RUSS COLLEGE of Engineering and Technology

Warm Mix Asphalt Perpetual Pavement

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Warm Mix Asphalt (WMA) Background

- Warm Mix Asphalt (WMA) was first Introduced in Europe in 1995
- Advantages:
  - reduced energy consumption in mix preparation,
  - reduced emissions and consequently reduced fumes and undesirable odors,
  - reduced binder aging,
  - extended construction seasons in temperate climates.
- WMA requires additives, which add to the cost, however the additional expenditure is offset by energy savings and reduced emissions

Four kinds of WMA

- Aspha-min
  - Addition of sodium aluminum silicate or zeolite in a machine.
- Evotherm
  - Includes additives in the form of an emulsion to improve the coating and workability of WMA mixes.
- Sasobit
  - Uses foam in the form of a paraffin-wax compound extracted from coal gasification.
- WAM-Foam
  - Uses a soft binder and a hard foamed binder added at different times during the mixing process.
- In ORITE research, only the first three are being investigated
  - WAM-Foam dropped from project in consultation with Ohio Department of Transportation (ODOT) engineers and Flexible Pavements of Ohio

Aspha-Min mixing at asphalt plant

Previous Research in the USA

- Field demonstration projects in Florida, North Carolina, and Tennessee
- National Center for Asphalt Technology (NCAT) at Auburn University reports on Aspha-min (Report 05-04) and Sasobit (Report 05-06)
  - Improved compaction at temperatures as low as 190°F (88°C)
  - No effect on resilient modulus or rutting potential
  - Potential for increased susceptibility for moisture damage
    - For Aspha-min this can be reduced by adding hydrated lime

ORITE research project

- Detailed field, controlled environment, and laboratory evaluation of Aspha-min, Evotherm, and Sasobit and Conventional mixes
  - Field study in Guernsey County, OH on State Route 541
  - Controlled load and environment test at ORITE's Accelerated Pavement Load Facility (APLF) in Lancaster, OH
  - Laboratory studies of cores, field-procured beams and prepared specimens
- Project sponsored by the Ohio Department of Transportation (ODOT) and the the US Federal Highway Administration (FHWA)

GUE-541 Field Study

- Four test sections on asphalt overlay of State Route 541 in Guernsey County between Kimbolton and Plainfield, West of I-77
  - Site selected by ODOT
  - Overlay constructed first half of September 2006
  - Contractor: Shelley and Sands, Inc.
- Overlay layers
  - Top: 1.25 in (3.18 cm) of selected mix
    - Aspha-min, Sasobit, Evotherm, or conventional Hot Mix Asphalt (HMA)
  - Bottom: 0.75 in (1.90 cm) HMA
- Section lengths: 2.70 miles (4.34 km) to 3.07 miles (4.94 km)

