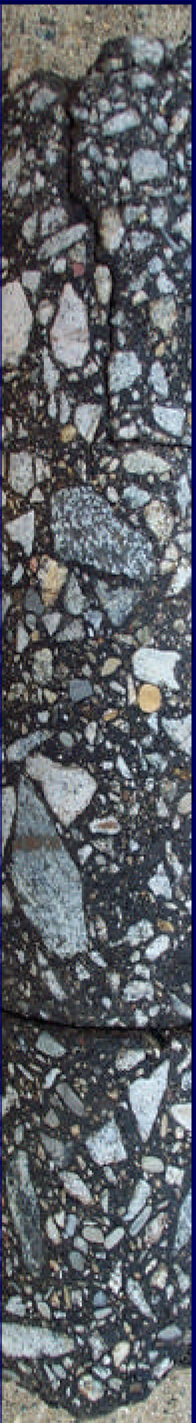
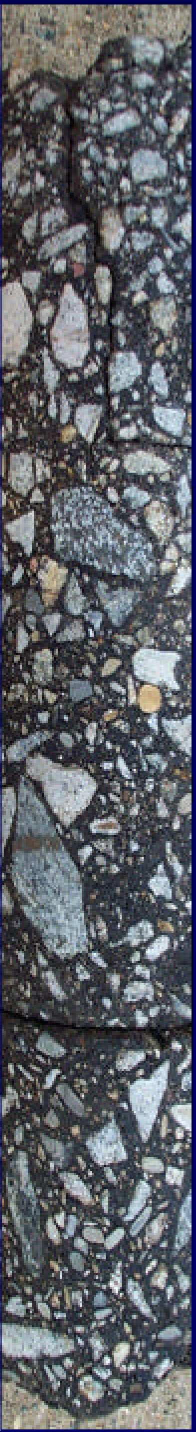


NJDOT Objectives

"NJ First" Vision
for 21st Century Transportation Systems

- Achieve the **state of good repair** for state's transportation system and maintain that system to ensure **maximum useful life** (fix it first)
- **Eliminate the backlog of deficient pavement** condition on state highways



Pavement Design Methodology

"Pavements are complex structures that are not fully understood"

Requirements:

Performance & Optimized Cost

In-Situ Properties

- Subgrade soil bearing capacity
- NDT of existing pavement
- Climate
- Traffic

Material Characterization

Superpave mix selection

Design Method

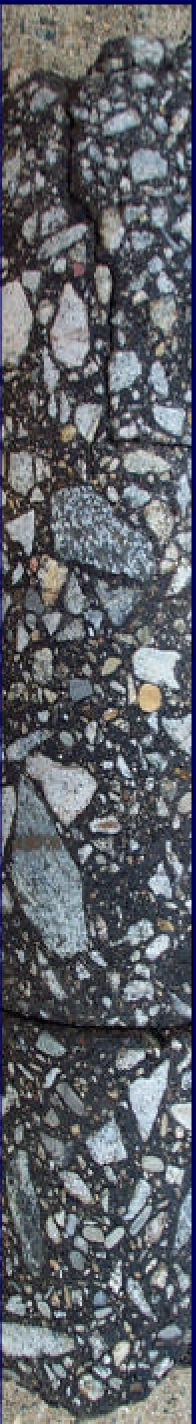
- Loading modeling
- Traffic modeling
- Failure criterion
- Method of design: Mechanistic or Empirical
- LCCA including user delay costs

