Bonded Pavements

Tack to the Max
NCAUPG

2/3/2010

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Bonded Pavement Definition

- A bonded pavement consists of asphalt overlays applied over a uniform, undisturbed and uncontaminated application of tack coat
- The tack is an undiluted Polymer Modified Emulsion Membrane (PMEM) applied at a higher designed application rate than conventional tack coat for enhanced performance of the overall pavement

Outline

- Tack – Why it is what it is!
- Does poor bonding affect pavements?
- Do we need bonded pavements?
  - Pavement structural design considerations
  - Simple experimental Demonstration
- Recent findings:
  - Effect of tack coat on pavement performance and distress mitigation
  - New tests and QC/QA possibilities
  - Specification recommendations
- Concluding remarks

Conventional Tack Coat

- Conventional Tack
  - Type – SS-1 or CSS-1
  - Quantity – 0.1 Gal/YD^2 (Diluted 50%)
  - Delivery – Distributor
- Why? – Aid Compaction and Avoid Delamination
  - Type – Stability/Cost/Availability
  - Quantity – Curing/Tracking/Cost-Benefit
  - Distributor – Availability/Speed
- Results
  - Minimum Lift Thicknesses
    - For effective service life
  - Pavement design assumed full bonding
  - No in place performance specifications

Construction Considerations

- Challenges with tack coats when conventionally applied
  - Relatively low application rate and uniformity
  - Contamination and tracking

Source: http://pavementinteractive.org
(Washington State Projects)

Does poor bonding affect pavements?

How bonded are pavement layers?

- Slippage cracks

California - 2003

How bonded are pavement layers?

- Slippage

Utah - 2009

How bonded are pavement layers (Cont.)?

- Slippage (Cont.)

How bonded are pavement layers?

- Premature pavement failure – within 1 year
  - Longitudinal cracking near the wheel path and rutting

Utah - 2008

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How bonded are pavement layers ?

- Premature pavement failure – within 1 year (Cont.)
  - Longitudinal cracking in the wheel path and rutting

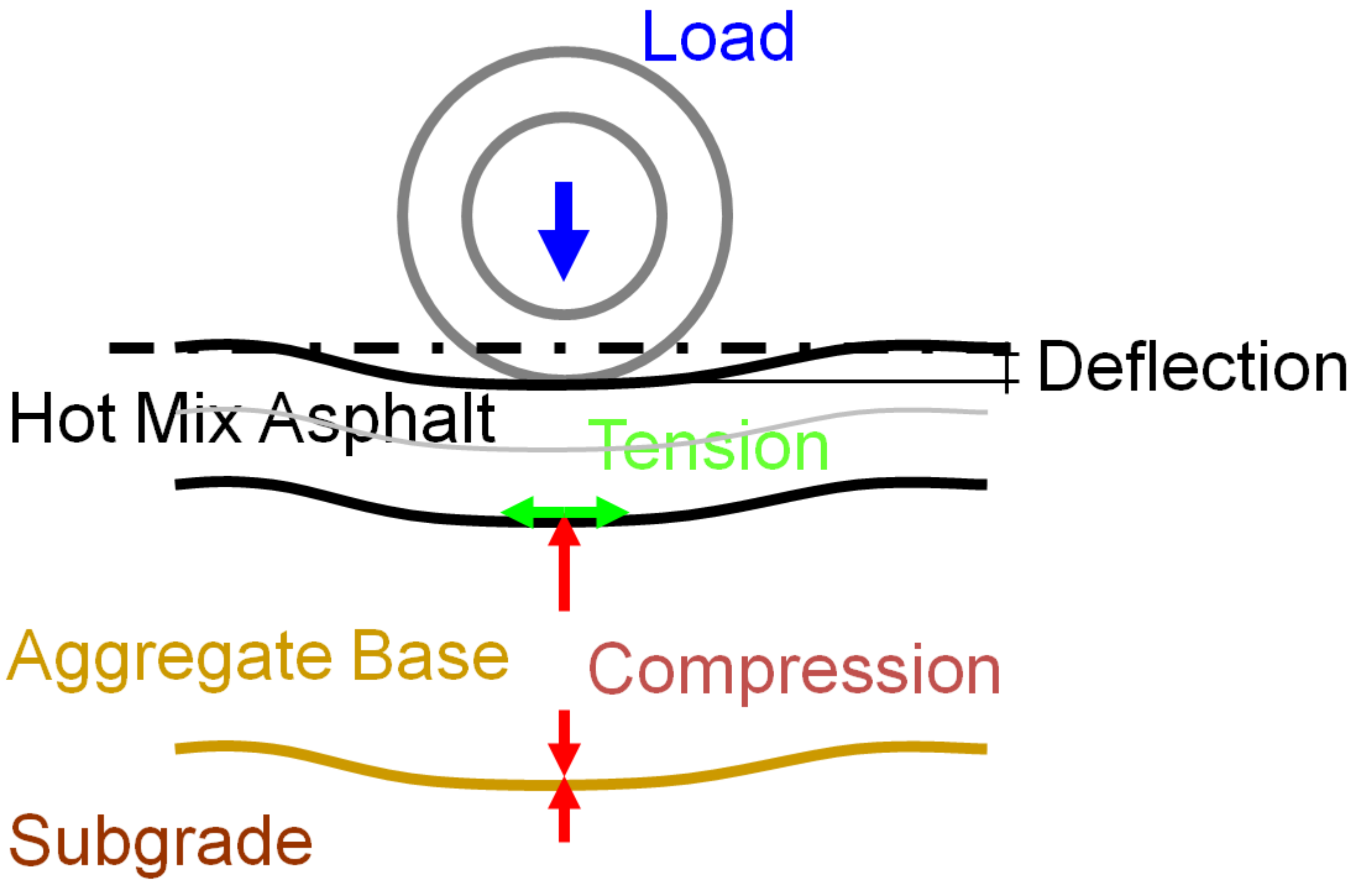
How bonded are pavement layers?

