Development of a Performance-Based Mix Design for Porous Friction Course

Adam J. Taylor, P.E.
Assistant Research Engineer
The National Center for Asphalt Technology

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Project Team

- Donald Watson, P.E.
- Nam Tran, PhD., P.E.
- Carolina Rodezno, PhD.
- Adam Taylor, P.E.
- Tommy James

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Overview

- Objective
- Results and Discussion – Highlights
  - Part 1
    - Evaluation of Mix Designs with Known Field Performance
  - Part 2
    - Experiment 1 – Increased P-200 Content
    - Experiment 2 – Binder Modifications
    - Experiment 3 – NMAS to Lift Thickness Ratio
- Conclusions and Recommendations

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Objective

- The purpose of this study was to evaluate laboratory test procedures, and their subsequent criteria, that would aid in the development of long-life porous friction course (PFC) pavements.
- Several laboratory tests were conducted to evaluate six PFC designs with good (3) and poor (3) field performance.
  - "Good" = Up to 18 years of Field Service
  - "Poor" = Replaced prior to 8 years of Field Service

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Mix Design Information

Mixture Source	Florida	Florida	New Jersey	Virginia	Georgia	South Carolina
Mixture Designation	Good	Poor	Good	Poor	Good	Poor
Aggregate Mineralogy	Limestone		Traprock		Granite	
NMAS, mm	19.0	19.0	9.5	12.5	12.5	12.5
Asphalt Type	PG 67-22	PG 76-22				
Binder Modifier	12% - #30 GTR	2.5% SBS Polymer				
Anti-strip	0.5% LOF 6500 by weight of binder					
Fiber, %	0.4	0.4	0.3	0.3	0.4	0.3
Asphalt Content, %	7.1	6.0	6.0	5.8	6.0	6.0
Total P-200, %	0.9	0.9	3.9	2.6	2.0	1.7

Mix Design Testing

- Volumetric Analysis (AASHTO T331)
  - Air Void Content, VMA, VCA and Film Thickness
- Cantabro Abrasion Loss (AASHTO TP108)
  - Durability
- Draindown (AASHTO T305)
  - Draindown Basket Method
  - Film Thickness and Production/Construction Issues
- Hamburg Wheel Tracking Test (AASHTO T324)
  - Susceptibility to Rutting and Stripping

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Mix Design Testing

- Tensile Strength Ratio (modified AASHTO T283)
  - Moisture Susceptibility
  - Indirect Tensile Strength
- Permeability (FM 5-565)
  - Falling head apparatus
- Texas Overlay Test (Tex-248-f)
  - Cyclic saw-tooth load
  - Max opening displacement of 0.025 inches
- Illinois Flexibility Index Test (I-FIT) (IL 405)
  - Fracture Resistance

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Shear Strength

- Same device used for ALDOT 430 Bond Strength
- Test whole PFC Gyratory Specimen
  - No interface
- 2 in./min load rate
- 25°C

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Part 1 – Evaluation of Mix Designs

Mix Design	Field Performance	Laboratory Test	Anticipated Criteria
Georgia	Good	➢ TSR	➢ 0.70 – unconditioned strength 50 psi min.
New Jersey	Good	➢ Cantabro	➢ 20% max loss - unconditioned
Florida	Good	➢ Hamburg	➢ 12.5 mm maximum @ 20,000 passes
Florida	Poor	➢ I-FIT SCB	➢ FI of 8.0 minimum
South Carolina	Poor	➢ OT	➢ 200 cycles minimum
Virginia	Poor	➢ Permeability	➢ 100 meters/day min.
		➢ Draindown	➢ 0.3% maximum