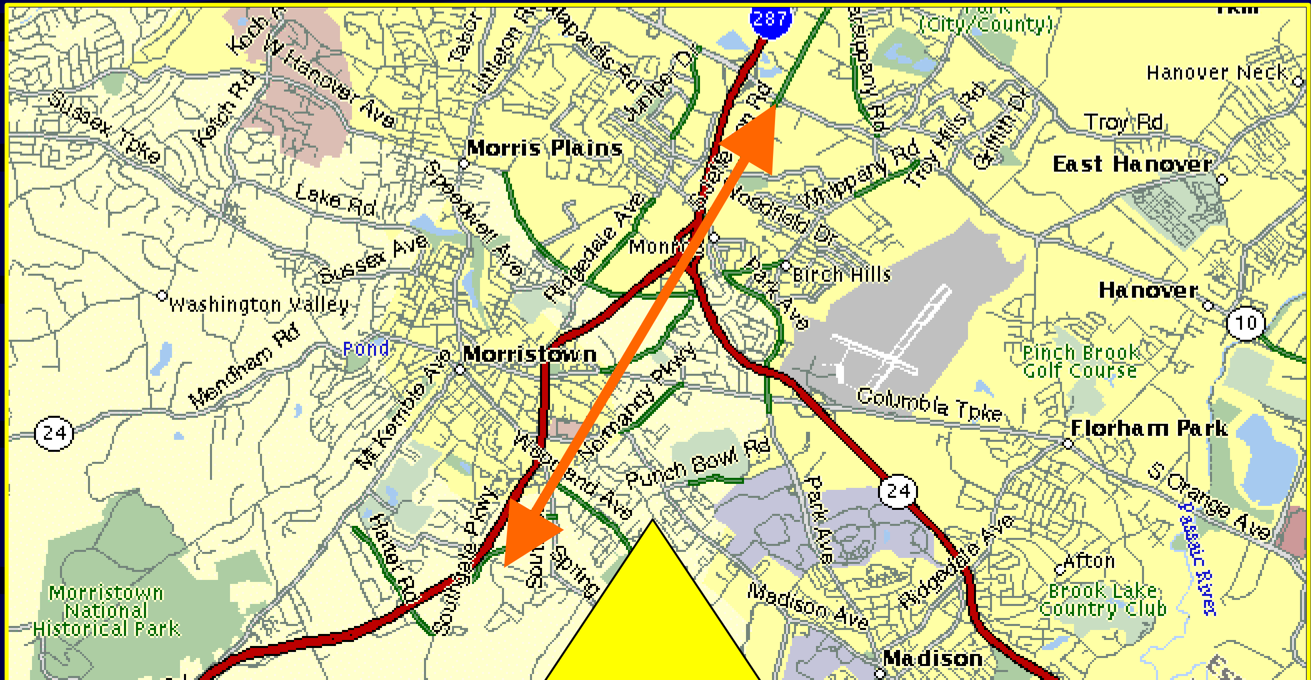
Introduction to I-287 Project

- 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
- Roadway geometry restricted due to location in the town of Morristown
- 24,000 trucks/day (2 way)
- Project limits: MP 35.5 to MP 38.8

Rt. I-287 Project Goals

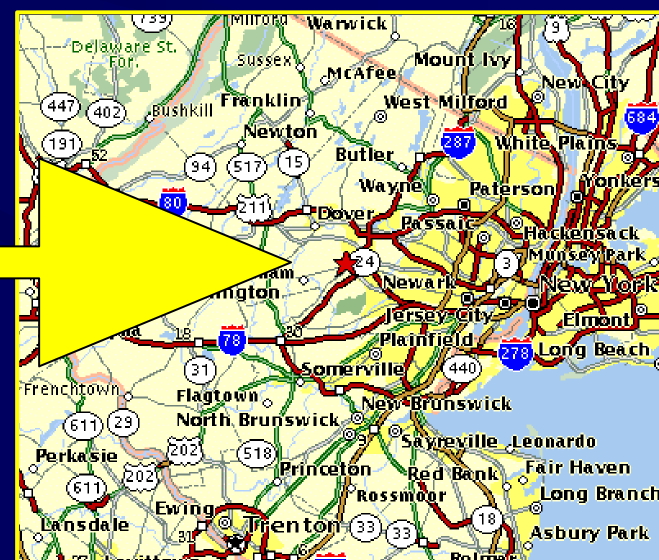
- Construct HOV lanes to increase capacity and coincide with the opening of I-287 to the north
- Rehabilitate pavement structure with minimal impact on roadway profile
- Provide a durable wearing surface
- Construct while maintaining existing number of travel lanes during peak traffic hours