- Coring of new layer is a routine QC/QA activity to verify in-place density/calibrate nuclear density gage
- How often do cores break at the interface between layers?

De-bonding →

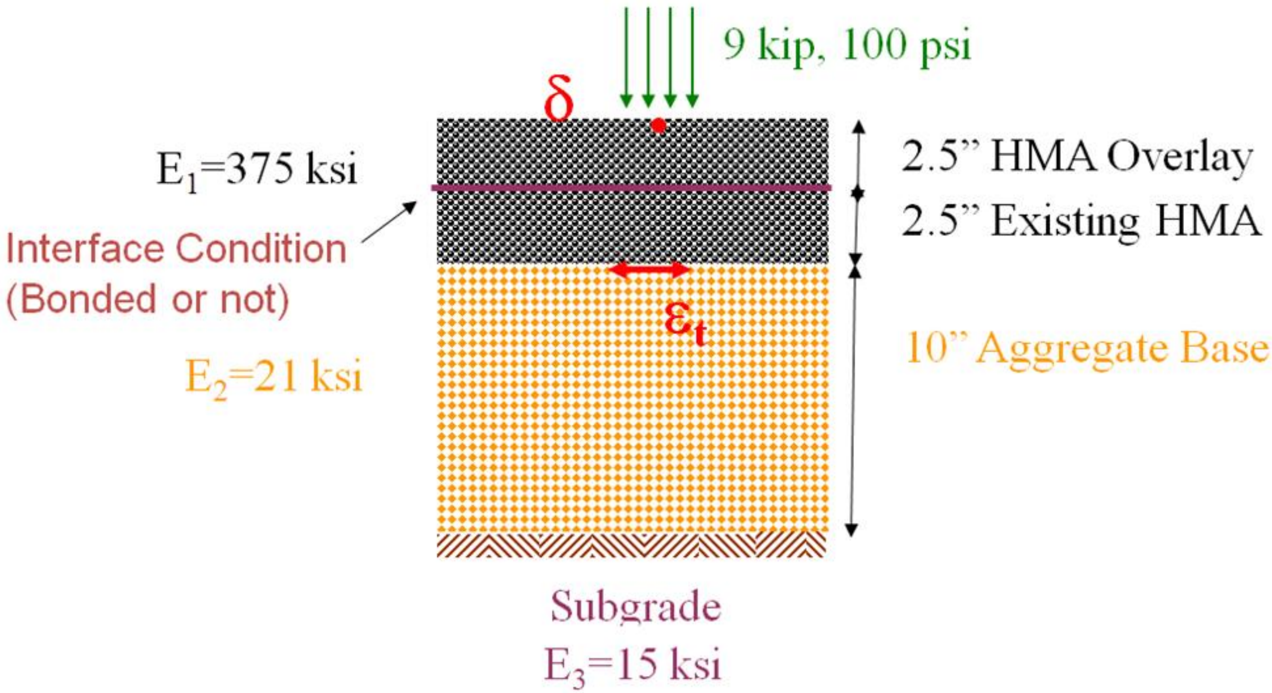
Utah - 2008

Pavement Structural Considerations



Pavement Structural Considerations (Cont.)