GUE-541 Forensic Assessment of Existing Pavement Structure

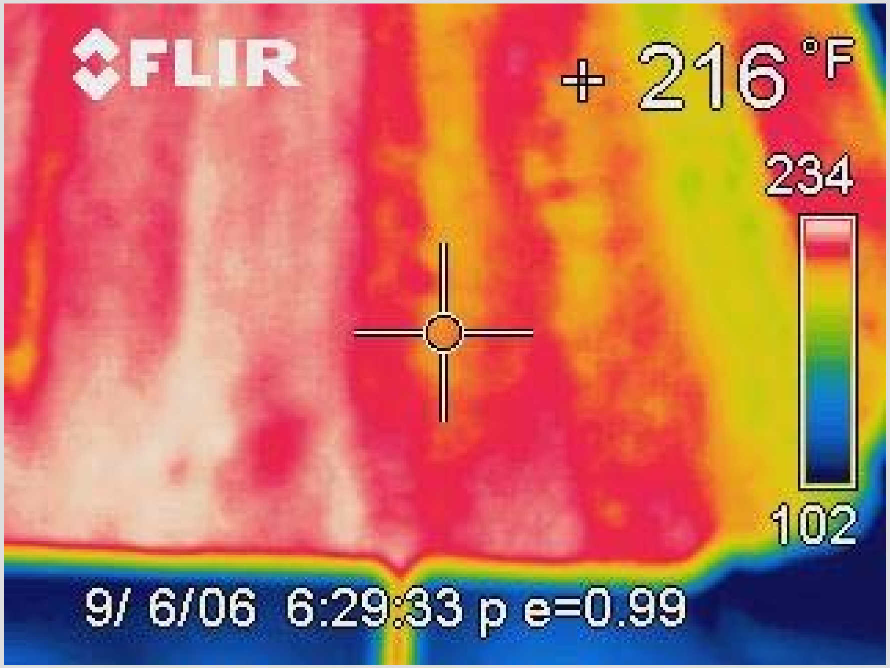
- Falling Weight Deflectometer (FWD)
  - Back calculate pavement layer stiffness
- Surface Profile
- Dynamic Cone Penetrometer (DCP)
- Forensic analysis used to identify weak spots needing remediation prior to overlay

GUE-541 Construction Monitoring

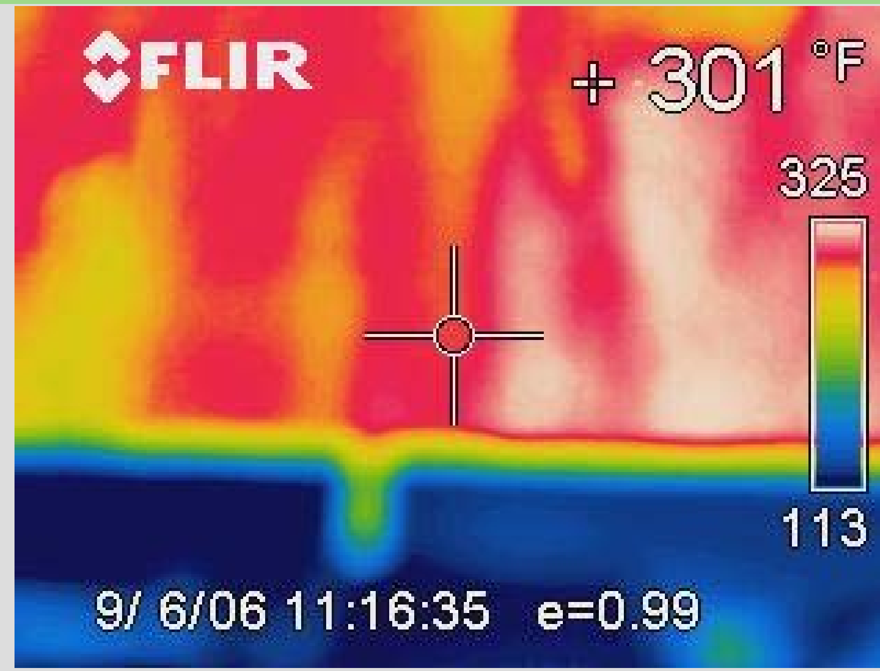
- FWD after overlay prior to traffic and at subsequent time intervals
- Periodic visual surveys of pavement surface condition
- Infrared camera used to measure temperature during construction
  - Temperature variations may be compared to possible variations in asphalt density
- Profilometer measurements
- Forensic analysis following Strategic Highway Research Program (SHRP) protocol of any sections showing distress during three-year research period

Infrared Camera

Images from APLF



Evotherm



Conventional HMA

Note with software program cursor can be moved and temperature read off upper right corner.

