Rehabilitation of 1st Avenue in NYC With A High Performance Thin Overlay

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1st Avenue in NYC

- In 1983 NYC DOT repaved 1st Avenue from 72nd St to 125th St with 18” reinforced PCC
- Newspaper article highlighted paving project

First major street paving in concrete in 30 years

For the first time within recent memory, a major street in Manhattan was being paved in concrete rather than the more commonplace asphalt. Economy was a prime factor. The three-mile job on First Avenue from East 72nd Street to East 125th Street in New York City had a pavement with a design life of 40 years and a cost reported to be $2 million lower than the nearest competing asphalt bid.
1st Avenue in NYC

- Pavement did not meet 40 year life
- After 25 years, PCC pavement was in very poor condition
- NYC DOT spent last 5 years trying to find a fix
1st Avenue in NYC
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- Cost of total replacement of 18” PCC pavement beyond NYC DOT budget
1st Avenue in NYC

- Utilities beneath the pavement
  - Gas lines
  - Water lines
  - Sewer lines
  - Steam line
Removing the PCC would most likely damage the utilities
- NYC DOT tries not to use compaction with vibration when paving streets
- After paving projects are completed NYC DOT tests utilities for leaks

Funding not available to replace PCC pavement and the utilities

1st Avenue in NYC
NYC is planning to improve bus service with a new bus lane on 1st Avenue and also add a bike lane.

Question – How to rehabilitate 1st Avenue?
1st Avenue in NYC
NYC DOT contacted Axeon Specialty Products (formerly NuStar Asphalt) and asked for suggestions.

Research at Rutgers University had developed a High Performance Thin Overlay (HPTO) Mix.
HPTO Mix Design

• Mix Performance Objectives
  – Improve rut resistance
    • Aggregate gradation and quality
    • Polymer-Modified Asphalt
  – Improve cracking resistance
    • Increased asphalt content
      – Slightly gap-graded mix
      – Mix design at 3% air void target (SGC = 50 gyrations)
    • Minimum 7% asphalt content
  • Polymer-Modified Asphalt
HPTO & 9.5 mm Mix Gradation Plot

Sieve Size (mm) Raised to 0.45 Power

Percent Passing

MD FlexGard
NJ I-5

0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0

Sieve Size (mm) Raised to 0.45 Power

Percent Passing

MD FlexGard
NJ I-5
Paulsboro HPTO – 5 years old

Original

After 5 years
NJ I-295 HPTO Project
NJ I-295 HPTO Project
1st Avenue in NYC

• Search to improve HPTO performance under severe conditions by beefing up the asphalt binder

• Highly Modified Asphalt (HiMA) developed by Kraton Polymers
  – Specialty SBS material with lower viscosity increase
  – Allows up to 7.5% polymer loading with workability
## Highly Modified Asphalt

<table>
<thead>
<tr>
<th>Distress</th>
<th>10” Unmodified</th>
<th>6” HiMA</th>
<th>Damage Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Deformation</td>
<td>2.05E-2</td>
<td>0.78E-2</td>
<td>38%</td>
</tr>
<tr>
<td>Compressive Deformation</td>
<td>1.27E-2</td>
<td>0.70E-2</td>
<td>55%</td>
</tr>
<tr>
<td>Longitudinal Cracking</td>
<td>1.31E-3</td>
<td>0.02E-3</td>
<td>1.5%</td>
</tr>
<tr>
<td>Vertical Cracking</td>
<td>7.72E-4</td>
<td>4.41E-4</td>
<td>57%</td>
</tr>
<tr>
<td>Transverse Cracking</td>
<td>8.65E-4</td>
<td>0.79E-4</td>
<td>9.1%</td>
</tr>
</tbody>
</table>

Source: Kluttz; Kraton Polymers
NCAT Test Track HiMA Section

- 10 million ESALs applied by September 2011
- HiMA section performed better than or equal to control section despite 1.25” thinner
  - HiMA section has 50% of rutting in control section
  - No cracking in HiMA or control section
- Measured strain and laboratory testing indicate HiMA has 64 times the fatigue life of the control section