- Pavement section for Mechanistic Empirical analysis
  - Effect of overlay interface (bonded or not bonded)
  - Calculation of deflection and strains using linear elastic program



ESAL's to Failure – Based on Asphalt Institute Rebound Equation

$$ESAL = \left(\frac{1.0363}{\delta_{rrd}} \right)^{4.1017}$$

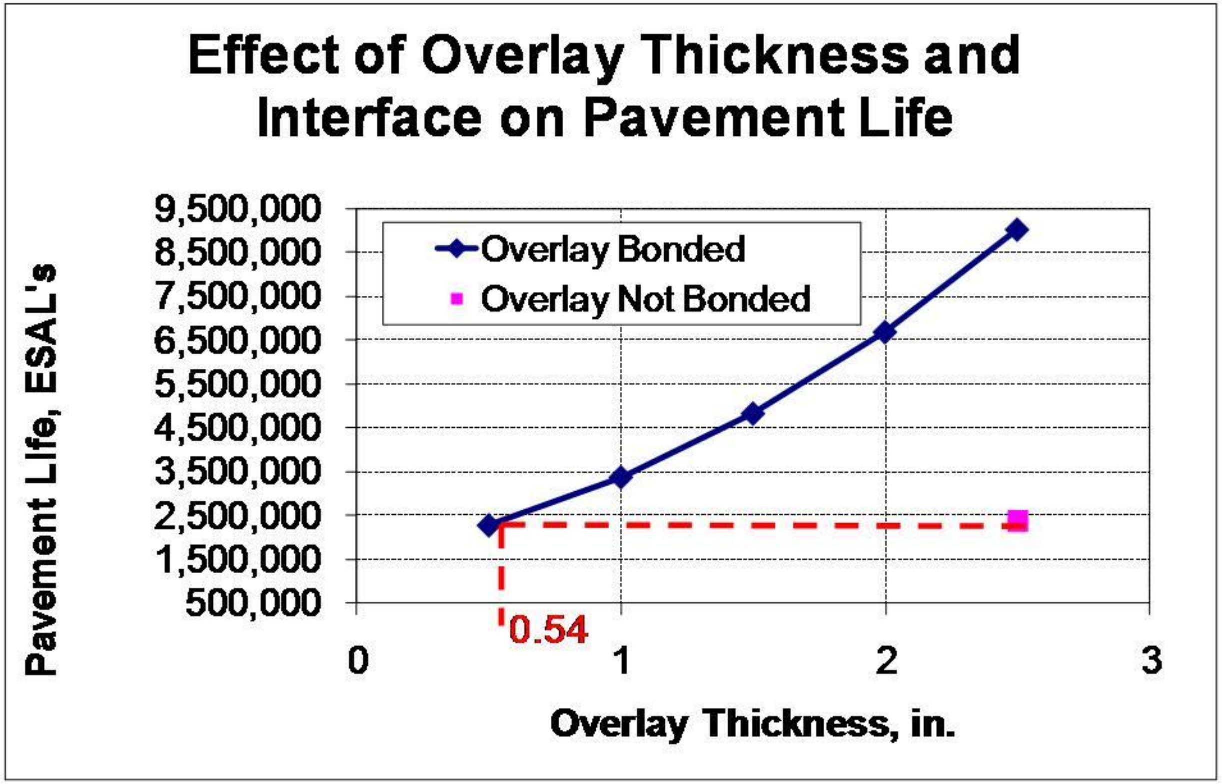
ESAL: Equivalent Single Axle Load (Remaining Life)

d_{rrd}: Representative rebound deflection

ESAL's to Failure – Based on Asphalt Institute Rebound Equation

Overlay Not Bonded		
Overlay Thickness	Deflection	Life (EASL's)
2.5	0.02891	2,375,942
Overlay Bonded		
Overlay Thickness	Deflection	Life (EASL's)
0.5	0.02917	2,290,272
1	0.02652	3,384,896
1.5	0.02431	4,836,628
2	0.02246	6,691,747
2.5	0.02088	9,025,646

ESAL's to Failure – Based on Asphalt Institute Rebound Equation



- 0.54" bonded overlay is equivalent to 2.5" not bonded
- Pavement life is increased 3.9 times when 2.5" overlay is fully bonded versus not bonded

ESAL's to Failure – Based on Asphalt Institute Fatigue Equation

$$N_f = 0.0796(\varepsilon_t)^{-3.291}(E_1)^{-0.854}$$

N_f: Number of load repetition to result in 20% of area cracked (fatigue distress)