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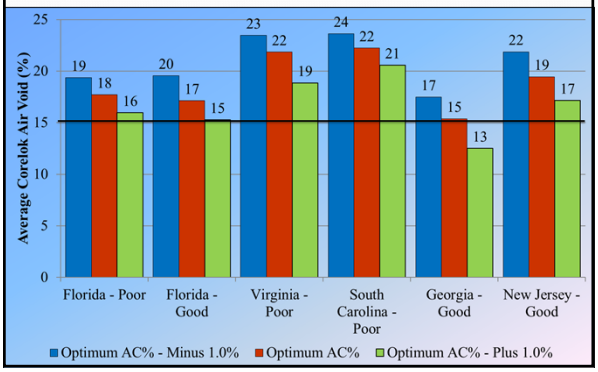
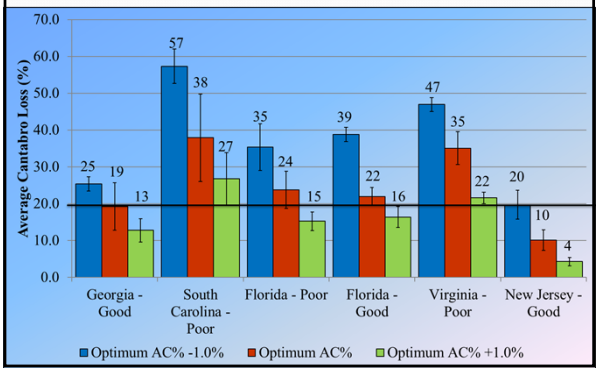
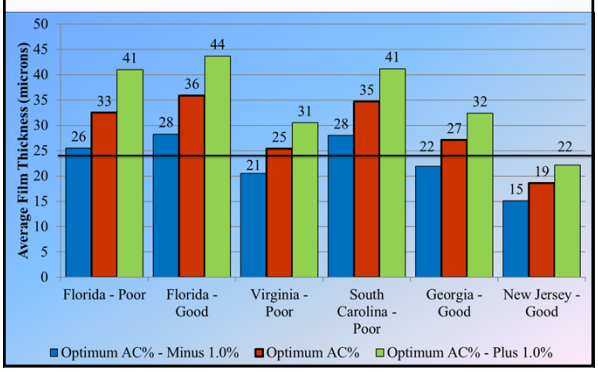
Part 1: Air Voids – Corelok Method