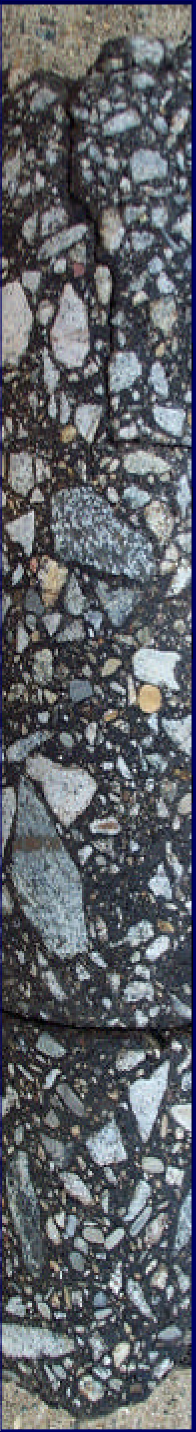
Project Location

- Initial construction 1968
- Rehab design 1993



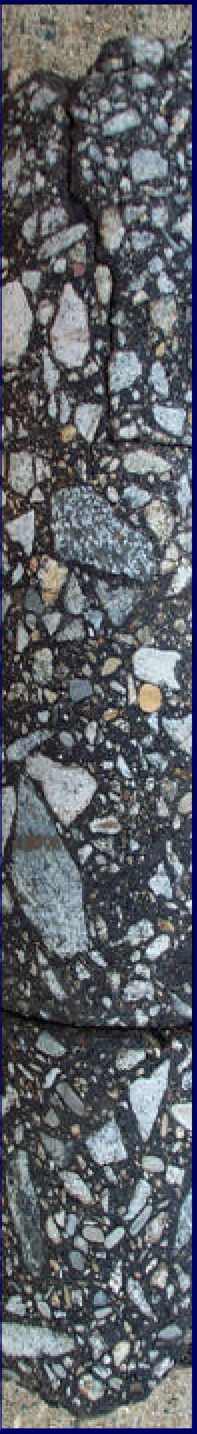
Rt. I-287 Pavement History

- Pavement Composition
  - – 3” HMA Surface Course
  - – 7” HMA Base Course [stone mix]
  - – 8” Dense Graded Aggregate [crushed stone]
  - – 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

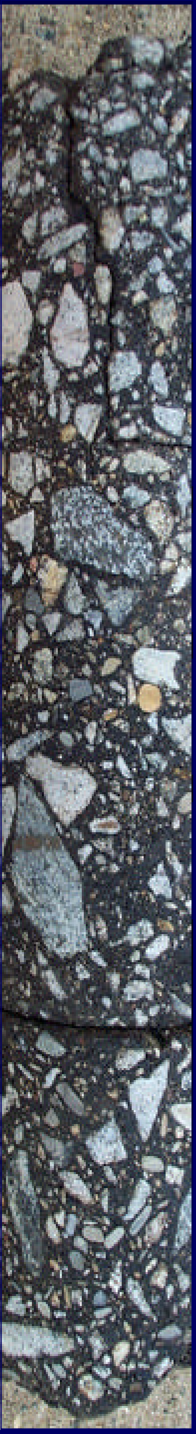
Proposed Quantities

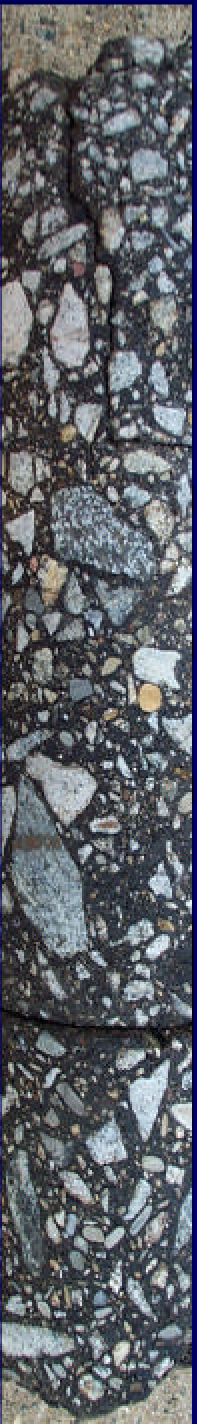
- 75,000 tons HMA polymer surface mix
- 225,000 tons HMA base mix

Rt. I-287 Pavement Condition

- 1994 Visual Condition Survey
  - Lanes 2 and 3
    - Moderate to high severity fatigue cracking
    - Wheel path longitudinal cracking
    - Some high severity patching
    - Rutting >1”
  - Lane 1
    - Low severity cracking
    - Rutting<1”

Typical Surface Appearance





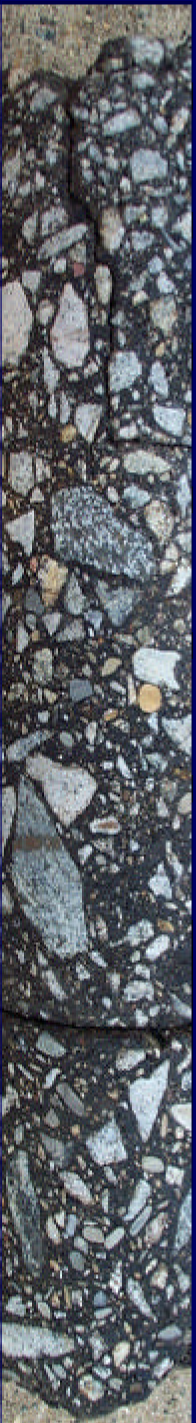
Rt. I-287 Pavement Coring

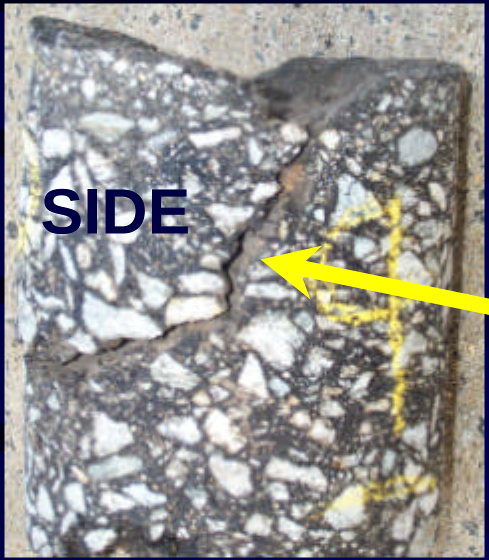
- Initial indications were that cracks penetrated through all bound layers
- Coring results
  - Cracks originated at surface with majority stopping at the base layer (3” depth)
  - Materials testing
    - 25 Pavement cores