e_t: Tensile strain at the bottom of the HMA layer

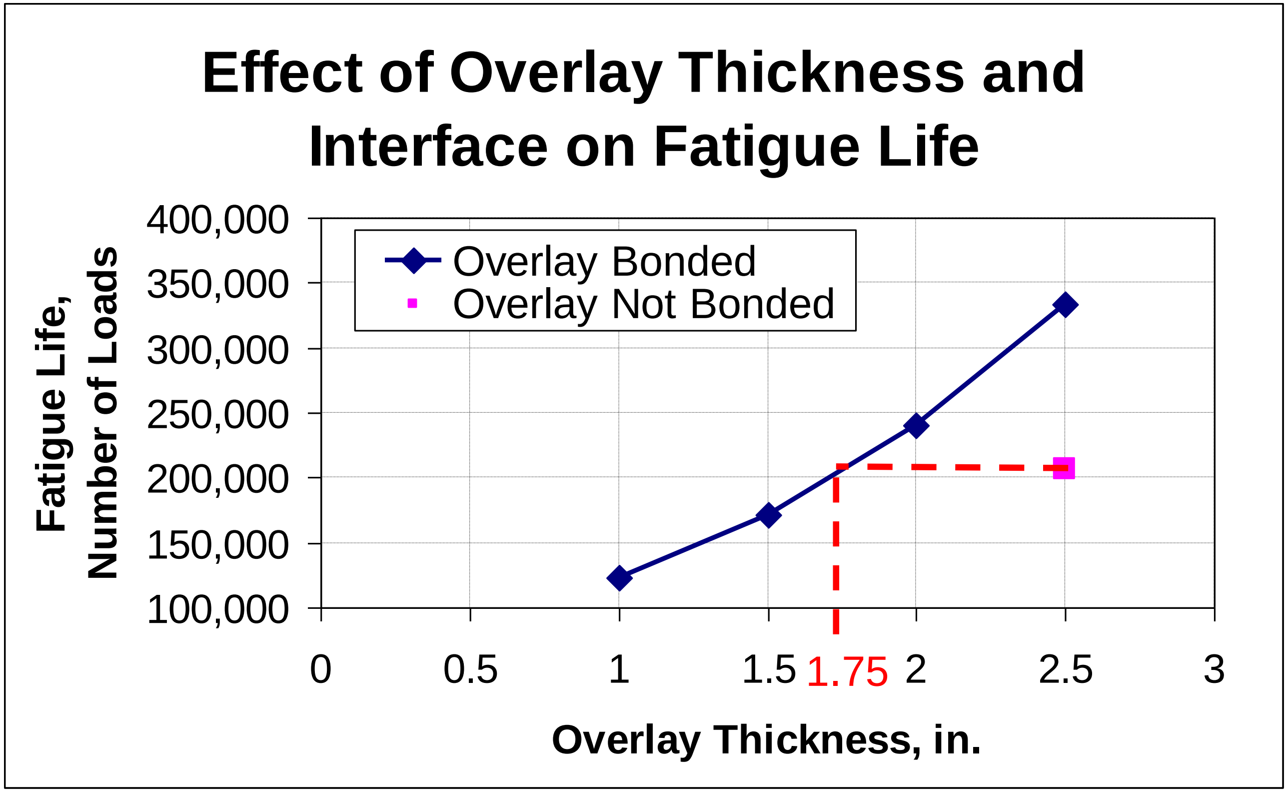
E_1: HMA modulus

ESAL's to Failure – Based on Asphalt Institute Fatigue Equation

Overlay Not Bonded		
Overlay Thickness	Fatigue Analysis	
	εt	# of Loads
2.5	0.0004023	206,593

Overlay Bonded		
Overlay Thickness	Fatigue Analysis	
	εt	# of Loads
1	0.0004707	123,222
1.5	0.0004256	171,651
2	0.0003844	239,976
2.5	0.0003477	333,876

ESAL's to Failure – Based On Asphalt Institute Fatigue Equation



- 1.75" bonded overlay is equivalent to 2.5" not bonded
  - Potential lift thickness reduction of 30%
- Pavement life is increased by 62% when 2.5" overlay is fully bonded versus not bonded

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Do we need bonded layers?

- Simple plywood experiment
  - About 60 lb load (mini Michael Jackson "look")
  - 11 sheets of plywood: 48" x 8" x 11/32" each
  - Measure deflection over 36" span
  - Compare effect of full slip versus full bond between plywood sheets

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Simple Plywood Experiment (Cont.)

