California Warm-Mix Asphalt HVS Study

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Warm-mix asphalt Technical Working Group
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Summary

• Objectives
• Study questions
• Experiment design
• Experiment layout
• Pavement and mix design
• Test track construction
• HVS overview
• Testing plan
• Test summary
• Deliverables
Objectives

• Determine whether the addition of additives to reduce the production and construction temperatures of asphalt concrete influences performance

• Additives tested:
  - Advera
  - Evotherm
  - Sasobit
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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 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 I**
  - Early rutting potential at elevated temperatures
  - FMFC Laboratory testing
    - Shear
    - Fatigue beam (wet & dry)
    - Hamburg Wheel Test
- **Phase II**
  - Moisture sensitivity
  - LMLC Laboratory testing
- **Phase III**
  - Aged rutting?
- **Phase IV**
  - Fatigue?
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
Experiment location

Graniterock quarry and plant
Experiment location

- Quarry operations
- Proposed site
- Quarry pit
- Access road
- Haul road for early opening assessment
- AC Plant
Experiment location

- Preferred site - 80mx8m
- Quarry operations access road (sealed)
- Shed roof will require gutter
- Slope direction
Before construction
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Pavement and mix 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
Pavement and 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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Test track construction

- Base
  - One-day construction
  - Some over watering
  - QC
    - Density
    - FWD testing
    - LWD testing
  - Moisture sensors installed
Base construction
Base construction
Base construction
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
  - Tack coat
  - 4 x upper lifts placed

- **Strain gages installed on base**
Test track construction
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• Lab compact specimens
  - Mix sampled during construction
  - Slabs compacted with rolling wheel
  - Cut and cored for testing

• Field compact specimens
  - Trench on section
  - 400x400mm slabs
  - Cut and cored for testing
Test track construction
Test track construction
Test track construction - QC

- **Base**
  - Density & moisture content
  - Stiffness (FWD, LWD)
- **Mix**
  - Temperature
  - Binder content
  - Air void content
  - Moisture content
  - Grading
  - Density
- **Test track**
  - Temperature
  - Density
  - Thickness
  - Stiffness (FWD)
  - Skid resistance
Test track construction - QC

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

• Control section
  - Test complete
  - 12.5 mm rut after 195k reps
  - Load at 60kN, temp at 55°C
  - 240,000 ESALs

• Advera
  - 100,000 reps applied to date

• Evotherm, Sasobit

• Results will be released on completion of all testing
Phase I HVS test
Control - 195,000 reps
Control - rut progression

- Maximum Rut (mm) vs. Number of Load Repetitions (Million)
- Graph shows increasing rut depth with increasing repetitions
- Line represents the progression of rut depth over time
- Data points indicate variability in rut depth with repetitions
- 600FD line highlights a specific trend or condition
Control - profile

Average Profile for Section 600FD Up to Repetiton 187000

Transverse Distance (mm)

Average Profile (mm)

-10  -8  -6  -4  -2  0  2  4

-1000 -500  0  500  1000  1500

- Repetition=155000
- Repetition=185100
- Repetition=185200
- Repetition=185500
- Repetition=186000
- Repetition=187000
Control - contour plot

Section 600FD, Repetition = 0.195 Million

Transverse Distance (mm)

Stations

Color Map for Profilometer Reading (mm)

-10.5 -8.3 -6.1 -3.9 -1.8 0.4 2.6 4.8
Phase I test summary

- Laboratory testing
  - Fatigue beam, shear, and HWT specimen prep
  - Testing in progress
  - Results released on completion of all testing
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Deliverables

- Detailed work plan
- Construction report
- Detailed 1\textsuperscript{st} level analysis reports for each phase
- Laboratory testing report
- Detailed 2\textsuperscript{nd} level analysis report
- Summary report