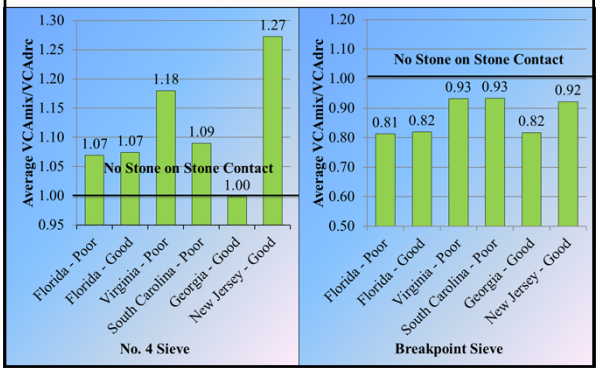
Part 1: Cantabro Loss



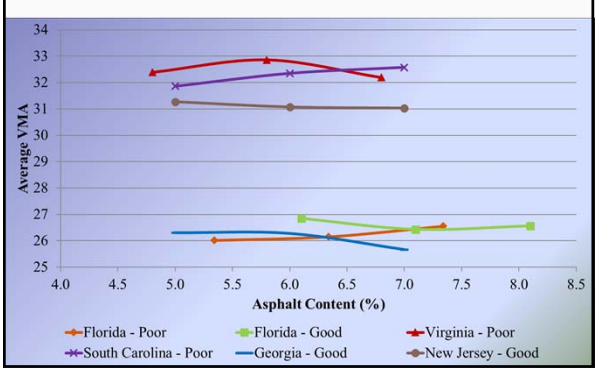
Part 1: Film Thickness



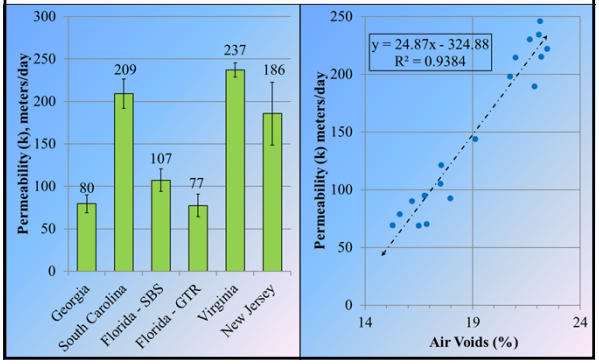
Part 1: VCA Ratio



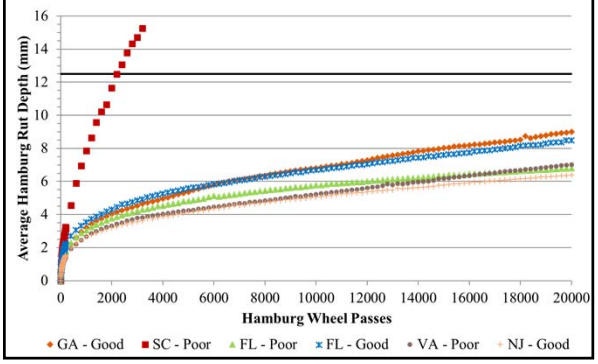
Part 1: VMA Curves



Part 1: Permeability Rates



Part 1: Hamburg Wheel Tracking



Part 1: ITS and TSR

Mix ID	Total AC (%)	Fiber (%)	Avg. Air Voids (%)		Avg. ITS (psi)		TSR
			Cond.	Uncond.	Cond.	Uncond.	
FL - Poor	6.3	0.4	17.2	21.0	52.8	72.5	0.73
FL - Good	7.1	0.4	17.6	15.2	54.0	50.1	1.08
VA - Poor	5.8	0.3	20.8	18.2	53.2	59.5	0.89
SC - Poor	6.0	0.3	21.2	21.2	36.7	45.2	0.81
GA - Good	6.0	0.4	13.9	14.0	57.7	74.3	0.78
NJ - Good	6.0	0.3	18.2	18.2	64.5	76.2	0.85

Mix ID	Conditioned			Unconditioned		
	N	Mean	Grouping	N	Mean	Grouping
NJ - Good	3	64.5	A	3	76.2	A
GA- Good	3	57.7	A B	3	74.3	A B
FL – Poor	3	54.0	B	3	72.5	A B
VA – Poor	3	53.2	B	3	59.5	B C
FL – Good	3	52.8	B	3	50.1	C
SC - Poor	3	36.7	C	3	45.2	C

p=0.000 R^2 = 90%

p=0.000 R^2 = 88%

Part 1: Shear Strength

MIX ID	SHEAR STRENGTH, PSI			MIX ID	AREA TO PEAK (LB./IN.)		
	Avg.	Grouping			Avg.	Grouping	
Florida - Poor	170.4	A		New Jersey - Good	606.5	A	
Georgia - Good	162.0	A	B	Florida - Poor	541.9	A	B
Florida – Good	149.2	A	B	Georgia - Good	510.9	A	B
New Jersey - Good	138.6	A	B	Virginia - Poor	492.5	A	B
South Carolina - Poor	122.2	B		South Carolina - Poor	461.6	B	
Virginia - Poor	121.1	B		Florida – Good	427.6	B	

Recommended PFC Design Criteria

Property	Criteria
Unconditioned Cantabro Loss, %	20 Max
Air Void Content, %	15 -22
Permeability, meters/day	50 Min (But agency dependent)
Draindown at Production Temperature, %	0.30 Max
Hamburg Wheel Tracking Test, mm (PG 76-22 @ 20,000 passes)	12.5 mm Max
Tensile Strength Ratio	0.70 Min
Conditioned Indirect Tensile Strengths, psi	50 Min
Unconditioned Indirect Tensile Strengths, psi	70 Min
Shear Strength, psi	125 Min.
SCB I-FIT Flexibility Index (Optional)	25.0 Min