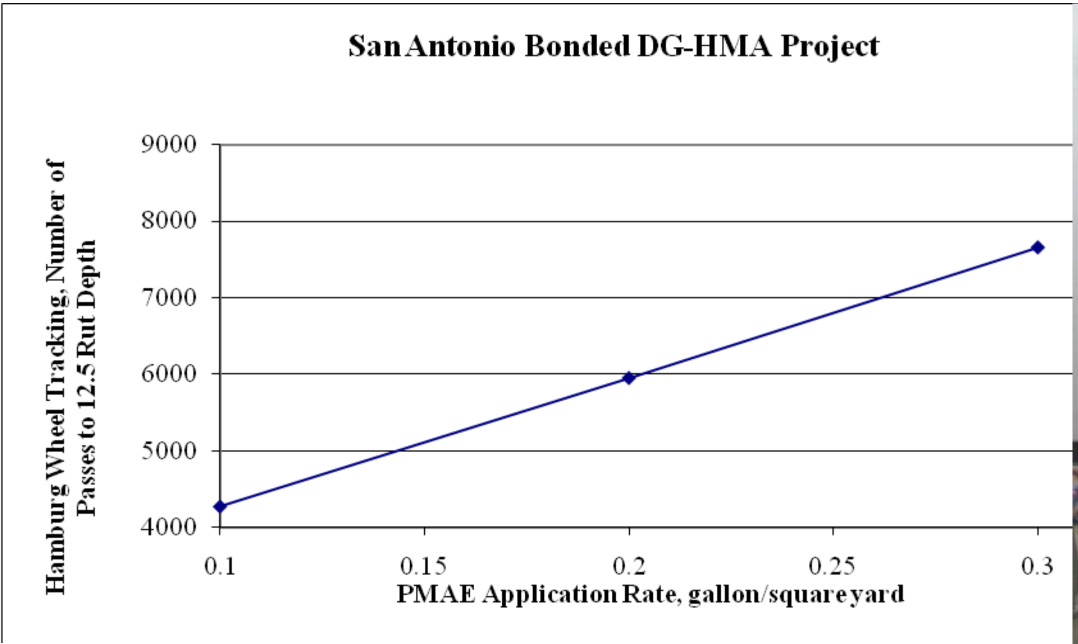
- Deflection comparison
  - 21 times greater with full slip than with full bond!

Bonded Layer Field Performance Research

- Control sections constructed using conventional placement methods
- Comparative sections placed using Vogele SP-1800 or RoadTec SP-200 spray pavers over various applications of PMEM
  - 2007 Commercial DG-HMA placed at 2” thick
  - 2008 Commercial DG-HMA placed 1.5” thick
  - 2008 HMA placed at 1” and 1.25” thick
  - 2008 HMA placed at 1.75” thick
  - 2008 12.5 mm Superpave placed at 1.5” thick
  - 2009 DG-HMA placed at 1.5” thick
  - 2009 DG-HMA placed at 1.75” thick
  - 2009 12.5 mm Superpave placed at 1.5” thick

Bonded Layer Research Findings Improved Rutting Resistance

- Reduced rutting potential with dense graded HMA
  - Potential for rutting has been shown to decrease, not increase, when increasing shot rate –2” overlay project in 2007



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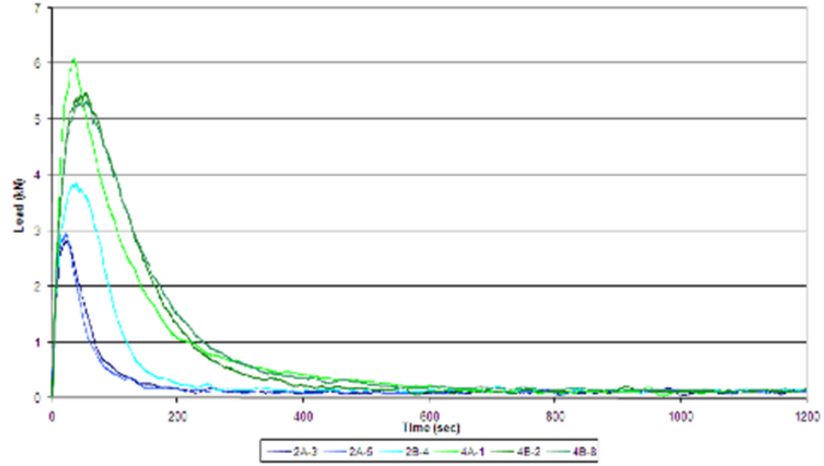
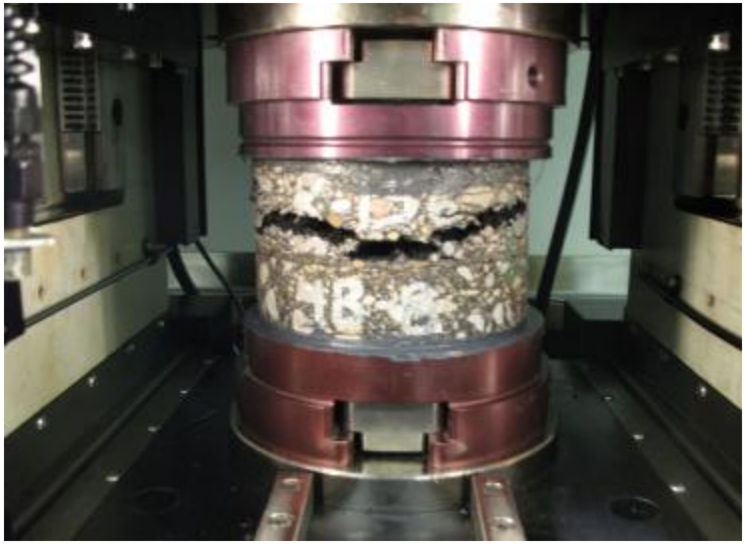
Bonded Layer Research Findings Bond Strength

