Rutting Evaluation of HMA & WMA Under High Aircraft Tire Pressure and Temperature at NAPMRC

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“Rutting Evaluation of Hot and Warm Mix Asphalt Concrete Under High Aircraft Tire Pressure and Temperature at National Airport Pavement and Materials Research Center (NAPMRC)”

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- Accepted for publication in the Transportation Research Record: Journal of the Transportation Research Board.
- Selected as “Practice Ready Paper”.

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Navneet Garg, PhD (FAA)
Hasan Kazmee, PhD (ARA)
Tim Parsons, (ARA)
Outline

• Introduction

• Objectives

• Full Scale Tests at NAPMRC (TC1)

• Results

• Summary

• Future Research
FAA Airport Technology R&D Program

• Research conducted at the FAA William J. Hughes Technical Center, Atlantic City, NJ, USA.

• Sponsor: FAA Office of Airport Safety and Standards (AAS100), Washington, DC.

• Provide support for development of FAA pavement standard (Advisory Circulars).
XIV Seminario ALACPA de Pavimentos Aeroportuarios
XII Taller Federal Aviation Administration
VII Curso Rápido de Mantenimiento de Pavimentos de Aeródromos
28/05 al 01/06 2018 – Ciudad de Quito - Ecuador

Título/Title: NAPMRC
Autor/Author: Lia Ricalde, ARA Inc.
Aircraft Tire Pressure Trends

New X Category Limit

Old X Category Limit

Tire Pressure, bar

Aircraft (SWL-kg)
Aircraft Gross Weight Trends

[Published by the International Industry Working Group (IWWG), 2010]
National Airport Pavement Material Research Center (NAPMRC) – Outdoor Test Sections
National Airport Pavement Material Research Center (NAPMRC) – Indoor Test Sections
**Heavy Vehicle Simulator – Airport (HVS-A)**

- Wheel loads - 10,000 (44.48 kN) to 100,000 lbs (444.8 kN).
- Pavement temperatures up to 150°F (67°C)
- Test speeds - 0.17 to 5 mph (0.27 to 8 kmph)
- Single and Dual-Wheel configuration.
- Single wheel - radial aircraft tire size 52x21.0R22
- Dual wheel assembly (B-737-800)
- Wander Width – 6 feet (1.83 m)
Aircraft Gross Weight Trends
Research at NAPMRC

EVALUATION OF NEW ASPHALT TECHNOLOGIES FOR AIRFIELD PAVEMENTS
- Warm Mix Asphalt,
- Stone Matrix Asphalt,
- Polymer Modified Binders,
- RAP Mixes,
- Full-Depth Rehabilitation

PROBLEM: Lack of Guidance/Standards/Specifications
- Lack of Performance Data

Laboratory Performance Evaluation
- Evaluate:
  - Rutting
  - Fatigue
  - Moisture Susceptibility
  - Durability
  - Low Temperature Cracking

Full-Scale APT NAPMRC
- Full-Scale APT:
  - Rutting
  - Fatigue
  - Tire Pressure Effects
  - WMA
  - RAP/RAS
  - Full Depth Reclamation

Field Performance Evaluation
- Field Projects:
  - Lab Evaluation of Field Mixes
  - Construction Evaluation
  - Evaluate:
    - Mix Design Production,
    - Construction Support from AAS-100, ADO

Compare to P-401 HMA
Outline

• Introduction

• Objectives

• Full Scale Tests at NAPMRC (TC1)

• Results

• Summary

• Future Research
Test Cycle 1 (TC1) Objectives

- Compare WMA performance with P-401 HMA performance (rutting);
- Effect of tire pressure on pavement rutting;
- Effect of polymer modified binder (PMA) on pavement rutting;
- Effect of temperature on pavement rutting.
Outline

• Introduction
• Objectives
• Full Scale Tests at NAPMRC (TC1)
• Results
• Summary
• Future Research
Test Parameters – Traffic tests

Test Areas

- Failure Criteria: 1 in (25 mm) surface rut
- Test Speed: 3 mph (4.8 kph)
- Pavement Temperature: 120°F (49°C) measured at a depth of 2-inch (50 mm) below pavement surface

HVS-A

- Wheel Load: 61,300 lbs. (27.8 metric tons)
- Load Module: Single Wheel Load (SWL)
- Tire Pressure: South Test Area – 210 psi (1.45 MPa); North Test Area - 254 psi (1.75 MPa)
HVS-A TC1: Wander Pattern
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  • Results
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NAPMRC TC1: TIRE PRESSURE & BINDER EFFECTS on HMA

Rut Depth, inch

PG 64-22

PG 76-22

L3N: HMA PG76-22; 254 psi
L3S: HMA PG76-22; 210 psi
L4N: HMA PG64-22; 254 psi
L4S: HMA PG64-22; 210 psi

Pasess
NAPMRC TC1: TIRE PRESSURE & BINDER EFFECTS on WMA

- PG 64-22
- PG 76-22

Rut Depth, inch

Passes

L1N: WMA PG76-22; 254 psi
L1S: WMA PG76-22; 210 psi
L2N: WMA PG64-22; 254 psi
L2S: WMA PG64-22; 210 psi
NAPMRC TC1: MATERIAL & BINDER EFFECTS AT LOW TIRE PRESSURE

Titulo/Title: NAPMRC

Autor/Author: Lia Ricalde, ARA Inc.
NAPMRC TC1: MATERIAL & BINDER EFFECTS AT HIGH TIRE PRESSURE