Temperatures in Fahrenheit (216°F=102°C, 301°F=149°C)

Energy, Emissions, and Cost Assessment

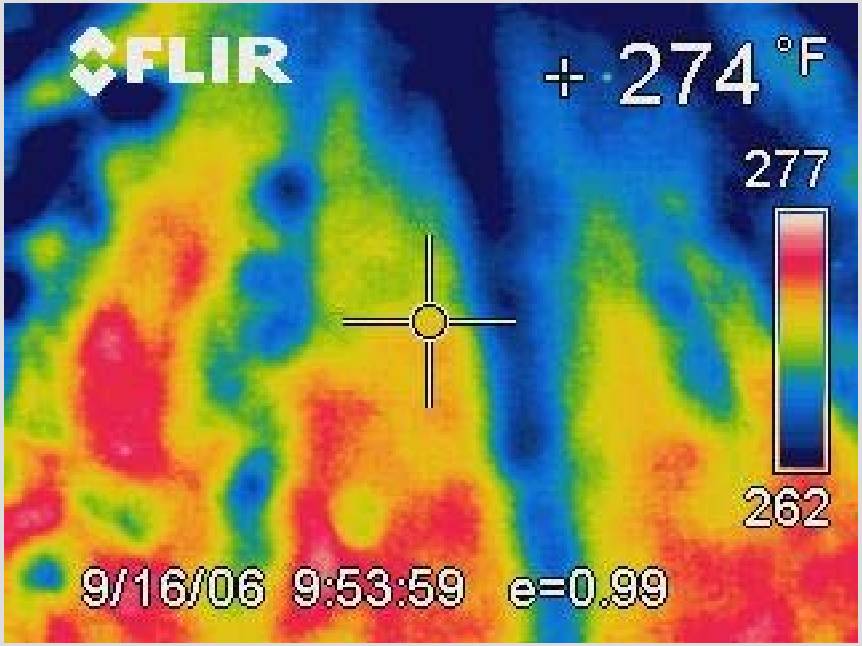
- Stack and Emissions tests by Mar-Zane Materials Quality Control Laboratory of Shelly and Sands
- Exposure/emissions sampling during construction by EES Group
  - Environmental sensors placed on paver and along side of road
- Construction costs for each section were also noted

Emissions sampling on paver

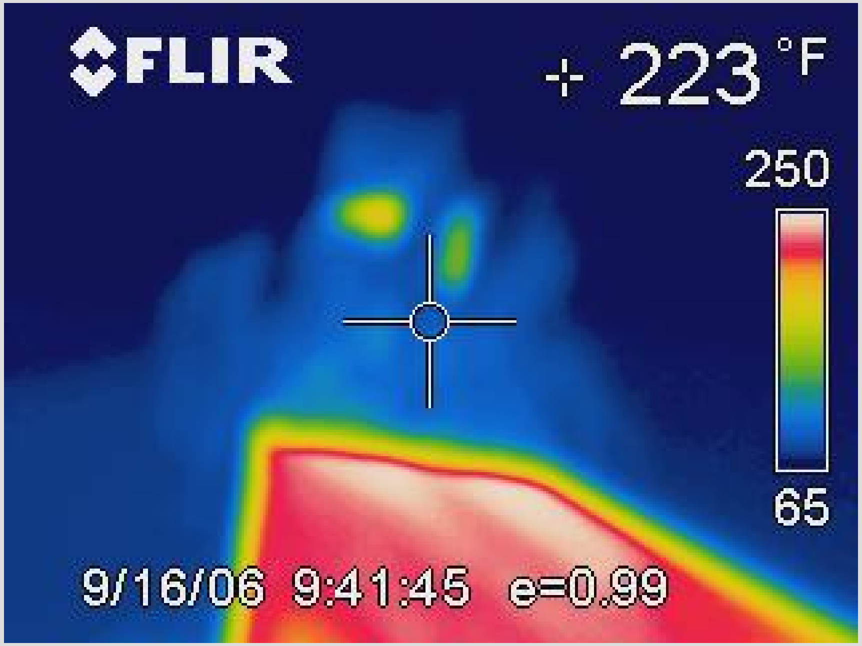
Roadside emissions sampling

Infrared Camera

Images from GUE 541



Sasobit WMA



Sasobit WMA

Temperatures in Fahrenheit (216°F=102°C, 301°F=149°C)