- Bond test
- Tensile vs shear
  - Strength
  - Energy



2008 12.5 mm 1.5” DG-HMA

50/50 SS1HP

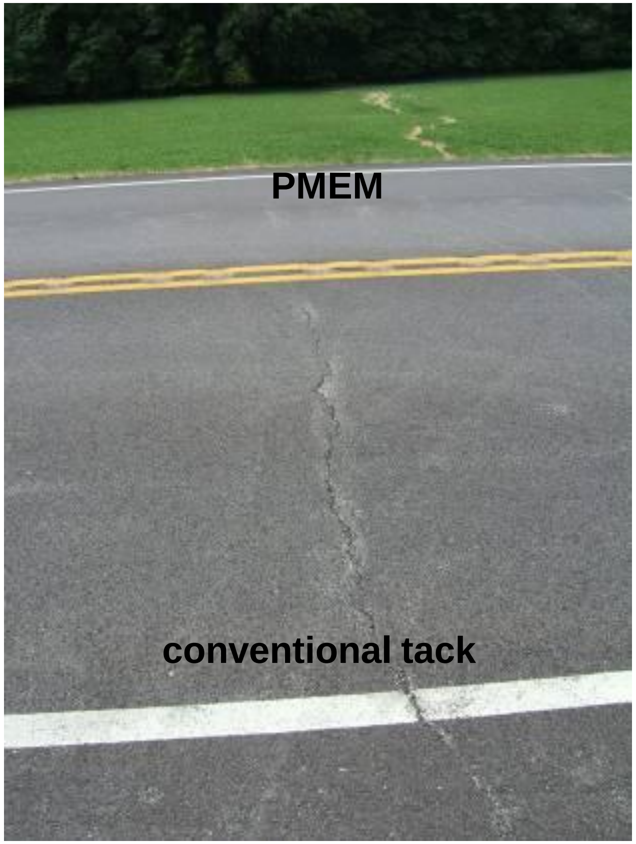


Undiluted PMEM

Bonded Layer Research Findings
Improved Cracking Resistance

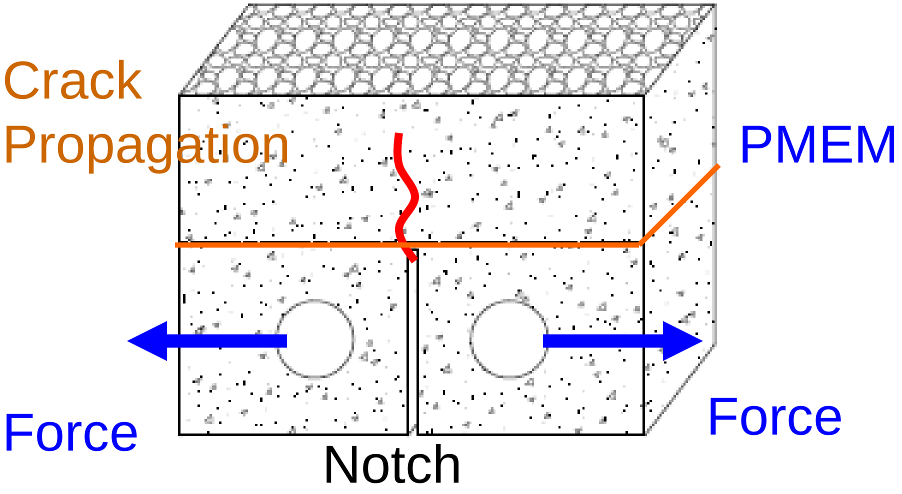
- University of Florida found that PMEM tack in OGFC had increased fracture resistance
- Improved cracking resistance
  - Reflective, fatigue, and top-down

