Development of New Moisture Sensitivity Test for HMA Pavements

Northeast Asphalt User/Producer Meeting
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Northeast Center of Excellence for Pavement Technology
Pennsylvania Transportation Institute
NCHRP Research Project 9-34

Improved Conditioning Procedure for Predicting the Moisture Susceptibility of HMA Pavements

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Period: April 2002 – March 2004
Research Team

Pennsylvania State University
University of Texas at El Paso
Advanced Asphalt Technology
PaveTex Engineering & Testing
Main Objective

ECS/SPT System:

Simple Performance Tests (SPT)

+ 

Environmental Conditioning System (ECS)
Project Objectives

- Sensitivity of SPT conditioned with ECS – Phase I
- Modifications to the ECS conditioning procedure – Phase II
- The most reliable ECS/SPT procedure
- Compare the ECS/SPT method with
  - ASTM D4867 – Conditioning & indirect tensile strength
  - Hamburg wheel tracking test
  - ECS/split tensile test as a potential surrogate
- Preliminary ECS/SPT test method in AASHTO standard format
What Is Important?

- Chemistry Extremely Important!

  Adhesion, Surface Energy, ...

- Practitioner’s Guide

  - What Properties to Look for?
  - System Compatibility?
  - What Adhesion Promoter and How Much?
What Is Important?

Pay attention to

mix, traffic, and environment

- Binder Content
- Binder Stiffness
- Air Void Level and Size
- Connectivity of Voids
- Traffic Effect: Pumping & Hydrostatic Pressures
Pore Pressure Effect

Pore Pressure Build-Up
Due to External Cyclic Stress
Hydraulic Scouring

Compression/Tension Cycle

Stripping Starts at the Surface
Progressing Downward

Saturated Surface
Need a Mechanical Mixture Test

Minimize Moisture Damage
New Mixture Tests

- There are shortcomings with existing tests

- NCHRP 9-34:
  - Trying to have one reliable testing system for both rutting & moisture damage
  - Conduct at two phases
# Phase-I Tests

## Testing Matrix for SPT Sensitivity

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<th>Agg.</th>
<th>SPT Tests</th>
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<td></td>
<td>Dynamic Modulus</td>
<td>Axial Creep</td>
<td>Axial Repeated</td>
<td>ASTM D4867</td>
<td>HWTD</td>
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Phase II

- Identify A Practical, Reliable ECS/SPT Method
  - Conditioning Temperature
  - Confining Pressure
  - Conditioning Time
  - Conditioning Load
  - Conditioning Load Duration
Phase II

HMA Variables Considered

- Gradation
- Binder Content
- Binder Type
- Air Voids
- Adhesion Promoter Agent
Where Are We?

Phase-I

- Materials Selected & Procured
- TSR and HWTD Completed
- ECS/SPT Testing in Progress
Materials

- Limestone from Colorado Materials, Hunter, TX.
- Sandstone from Martin Marietta Materials, Sawyer, OK
- Granite from Vulcan Materials, Richmond, VA
- Unmodified PG 70-22
Environmental Conditioning System

- Developed at OSU as part of SHRP A-003A
- SHRP Period 1987-1993

- Improved at UTEP under TxDOT Project
  - Repeatability
  - Rigidity
  - Strain Measuring System
  - Controlling Water Temperature
  - Confining Pressure
Environmental Conditioning System

Environmental Conditioning Chamber

Loading Subsystem

Personal Computer
Signal Conditioning Unit

Differential Pressure Gauge

Vent Valves
Drain Valves

Pressures Gauges
Air Flow Meters

Vacuum Regulator
Vacuum Valve
To Vacuum Pump

Water Flow Meters

Vacuum Pump

To Compressor Air Filter
Current ECS Testing

Measure Resilient Modulus  
before and after Conditioning

- Specimen Size: Dia: 100 mm, H: 100 mm
- Conditioning Temperature  60 °C
- Confining Pressure  2.5 inches of mercury
- Conditioning Time  6-18 hours
- Conditioning Load  200 lbs
- Haversine Load
  - 50 to 100 Microstrain
  - 0.1 sec loading period – 0.9 sec rest period
Simple Performance Tests

Candidate Tests

- Dynamic Modulus
- Creep Test (Flow Time Test)
- Repeated Load Test (Flow Number Test)
Dynamic Modulus Test

- Stress
- Strain

\[ E^* \]

Rutting
Fatigue Cracking

Time

\[ ? \frac{?}{0} \]

\[ ?_0 \]
Creep Flow Time Test

- Rutting
Repeated Load Perm. Deformation Test

- Rutting
Comparisons

Compare the ECS/SPT method with

- ASTM D4867 – Conditioning & indirect tensile strength
- Hamburg wheel tracking test
- ECS/Split Tensile test as a potential surrogate
Tensile Strength Ratio
Moisture Sensitivity – ASTM D 4867

- Compaction:
  - Superpave Gyratory Compactor
  - Eight specimens

- Two subsets with equal voids
  - One - “dry”
  - One – “conditioned”
Moisture Sensitivity – ASTM D 4867

- Conditioning
  - freeze cycle
  - hot water soak

16 hours @ -18 °C
24 hours @ 60 °C
Moisture Sensitivity – ASTM D 4867

Determine Tensile Strength Ratio (TSR)

Avg Dry Tensile Strength

51 mm / min @ 25 °C

Avg Wet Tensile Strength

TSR = \frac{\text{Wet}}{\text{Dry}} \approx 80 \%
Hamburg Wheel Tracking
Hamburg Wheel Tracking Device (HWTD)

 Halifax Procedure

½” Rut Depth
Test Temp.: 50 °C
# of Passes: 20,000
Hamburg Wheel Tracking - Specimens

Two Cylindrical Specimens
Hamburg Wheel Tracking - Specimens
Results
TSR Results

ASTM D4867

Tensile Strength Ratio (Percent)

0 20 40 60 80 100

Sawyer Sandstone  Texas Limestone  Virginia Granite

Aggregates Used in Phase I
HWTD Results

Hamburg Wheel Tracking Test
Test Method Tex-242-F

Rut Depth, mm

No. of Passes

0 5000 10000 15000 20000 25000

0 1 2 3 4 5 6
HWTD Results

HWTD - Temp = 50 C, 20,000 passes

Max. Impression (mm)

Sawyer Sandstone  Texas Limestone  Virginia Granite

Aggregates Used in Phase I
ECS/SPT Results

RepeateD Axial load Strain Test

Axial Permanent Strain, %

Pulses

0  2000  4000  6000  8000  10000  12000

-0.10  0.00  0.10  0.20  0.30  0.40  0.50  0.60
SUMMARY

- Can SPT be Used with ECS System to Identify Moisture Damage?
- If So, What Modifications Are Required?
- What Would be the Most Reliable ECS/SPT Procedure?
- How Does It Compare with the Following?
  - ASTM D4867 – Conditioning & indirect tensile strength
  - Hamburg wheel tracking test
  - ECS/split tensile test as a potential surrogate
Thank You!