Penetration and Air Voids

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

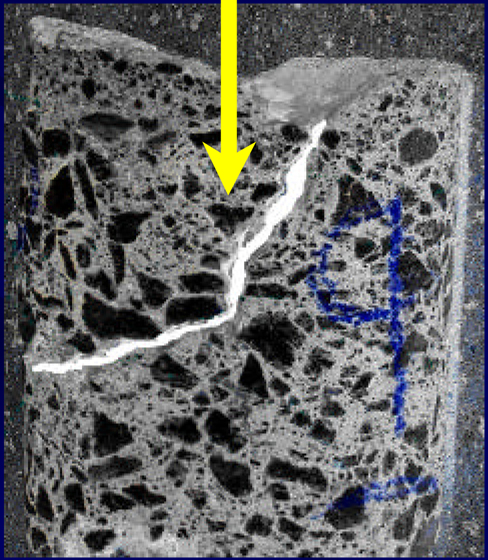
Example of Surface Cracking



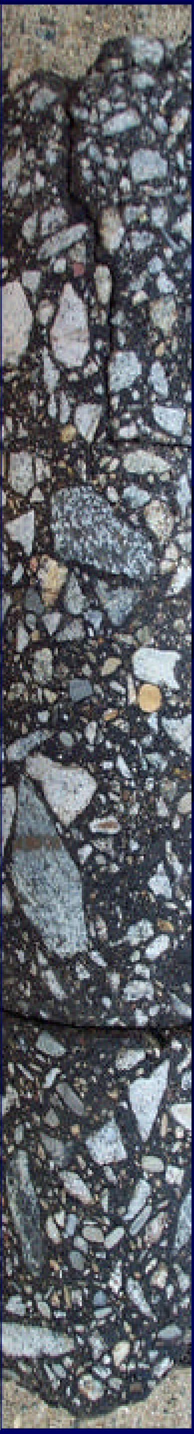


PHOTOGRAPH
OF CORE

CRACK

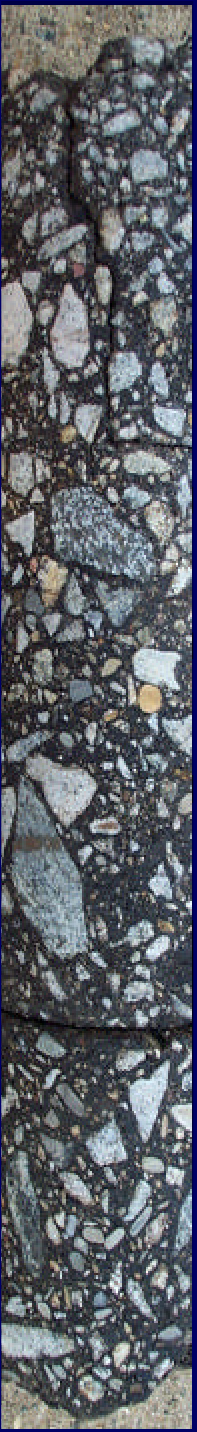


NEGATIVE
ENCHANCED
IMAGE



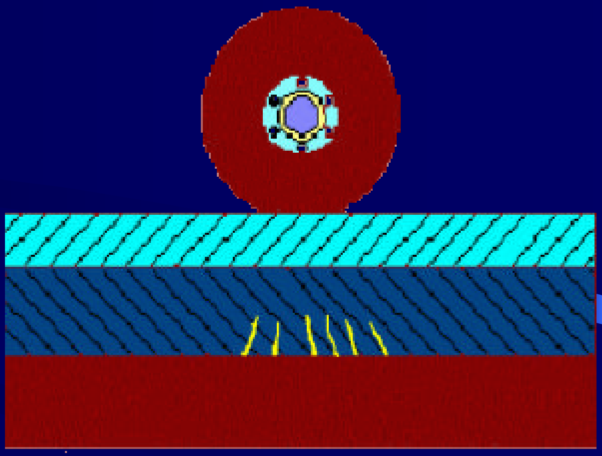
Pavement Distress

- Pavement is surface cracked
- Classical models do not help us to predict this distress
- Possibly a result of very hard binder in the surface mix