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<th>Passes</th>
<th>Rut Depth, inch</th>
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<tr>
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<tr>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>4500</td>
<td></td>
</tr>
</tbody>
</table>

- L1N: WMA PG76-22; 254 psi
- L2N: WMA PG64-22; 254 psi
- L3N: HMA PG76-22; 254 psi
- L4N: HMA PG64-22; 254 psi

Titulo/Title: NAPMRC

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NAPMRC TC1: TEMPERATURE, MATERIAL & BINDER EFFECTS AT HIGH TIRE PRESSURE

- L1N: WMA PG76-22; 254 psi; 120 deg.F
- L3N: HMA PG76-22; 254 psi; 120 deg.F
- L1C: WMA PG76-22; 254 psi; 90 Deg.F
- L3C: HMA PG76-22; 254 psi; 90 deg.F
Titulo/Title: NAPMRC

Autor/Author: Lia Ricalde, ARA Inc.
NAPMRC-TC1 NORTH TEST AREA (254-psi; 120°F)

No. of Passes to Failure: 610
Traffic Tests Terminated: 2914

No. of Passes to Failure: 170
Traffic Tests Terminated: 496

No. of Passes to Failure: 870
Traffic Tests Terminated: 3968

No. of Passes to Failure: 150
Traffic Tests Terminated: 620
NAPMRC-TC1 CENTER TEST AREA (254-psi; 90°F)

No. of Passes to Failure: No Failure
Traffic Tests Terminated: 5022

No. of Passes to Failure: 3000
Traffic Tests Terminated: 5022

No. of Passes to Failure: No Failure
Traffic Tests Terminated: 5022

No. of Passes to Failure: 2600
Traffic Tests Terminated: 5022

Titulo/Title: NAPMRC

Autor/Author: Lia Ricalde, ARA Inc.
### TC1 Post traffic Tests

#### Loose Mix with Two Replicates

<table>
<thead>
<tr>
<th>Test Priority</th>
<th>Schedule Priority</th>
<th>Test Objective</th>
<th>Test Type</th>
<th>Number of Reported Tests</th>
<th>Standard Specification</th>
<th>Performing Organization</th>
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<td>Bulk Specific Gravity, G&lt;sub&gt;mb&lt;/sub&gt;</td>
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<td>FAA Materials Lab</td>
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<td>Rutting Potential</td>
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<td>2</td>
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<td>IDT Dynamic Modulus</td>
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<td>Semi-Circular Bend (Intermediate Temp)</td>
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<td>8</td>
<td>AASHTO TP105</td>
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#### Field Cores with Two Replicates

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<th>Test Type</th>
<th>Number of</th>
<th>Standard Specification</th>
<th>Performing Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quality Assurance</td>
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<td>Fatigue Performance</td>
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<td>6</td>
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<td>AASHTO TP105</td>
</tr>
</tbody>
</table>
Indirect Tensile Strength of Field Cores and Laboratory Compacted Specimens

Test Lanes and Mix Type

L1 WMA PG76-22
L2 WMA PG64-22
L3 HMA PG76-22
L4 HMA PG64-22
L5 WMA PG76-22
L6 HMA PG76-22

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• Future Research
Summary

• Comparable Performance in rutting.
• Cracking performance need to be evaluated (TC2).

Compare WMA performance with P-401 HMA performance (rutting)

Effect of tire pressure on pavement rutting;

Effect of polymer modified binder (PMA) on pavement rutting;

Effect of temperature on pavement rutting.

• Rutting performance of HMA/WMA is more sensitive to temperature than tire pressure.
• Significant effects on mixes with unmodified binders.
• Insignificant effects on mixes with PMA.

Compare WMA performance with P-401 HMA performance (rutting)
Outline

• Introduction
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Test Cycle 2 (TC2) Objectives

- Compare Warm Mix Asphalt (WMA) performance with P401 Hot Mix Asphalt (HMA) performance
- Rutting (at high temperature)
- Fatigue

- Evaluate different WMA technologies
  - Waxy additive
  - Chemical additive
  - Hybrid

- Compare WMA/RAP performance with P401 Hot Mix Asphalt (HMA) performance
- Rutting (at high temperature)
- Fatigue
Pavement Cross Section: TC2 Outdoor Lanes

- **P-401 HMA/WMA SURFACE**
  - 9 inches

- **P-209 CRUSHED STONE BASE**
  - 8 inches

- **P-154 SUBBASE**
  - 12 inches

- **SANDY SUBGRADE**
  - CBR 15
Pavement Cross Section: TC2 Indoor Lanes

9 inches
WMA/RAP SURFACE

8 inches
P-209 CRUSHED STONE BASE

12 inches
P-154 SUBBASE

3 inches
WMA SURFACE

6 inches
WMA/RAP

CBR 15
SANDY SUBGRADE
TC2 Test Sections Plan View

- **MATERIAL**
- **RUTTING** (test at high temperature)
- **CRACKING** (test during winter)
- **Tire Pressure** 254 psi
Future Research

PANDA-AP (Pavement Analysis using Non-linear Damage Approach for Airports) is currently being developed.

- Implements mechanistic-based models that account for damage and rutting not only in the asphalt concrete layer but also unbound pavement layers (including base, sub-base, and subgrade).
- Drucker-Prager CAP model for unbound materials, and stress-dependent material behavior.
- Compare performance of different asphalt mixes, and pavement structures. Results from NAPMRC and NAPTF are being used to calibrate PANDA-AP.
Questions?