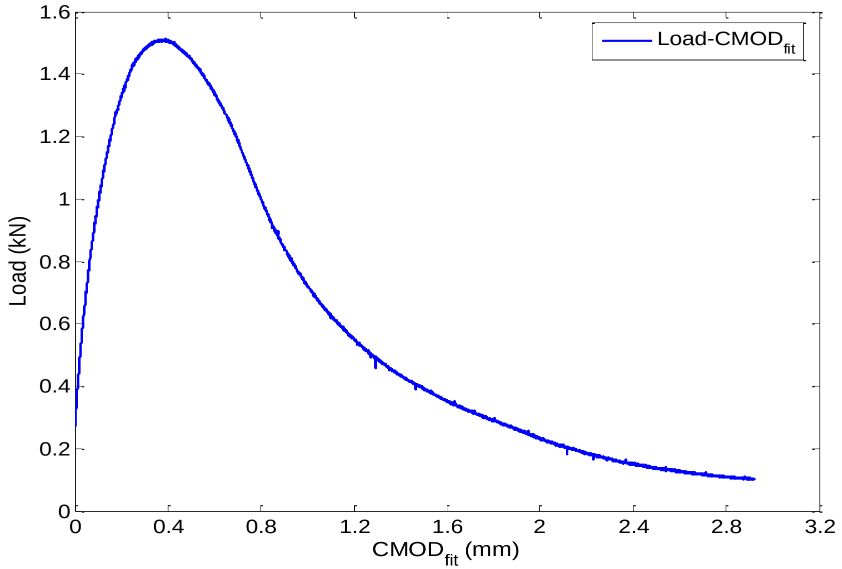
2008 1.75" DG after 9 months	
Shot Rate (gal/sy)(res.)	**Reflected cracks per 1000 meters**
0.03	24.8
0.09	1.8
0.12	0.0



Bonded Layer Research Findings Improved Cracking Resistance (Cont.)