Pavement Models

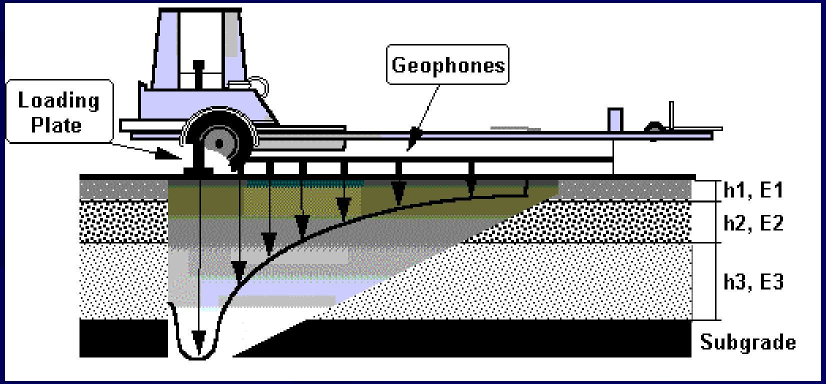
- Classical Pavement Design
  - Fatigue Cracks Start at bottom
  - Pavement rutting controlled by sub-grade strain
- On Site
  - Extensively cracked pavement
  - Cracks originate at the top and restricted to top 3 inches
  - Few cracks through entire layer



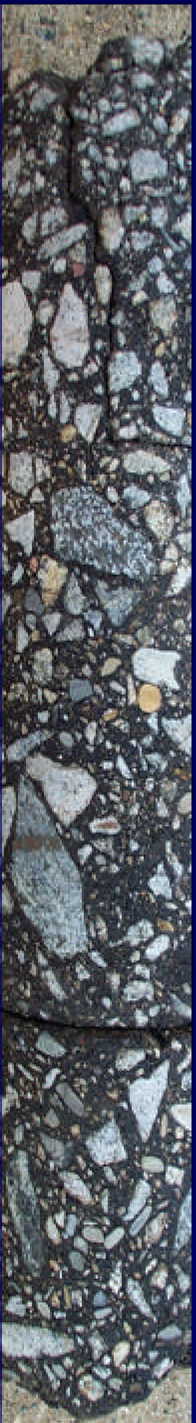
Typically cracks assumed to start here!

Route I- 287 FWD Testing

- FWD testing was conducted on all traffic lanes to determine the stiffness of the pavement layers
- The stiffness of the combined asphalt layer (85 percentile deflection) were as follows:
  - NB1 7,100 MPa
  - NB2 5,600 MPa
  - NB3 4,600 MPa
  - SB1 7,600 MPa
  - SB2 5,300 MPa
  - SB3 4,900 MPa

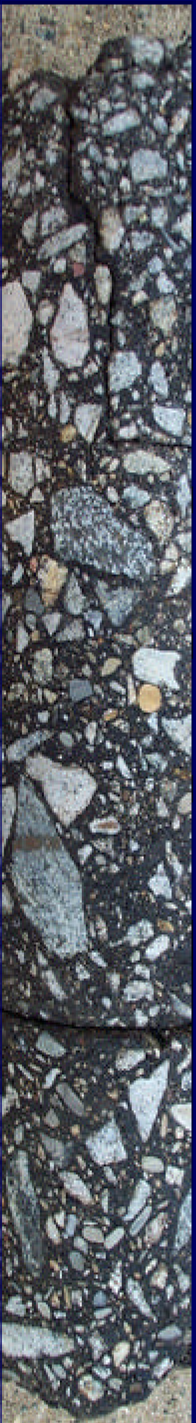


- NB= North Bound, SB= South Bound, 1= fast lane, 3= slow lane.
- Lane 3 has considerably lower stiffness compared to lane 1.



