Analysis of the FWD Data Collected on Flexible Pavements during First Cycle of Accelerated Pavement Testing at NAPTF

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Outline

- Background
- FWD Testing Procedure and Schedule
- Back-Calculation Method
- Results and Discussions
- Summary and Conclusions
Background – The Facility

The Test Vehicle
Background - Layout and Cross Section
Background – Traffic Program

- Six-wheel gear for the north half
- Four-wheel gear for the south half
- Wheel load history
  - 45 kips (200kN) for 20,000 passes
  - 65 kips (289kN) for the next 30,000 passes
FWD Testing – Schedule and Layout

- **Uniformity Tests**
  - 10 ft x 10 ft grid
  - 8 months before trafficking

- **Routine Tests**
  - Three lines:
    - North and south wheelpaths
    - Centerline of the test track
  - Every now and then during trafficking
FWD Testing Lines

North Half

LANE 1
LANE 2
LANE 3
LANE 4
LANE 5

South Half

LANE 6
FWD Back-calculation Procedure

- Three layer system
  - Combine HMA layer
  - Combine AB and ASB layer
  - Bedrock below thick subgrade except for two layer pavements

- Multi-layer elastic theory

- Kalman Filter based search algorithm

- Matching measured deflections by adjusting layer stiffness
Results and Discussions

- Overall layer stiffness shortly after construction
- Effect of Temperature and Age on HMA stiffness
- Comparison of back-calculated and estimated stiffness master curves
- Effect of traffic on stiffness
  - HMA layer
  - Base layer
  - Bas + subbase combined layer
  - Subgrade
Overall Layer Stiffness – Chart

Uniformity Test Results

- Material=AB + ASB
- Material=P-401: HMA
- Material=Subgrade: High Strength Subgrade
- Material=Subgrade: Medium Strength Subgrade
- Material=Subgrade: Low Strength Subgrade
- Material=P-209: Crushed Stone Base
## Overall Layer Stiffness - Numbers

<table>
<thead>
<tr>
<th>Test Item ID</th>
<th>P-401: HMA</th>
<th>P-209: Crushed Stone Base</th>
<th>AB + ASB</th>
<th>Subgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFS</td>
<td>4,326 (0.11)</td>
<td>219 (0.12)</td>
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<td>50 (0.12)</td>
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<tr>
<td>LFC</td>
<td>4,558 (0.18)</td>
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<td>176 (0.12)</td>
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Effect of Temperature and Aging on HMA Stiffness – LFS

P-401: HMA Layer in Test Item LFS

Back-Calculated Stiffness (MPa)

0 10 20 25
Pavement Surface Temperature (°C)

- Uniformity Test, Non-Centerline, 84 Days Old
- Routine Test, Centerline, 244 Days Old
- Routine Test, Centerline, 245 Days Old
- Routine Test, Centerline, 298 Days Old
- Routine Test, Centerline, 329 Days Old
- Routine Test, Centerline, More than 329 Days Old
Effect of Temperature and Aging on HMA Stiffness – LFS

P-401: HMA Layer in Test Item LFC

Back-Calculated Stiffness (MPa)

Pavement Surface Temperature (°C)
Comparison of Stiffness Master Curves

P-401: HMA Layer in Test Item LFC

- Back-Calculated for Centerline, More than 329 Days Old
- Estimated Stiffness Master Curve
- Estimated Stiffness Master Curve Scaled by 0.85

Back-Calculated Stiffness (MPa)

Pavement Surface Temperature (°C)
Effect of Traffic on HMA Stiffness - LFS

P-401: HMA Layer in Test Item LFS

Stiffness Ratio for Back-Calculated Stiffness

Number of Load Repetitions

×10^4
Effect of Traffic on HMA Stiffness - LFC

P-401: HMA Layer in Test Item LFC

Stiffness Ratio for Back-Calculated Stiffness

- LANE 2 (Tridem Axle Load)
- LANE 5 (Tandem Axle Load)
- Centerline, Untrafficked

Number of Load Repetitions $\times 10^4$
Effect of Traffic on Base Stiffness - LFS

P-209: Crushed Stone Base Layer in Test Item LFS

Stiffness Ratio for Back-Calculated Stiffness

Number of Load Repetitions

× 10^4
Effect of Traffic on Base + Subbase Stiffness - LFC
Effect of Traffic on Subgrade Stiffness - LFC

Low Strength Subgrade Layer in Test Item LFC

Stiffness Ratio for Back-Calculated Stiffness

Number of Load Repetitions

LANE 2 (Tridem Axle Load)
LANE 5 (Tandem Axle Load)
Centerline, Untrafficked
Observations

- Subgrade stiffnesses are strongly correlated to CBR values.
- Aging did occur in the first year but very little afterwards.
- Temperature effect on HMA stiffness can be predicted from mix design data.
- Effect of APT trafficking
  - Softening for HMA, crushed stone base, crushed stone base and aggregate subbase combined layer.
  - Stiffening for low strength subgrade.
Recommendations

- FWD data needs to be extensive to allow trend identification
- May need to account for material deterioration or strengthening when predicting pavement performance
- Temperature effect of HMA can be estimated from mix design
Questions?
Moisture Sensors in LFC

Cross Section for CC1_LFC_S along Traffic Direction

- Horizontal Distance (mm)
- Depth (mm)

- HMA
- Crushed Stone Base
- Crushed Quarry Screenings
- Low Strength Subgrade (CS&S)
All Moisture Readings

Moisture Sensor Readings at Different Depth for LFC

Moisture Content

Reading Time

Q2-99 Q3-99 Q4-99 Q1-00 Q2-00 Q3-00 Q4-00 Q1-01 Q2-01 Q3-01 Q4-01 Q1-02 Q2-02 Q3-02
Subgrade Moisture Content Change While Trafficking - LFC

Moisture Sensor Readings at Different Depth for LFC

Moisture Content

Repetition

Z=1301
Z=2336
Z=3352