Controlled Load and Environment Testing at the APLF

- WMA and HMA surface layers have been built and will be tested at the Accelerated Pavement Load Facility (APLF)
  - Same types as those used on GUE-541 (Aspha-min, Evotherm, Sasobit, and HMA)
  - Built on perpetual pavement sections at two thicknesses
- Planned Testing under load at three temperatures:

  high (100°F (38°C)),
  medium (70°F (21°C)),
  and low (40°F (0°C))
- FWD
- Collect Pavement Response data
- Infrared camera (during construction)

Accelerated Pavement Load Facility (APLF)

- Complete, full-scale two-lane pavement, base, and subgrade construction.
- Testing of Asphaltic Materials and PCC.
- Full environmental control to regulate humidity and temperature from 10°F (-12°C) to 130°F (54°C).
- Multiple test paths across the 32-ft (9.75 m) wide pavement.

- A rolling tire load of 9000 lb (40 kN) to 30,000 lb (133 kN) can be applied to simulate a passing truck with standard single or dual tires or wide single tires, up to 500 times per hour

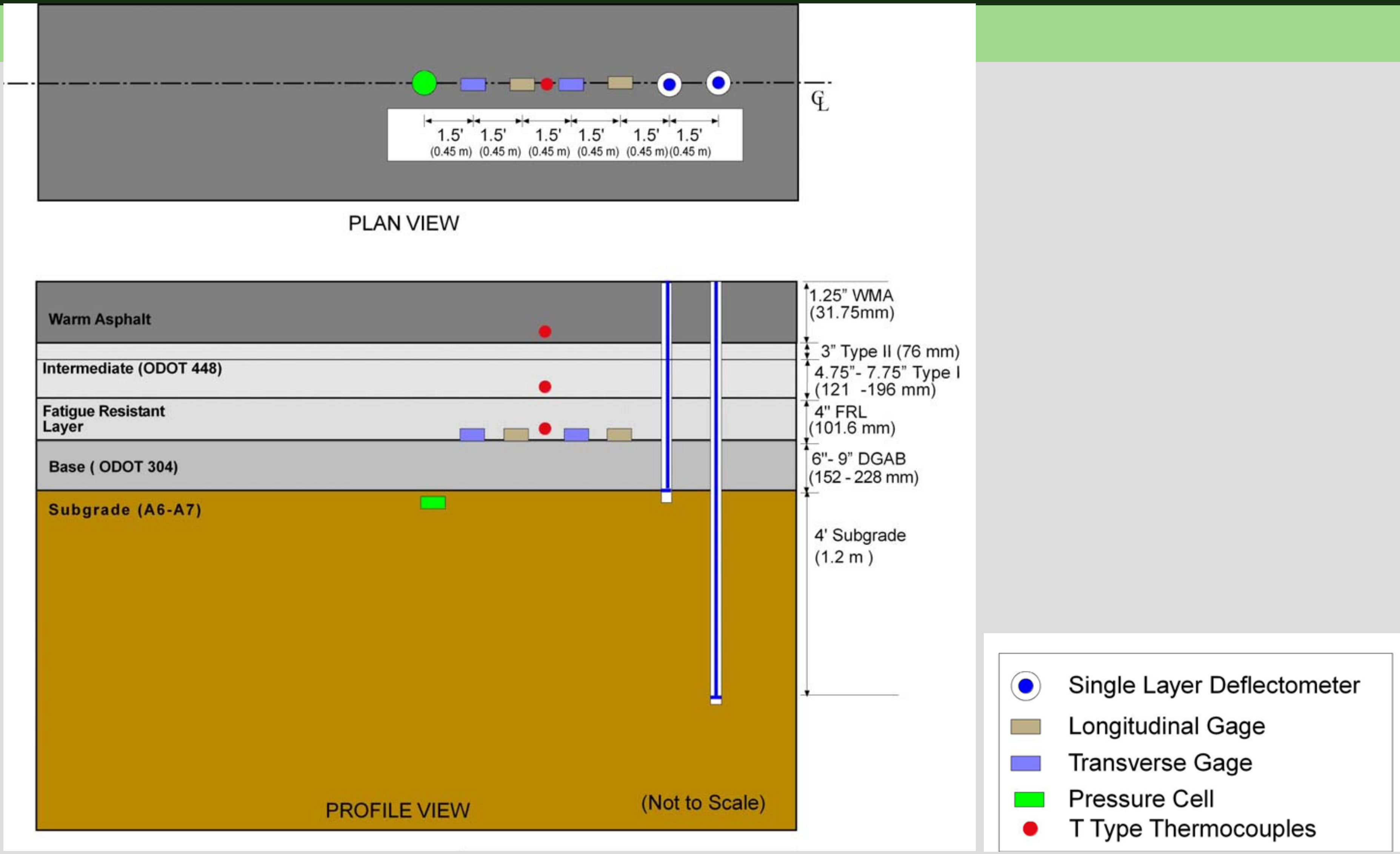
APLF Monitoring

- Environmental parameters
  - pavement layer temperature
  - Base temperature and moisture
  - Subgrade temperature, moisture, and groundwater table
- Load parameters
  - Displacement
  - Strain
  - Pressure
- Also seasonal response in terms of displacement and pressure

Pavements constructed in APLF

Surface	Direction of wheel →		Lane width
Evotherm WMA	1.25” (3.18 cm) Evotherm WMA 3” (7.62 cm) ODOT 448 Type II AC 4.75” (12.1 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 9” (22.9 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Evotherm WMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
Sasobit WMA	1.25” (3.18 cm) Sasobit WMA 3” (7.62 cm) ODOT 448 Type II AC 5.75” (14.6 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 8” (20.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Sasobit WMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
Aspha-min WMA	1.25” (3.18 cm) Aspha-min WMA 3” (7.62 cm) ODOT 448 Type II AC 6.75” (17.1 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 7” (17.8 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Aspha-min WMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
Conventional HMA	1.25” (3.18 cm) Conventional HMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Conventional HMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
	← 22.5 ft (6.9 m) →	← 22.5 ft (6.9 m) →	