Source: NCAT Research Synopsis; “Structural Evaluation of a Highly Polymer-Modified Asphalt Pavement”
1st Avenue in NYC

- Research at Rutgers University comparing HPTO mix with conventional PMA binder and Highly Modified Asphalt (HiMA)
1st Avenue in NYC

- Conventional PMA binder had a continuous grade of PG 80.4-27.3
- HiMA binder had a continuous grade of PG 95.4-31.03
Flow Number

AMPT Flow Number (cycles)

- Axeon FlexGard (Unaged): 590
- Axeon HiMA (Unaged): 982
- Axeon FlexGard (Aged): 1,079
- Axeon HiMA (Aged): 1,796
Texas Overlay Tester
Texas Overlay Tester

Hot Mix Asphalt Overlaid on PCC

Horizontal Tensile Stress due to Expansion/Contraction of PCC from Temperature

Horizontal Stress/Strain is modeled using Overlay Tester
Texas Overlay Tester

Overlay Tester Fatigue Life (cycles)

<table>
<thead>
<tr>
<th>Binder and Aging Condition</th>
<th>STOA</th>
<th>LTOA</th>
<th>STOA</th>
<th>LTOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>HiMA</td>
<td>&gt; 5,000</td>
<td>4,750</td>
<td>2,541</td>
<td></td>
</tr>
<tr>
<td>Flexgard</td>
<td>1,665</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Flexural Beam Fatigue

- Flexural Beam Fatigue Testing
  - Measure number of cycles to failure
  - Cycles to failure defined as stiffness = 50% of initial stiffness
Flexural Beam Fatigue

Fatigue Life, $N_{f,50\%}$ (Cycles)

Micro-strain ($\mu$s)

$N_{f,50\%} = k_1 \left( \frac{1}{\varepsilon_f} \right)^{k_2} \left( \frac{1}{E_0} \right)^{k_3}$

- Flexgard - LTOA
- HiMA - LTOA
- 12.5mm PG76-22 - LTOA
1st Avenue in NYC

- HPTO mix containing each binder was placed on 1st Avenue on September 25, 2012
  - HiMA placed between 100th and 101st Street
  - Conventional PMA placed between 101st and 102nd Street
- 1 1/2” thick overlay
1st Avenue in NYC
1st Avenue in NYC
1st Avenue in NYC

- Both sections performed well through August 2013
- NYC DOT selected HiMA based on laboratory testing and field performance
1st Avenue in NYC

- Rehabilitation Design
  - Micro-mill existing PCC pavement
  - Patch areas as required
  - Crack seal as required
  - Place PG 76-22 tack coat and Mirafi PGMG4 fabric
  - Overlay with 1 ½” HPTO mix with HiMA asphalt binder
    - Added Evotherm warm mix additive to lower mix temperatures and improve workability
    - Produced mix at 300°F

- Project completed September 2013
1st Avenue Micro-Milling
1st Avenue Micro-Milling
1st Avenue Micro-Milling
1st Avenue Crack Sealing and Patching
1st Avenue Crack Sealing and Patching
1st Avenue Tack Coat and Fabric
1st Avenue Tack Coat and Fabric
1st Avenue Paving – September 2013
1st Avenue Paving – September 2013
1st Avenue Paving – September 2013

[Image of equipment with text: Dens: 145.7 PCF, %MA: 97.88%, 100-%MA: 2.12%, %VOID: 2.12%]
1st Avenue Finished Pavement – September 2013
1st Avenue Finished Pavement – September 2013
1st Avenue Finished Pavement – September 2013
1st Ave @ 96th Street - Before
Summary

- Combination of HPTO mix and HiMA may provide a thin overlay solution for difficult urban pavement rehabilitations
- NYC DOT and Axeon Specialty Products will monitor pavement performance
Questions?