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  - Mike Cook

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  - Advera - Annette Smith
  - Evotherm - Everett Crews
  - Sasobit - John Shaw, Larry Michael
Summary

• Objectives
• Study questions
• Experiment design
• Experiment layout
• Pavement and mix design
• Test track construction
• HVS testing
• Laboratory testing
Objectives

- Determine whether the addition of additives to reduce the production and construction temperatures of asphalt concrete influences performance
- Additives tested:
  - Advera
  - Evotherm
  - Sasobit
Summary

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Study questions

• What is the comparative energy usage during mix preparation?
• Can satisfactory density be achieved at lower temperatures?
• What is the optimal temperature range for achieving compaction requirements?
• What are the cost implications?
• Does the addition of the additive influence rutting performance of the mix?
Study questions

• Is the treated mix more susceptible to moisture sensitivity given that the aggregate is heated to lower temperatures?
• Does the addition of the additive influence fatigue performance?
• Does the addition of the additive influence skid resistance?
• Does the addition of the additive influence the performance of the mix in any other way?
• If the experiment is extended to rubberized and open-graded mixes, are the benefits of adding the additives to these mixes the same as for conventional mixes?
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Experiment design

- **Phase 1**
  - Early rutting potential at elevated temperatures
  - FMFC Laboratory testing
    - Shear (T320)
    - Fatigue beam (wet & dry) (T321)
    - Hamburg Wheel Test (T324)
    - Tensile Strength Ratio (CT371)

- **Phase 2**
  - Moisture sensitivity?
  - LMLC Laboratory testing?

- **Phase 3**
  - Fatigue?

- **Phase 4**
  - Aged rutting?
Experiment layout

- **Location**
  - Graniterock AR Wilson Quarry, Aromas, CA
- **Test track**
  - 80m x 8m
- **Test sections**
  - 4 sections
  - 40m x 4m
  - 3 or 4 HVS experiments
Summary

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Pavement design

Layer: Bedrock
Thickness: Semi-infinite
Modulus: >3,000 MPa

Layer: Existing Subbase
Thickness: 250 mm
Modulus: 400 MPa

Layer: Imported Class 2 Aggregate Base
Thickness: 300 mm
Modulus: 150 MPa

Layer: DGAC
Thickness: 2 x 60 mm = 120 mm
Modulus: 1,000 MPa
Mix design

- **Mix design**
  - “Standard” Graniterock mix design
  - Mix design not changed for additives
  - PG64-16 binder
  - No anti-strip added

- **Control mix temperature**
  - 155°C (310°F)

- **Warm-mix temperature**
  - 120°C (250°F)
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Base construction
Base construction
Test track construction

- **Surfacing**
  - All mix produced first
  - 150 tons per mix
  - Stored in silos
  - 1st 25 tons “wasted”

- **Process**
  - Prime coat
  - 4 x lower lifts placed (60mm)
  - Tack coat
  - 4 x upper lifts placed (60mm)

- **Strain gages installed on base**
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction
Test track construction - QC

Control - Average 135°C (275°F)
WMA - 105°C to 117°C (220°F to 240°F)
Test track construction - QC

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Temperature (°C)
## Test track construction - QC

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<tr>
<td>Binder content (%)*</td>
<td>5.29</td>
<td>5.14</td>
<td>5.23</td>
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<td>MC before (%)</td>
<td>0.24</td>
<td>0.41</td>
<td>0.37</td>
<td>0.31</td>
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<td>MC after (%)</td>
<td>0.09</td>
<td>0.25</td>
<td><strong>0.32</strong></td>
<td>0.25</td>
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<tr>
<td>Air voids (%)</td>
<td>5.61</td>
<td>5.39</td>
<td><strong>7.13</strong></td>
<td>6.99</td>
</tr>
</tbody>
</table>

* Range 4.7 - 5.7, target 5.2
Test track construction
Test track construction - QC
Test track construction - QC
Summary

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HVS overview

• 1 of 2 Caltrans machines
• 8 worldwide + 2
• Designed and built in S. Africa
• Capability
  - 30 - 205kN (7-67kps)
  - 1,000 load applications/hour
  - 13km/h wheel speed
  - Uni/bidirectional
  - Channelized/wander
  - Dynamic loading
  - Dual, wide-based, aircraft tires
  - Environmental chamber
  - Mobile and self-propelled
HVS instrumentation

- Load calibration
  - WIM, hydraulic sensor
- Temperature
  - Thermocouples/temperature buttons
- Deflection
  - Road surface deflectometer (RSD)
  - Multi-depth deflectometer (MDD)
  - Joint deflectometer (JDMD)
- Permanent deformation
  - Laser profilometer
  - Multi-depth deflectometer (MDD)
- Tire contact stress
  - 3-d load cell
Phase 1 testing plan

- **Pavement temp**
  - 50°C at 50mm (122°F at 2in)
  - 55°C at 50mm after 155,000 reps
- **Load**
  - 40kN (9,000 lbs)
  - 60kN after 185,000 reps
- **Tires**
  - Dual, 720kPa (104psi)
- **Traffic**
  - Unidirectional, channelized
- **Failure criteria**
  - 12.5mm (½ in) rut
Control - 195,000 reps
Rut progression

Number of Load Repetitions

Control
Control - profile

![Graph showing average displacement vs. transverse distance](image)

- Transverse Distance (mm)
- Average Displacement (mm)

- Control
- 600FD
Control – contour plot

Transverse Distance (mm)

Stations

Color Map for Profilometer Reading (mm)
Summary

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FMFC sampling
Lab - Experimental design

- **Shear (RSST-CH)**
  - AASHTO T320
  - 2 temperatures (45°C and 55°C)
  - 3 stresses (70kPa, 100kPa, 130kPa [230kPa])
  - 3 replicates
  - 6 frequency sweeps

- **Flexural Fatigue Beam**
  - AASHTO T321
  - 3 temperatures (10°C, 20°C and 30°C)
  - 2 strains (200µstrain and 400 µstrain)
  - 3 replicates
  - 6 frequency sweeps
Lab - Experimental design

- **Moisture sensitivity**
  - Hamburg Wheel Test
    - AASHTO T324 - 4 replicates
  - Tensile Strength Ratio
    - CT371 - 3 replicates
  - Flexural Fatigue Beam (wet)
    - AASHTO T321
    - 3 temperatures (10°C, 20°C and 30°C)
    - 2 strains (200µstrain and 400 µstrain)
    - 3 replicates
    - 6 frequency sweeps
RSST - Cycles to 5% PSS
Rut progression

![Graph showing rut progression with number of load repetitions on the x-axis and total rut (mm) on the y-axis. The graph includes a line labeled 'Control.' The x-axis ranges from 0 to 300,000 load repetitions, and the y-axis ranges from 0 to 14 mm.]
Master curve (Fatigue beam, dry)

WMA FMFC (Dry, $T_{\text{ref}} = 20^\circ$C)

Reduced $\ln(\text{freq})$ (Hz) vs. $E^*$ (MPa)
Way forward

• Complete lab study
• Begin Phase 2 HVS testing
  - Moisture sensitivity or fatigue
• Reports
  - 1st Level Report – Construction
  - 1st Level Report – Phase 1 rutting study
  - End June 2008.