Instrumentation in APLF



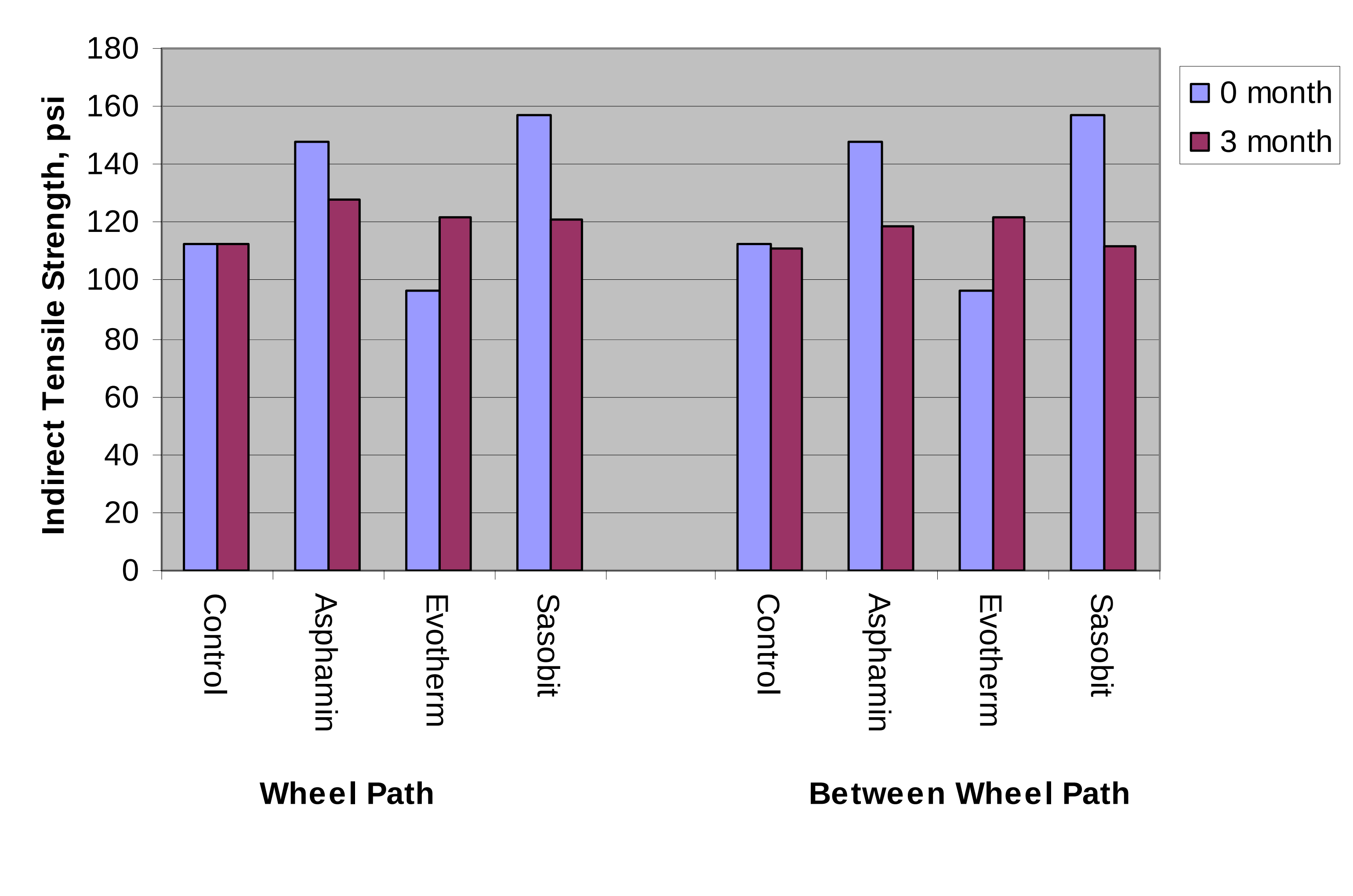
Laboratory Tests

- Based on samples of mixes and additives taken at the APLF and at GUE-541
- Samples taken at the time of construction
- Additional core samples taken or to be taken at GUE-541 after construction
  - Three months, one year, two years
- Testing by both ORITE and NCAT

ORITE Laboratory Tests

- Density Tests at time of construction, and after three months, one year, and two years.
- Bond strength between layers
- Assessment of reduced aging during construction.
- Indirect tensile strength determined at 77 °F (25°C), after three months, one year, and two years.
- Assessment of in-place densification under traffic, and relation to air voids at time of construction.
- Aging of binder as a function of time.
- Beam fatigue tests (AASHTO T321).
- Fracture energy – an alternative method of assessing resistance to cracking.
- Other methods of assessing cracking potential may also be used, such as the TTI overlay tester.
- Low-temperature cracking (IDT test (AASHTO T322))

Indirect Tensile Strength (0 & 3 month cores)



NCAT Laboratory Tests

- Moisture content in truck at time of application,
- Gyratory compaction,
- Volumetric properties,
- Hamburg Tests for moisture susceptibility and rutting,
- Rutting potential,
- Maximum specific gravity,
- Tensile strength ratio test,
- Anticipated in-place field density
- Thermal stress restricted specimen test may be conducted as an option

http://webce.ent.ohiou.edu/orite/