FWD Structural Analysis

- 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 remained



FWD Results

Lane 3
slow lane
heavy traffic

Cracked
top layer

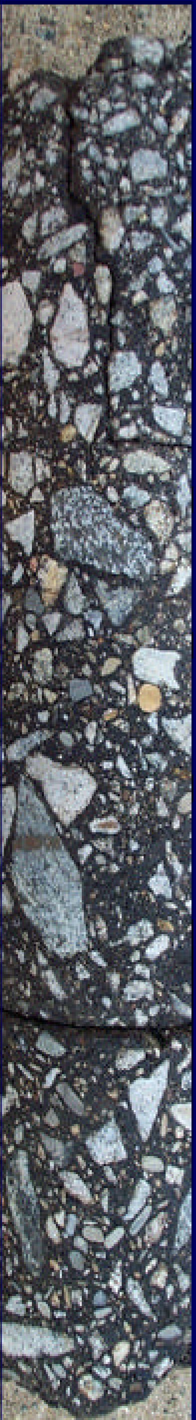
Sound
base of
high
stiffness

Combined Stiffness
= 4,750 MPa

Sound
pavement
structure
with
minimal
cracking

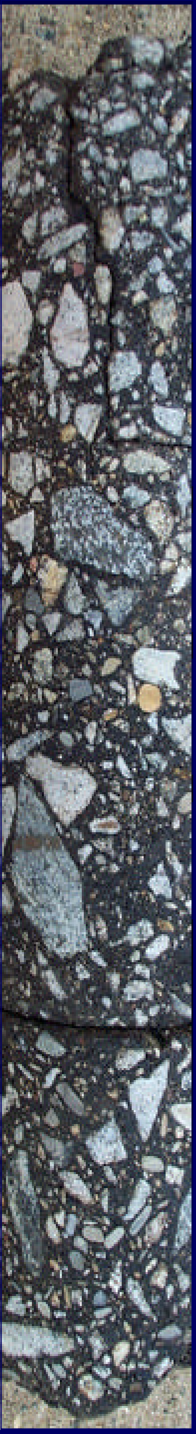
Lane 1
fast lane
light traffic

Combined Stiffness
= 7,350 MPa



Rt. I-287 Pavement Rehabilitation

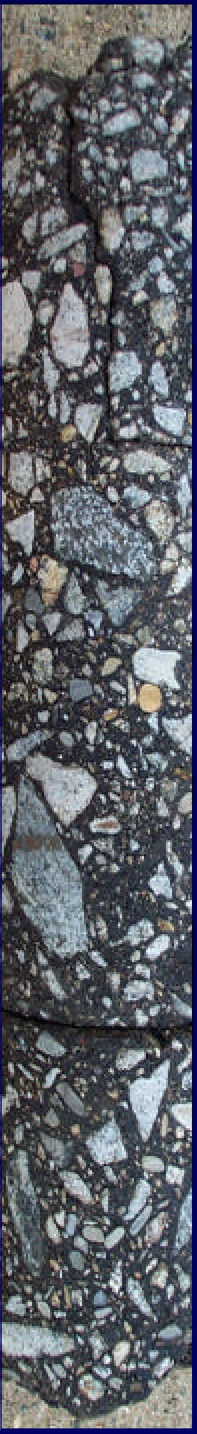
- Mill 3” depth (removes most cracks)
- Overlay
  - 2” HMA surface course, polymer modified
  - 2” minimum HMA base course [stone mix]
  - Test area with 1200 tons of NJ’s first Superpave mix
  - Minimal modification needed to convert existing mixture to meet 12.5 mm Superpave requirements



Project Summary

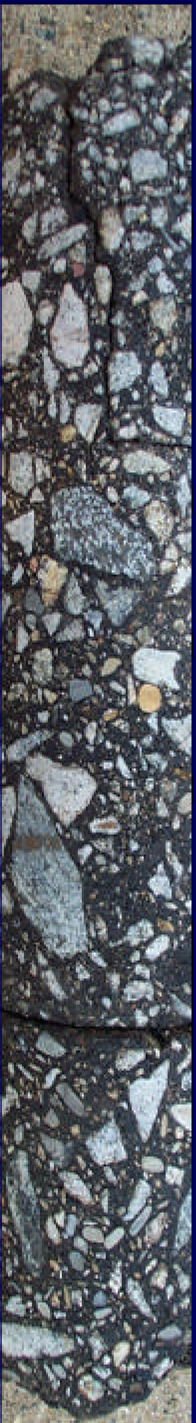
- Adequate service life achieved with only a relatively thin overlay
- Existing structural capacity 7,000,000 ESALs
- Rehabilitated structural capacity 69,000,000 ESALs
- Superpave mix not much different than New Jersey’s current “HD” mix
- 2001 PMS data indicates zero defects

Current Rt. I-287 Condition



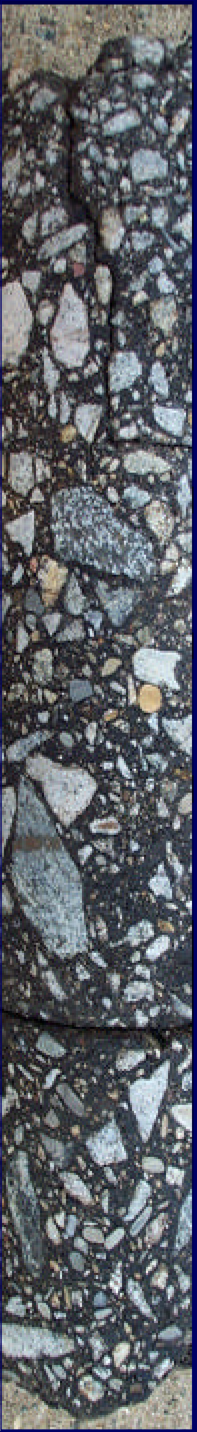
Route I-78 History

- Route I-78 EB from MP 31 to MP 43 in New Jersey
- Rehabilitation project designed by NJDOT forces Jan 1998
- Original Construction 1970: 6”-7” HMA, 9”-13” crushed stone base, 12”-14” subbase
- Resurfaced in 1986 (mill 2”, resurface 6”)
- Initial pavement investigation visual survey & coring
- Core recovery: 1.5”-12” HMA
- Severely Distressed Pavement; high severity cracking and raveling