- Improved cracking resistance from fracture energy
- Field core results

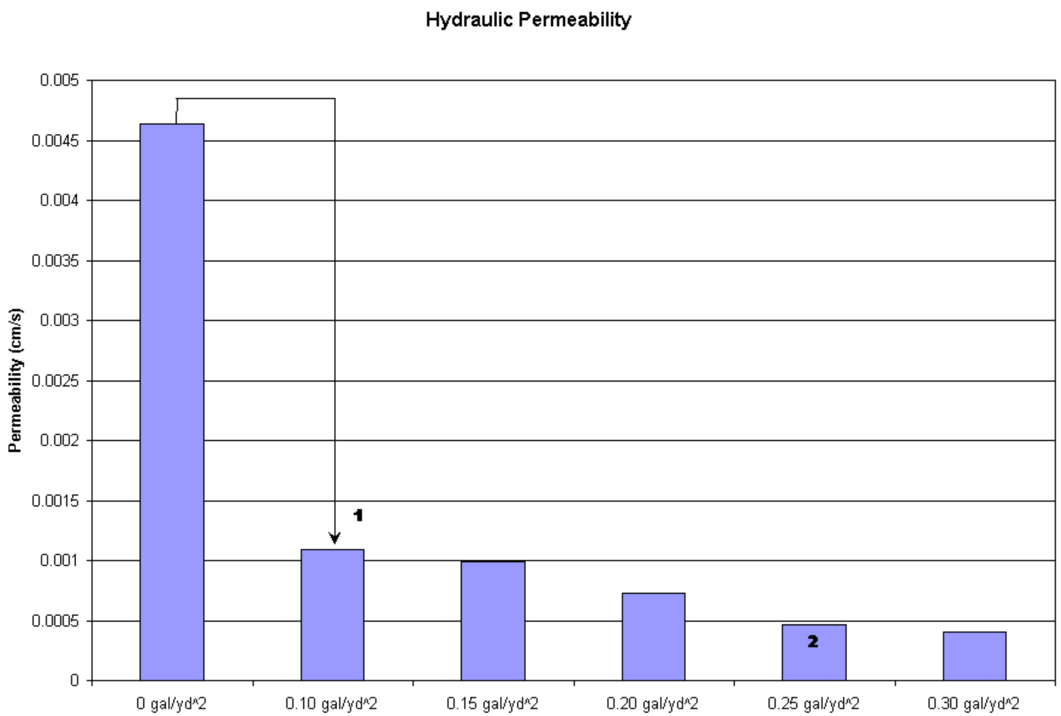


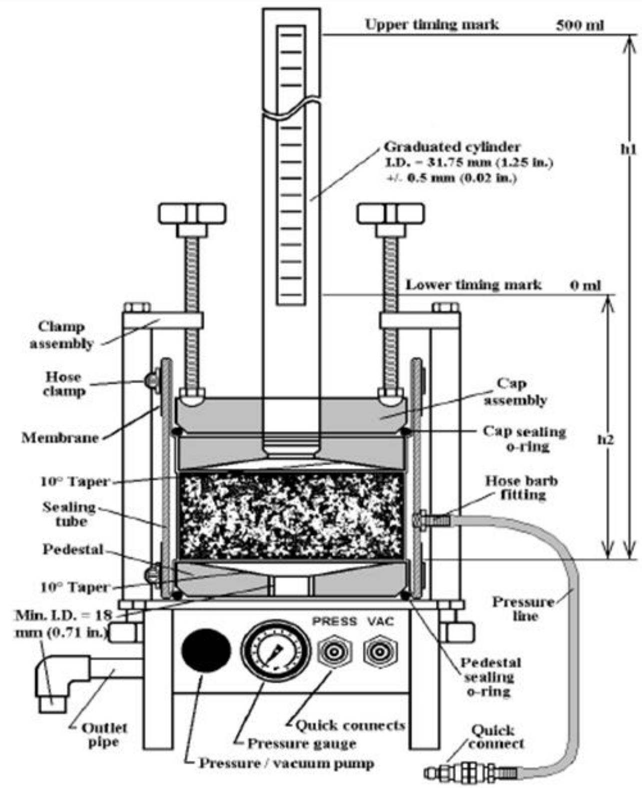


2008 1.75" DG Field Core Fracture Energy			
Section #	**Tack Coat Type**	**Application Rate, gal/yd2**	**Fracture Energy, J/m2**
1	**50:50 Dilute CSS-1h**	**0.08**	**319**
7	**PMEM**	**0.11**	**459 (44% increase)**

Bonded layer Research Findings
Reduced Permeability

- Seals the existing pavement by increasing the PMEM application rate





Hydraulic Permeability Test

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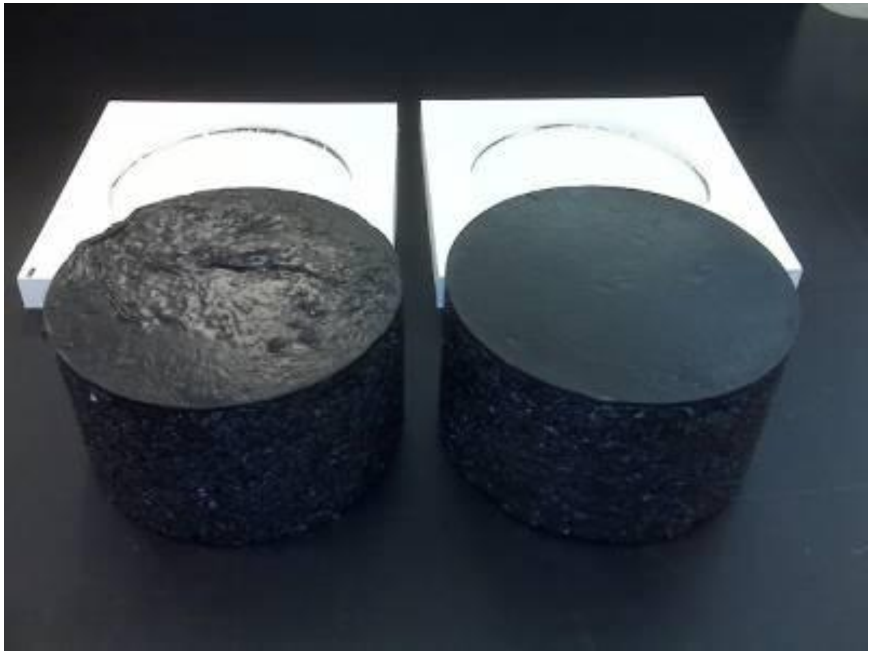
Bonded Layer Research Findings Constructability

- Non-tracking application of tack coat
  - Construction process does not limit the amount of tack placed
- Easier compaction with less damage to mixture
  - Better joint compaction
  - Better density values compared to traditional tack

Bonded Layer Research Findings
New Testing Oopportunities

- Laboratory protocols developed for composite systems
  - Unique concept for asphalt laboratories
  - Interaction effects of underlying layer, bonding layer, and new surface mix



- Additional performance related tests developed

→ Offers QC/QA opportunities

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Construction Considerations

- Challenges with tack coats when conventionally applied
  - Relatively low application rate and uniformity
  - Contamination and tracking

Source: http://pavementinteractive.org (Washington State Projects)

Alternative To Conventional Track Coat Application Method

- More efficient delivery system for the tack coat
  - Tack evenly placed
  - Tack undisturbed by construction process
  - Enhanced tack materials
    - Polymer modified emulsion
    - Increased application rates
- Followed immediately by application of the asphalt layer

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Spray Pavers

- Self-priming paver (on board emulsion tank)
- Capable of spraying the PMEM, applying the hot mix asphalt overlay and leveling the surface of the mat in one pass

- Self-priming paver (on board emulsion tank)

Road – Tec SP200

Vogele SF1800

Summary – Bonded Pavement Benefits

- Distress Mitigation
  - Improved Compaction – Joint Densities
  - Increased Bond Strength – Reduced risk of delamination, especially with thinner lifts
  - Permeability – effectively seals the pavement
  - reduce risk of rutting
  - Increase resistance to cracking
- Economic Impacts
  - Increased Pavement life through enhanced fatigue resistance
  - Potential reduction in lift thickness with equivalent structural capacity

Thank you

- Questions

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