Route 78 EB

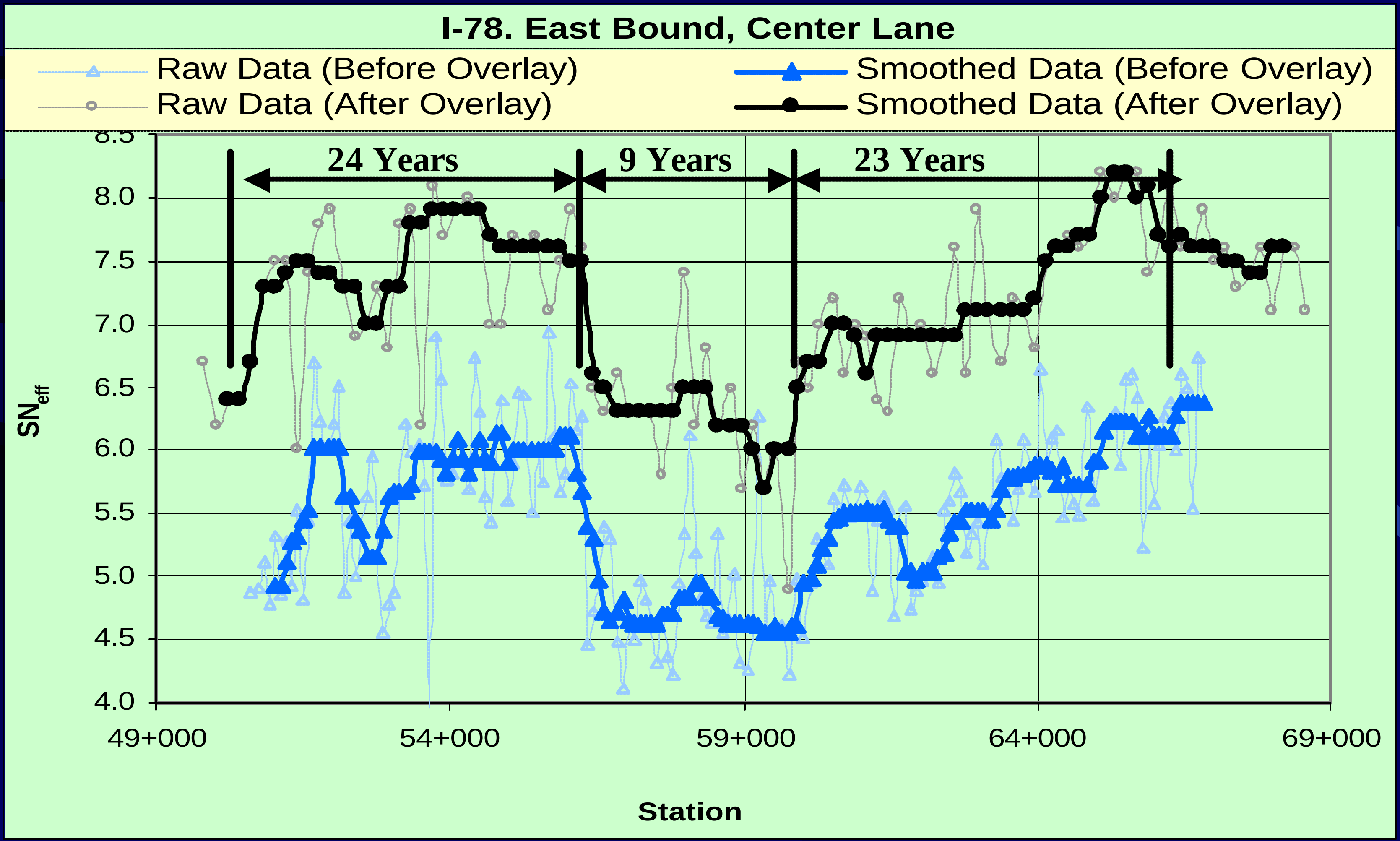
- The resurfacing project was designed based on material parameters estimated from a visual distress survey and pavement coring.
- Initial design 2” milling and 4” overlay (holding action)
- FWD added in construction plans
- FWD testing was performed to evaluate the effectiveness

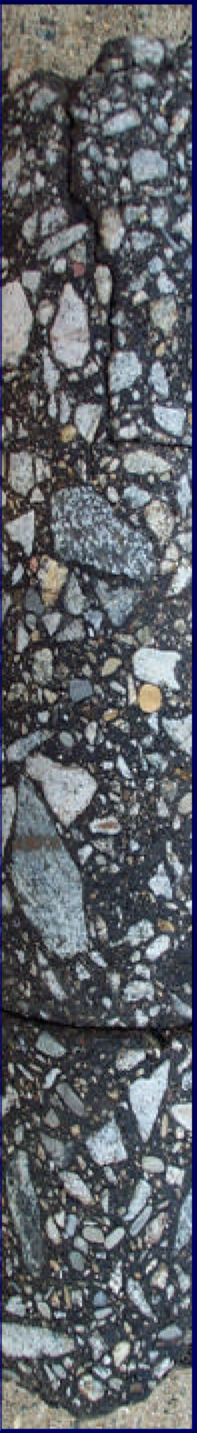


Role of NDT on Rt. I-78 Project

- Incorporation of FWD:
  - Elastic modulus of HMA (E_{AC})
  - Subgrade resilient modulus (M_R)
  - Effective structural number (SN_{eff})
  - SN_{eff} profile of project
- Overall pavement condition estimated service life
- Effectiveness of pavement treatment
  - structural increase from the overlay
- Detailed pavement analysis
  - in-situ material properties

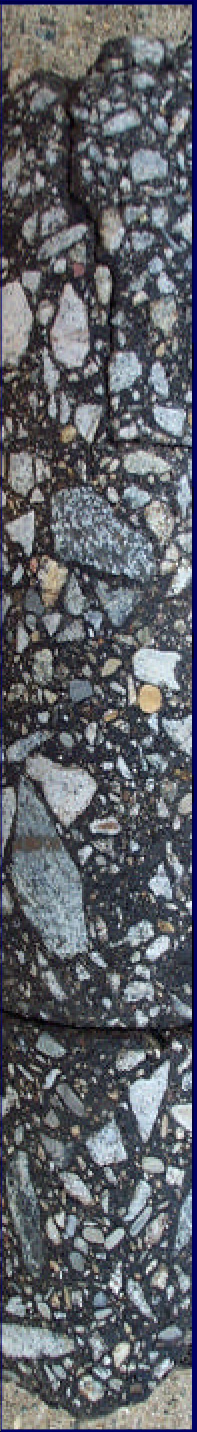
FWD Typical Results
Pavement Evaluation
Route 78 EB
MP 30.5 to MP 42.7





Route I-78 FWD Evaluation

Lane	Before Overlay		After Overlay	
	E_{AC} MPa (ksi)	SN_{eff}	E_{AC} MPa (ksi)	SN_{eff}
Left	5799 (830)	5.6	8400 (1210)	7.1
Center	3900 (570)	5.6	6100 (890)	7.1
Right	6300 (900)	5.4	7900 (1150)	7.0
Auxiliary	6600 (950)	5.5	6700 (970)	7.2



Route I-78 Material Properties and Estimated Service Life

		Left Lane		Center Lane		Right Lane	
		Before Overlay	After Overlay	Before Overlay	After Overlay	Before Overlay	After Overlay
E_{AC}@20°C Mpa (ksi)		5300 (760)	7900 (1150)	3800 (550)	5900 (860)	5700 (800)	7600 (1100)
Subgrade M_r kPa (psi)		11500 (11200)	69900 (10200)	88500 (12800)	75100 (10900)	72000 (10500)	69600 (10100)
MP30.7-37.4	SN_{eff}	5.6	6.9	5.3	6.9	5.2	6.8
	Life in Years		13		13		12
MP37.4-42.7	SN_{eff}	5.6	7.2	5.8	7.3	5.6	7.2
	Life in Years		21		23		21

The FWD
testing was performed both before and after milling and resurfacing of the HMA pavement. The FWD test data was back-calculated using the PADAL [l] program to determine the elastic modulus of AC pavement (EAc), subgrade resilient modulus (IV&), and the effective structural number (SN,,) of the roadway. A follow-up design that was performed in accordance with AASHTO Guide for Design of Pavement Structures [2] indicated that the structural number of the pavement had increased an average of 1.6, with a service life of 15 to 19 years. FWD results also indicated that few sections of the roadway had higher deflections and needed more extensive rehabilitation. The service life of the overlay for these sections was estimated to be approximately 12 to 13 years.
highlight the importance of FWD testing and the
back-calculation procedure as a tool for optimizing project level design efforts. This project confirmed that FWD testing is instrumental in identifying deficient sections, optimizing pavement treatments, and therefore providing the most cost-effective solution for those charged with managing their project resources. Demonstrating the success of using FWD, NJDOT incorporated this approach for the 12-mile segment of Route 78 in the WB direction the following year.