Part 2 – Experiment 1: Increased P-200 Content

Mix Design	Field Performance	Added BHF	Cellulose Fiber	Binder	Laboratory Test
Georgia	Good	2%	0.4%	PG 76-22 (SBS)	➢ Tensile Strength Ratio ➢ Cantabro ➢ Hamburg ➢ I-FIT SCB ➢ OT ➢ Permeability ➢ Draindown ➢ No-Notch I-FIT
		4%			
South Carolina	Poor	2%	0.3%		
		4%			

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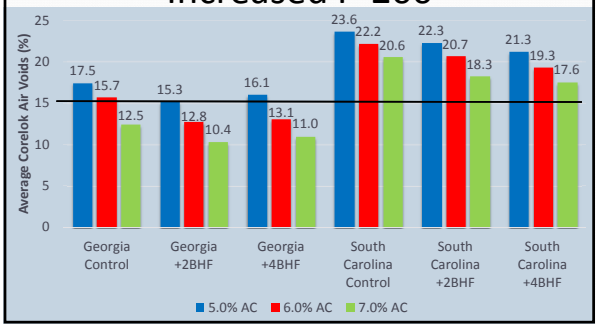
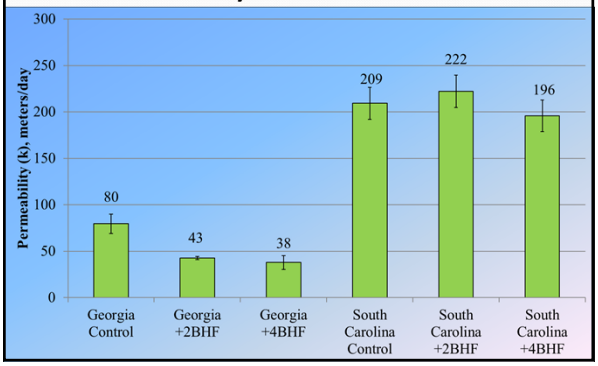
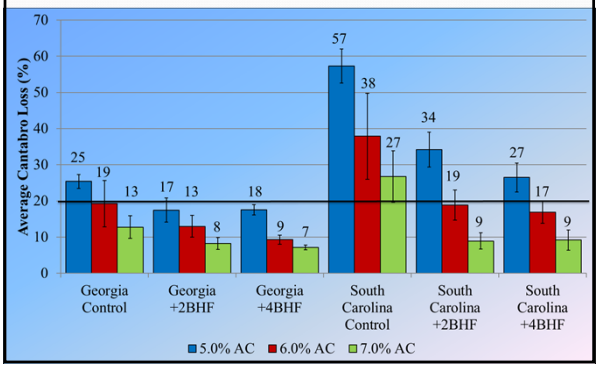
Corelok Air Voids – Increased P-200



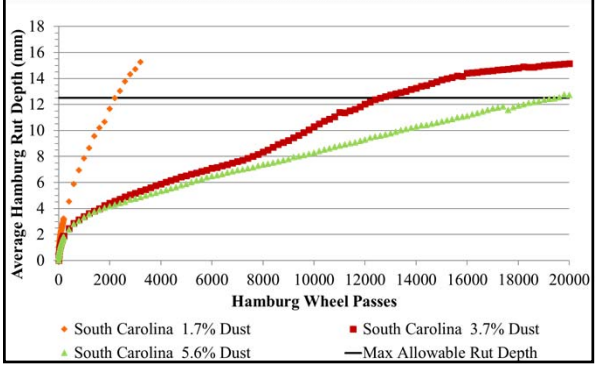
Permeability – Increased P-200



Cantabro – Increased P-200



Hamburg - SC Mix - Increased P-200



Increased P-200 – TSR and ITS

Mix ID	Conditioned					Unconditioned				
	N	Mean	Grouping			N	Mean	Grouping		
Georgia +2BHF	3	86.4	A			3	100.3	A		
Georgia +4BHF	3	82.4	A			3	99.8	A		
Georgia Control	3	57.6		B		3	74.3		B	
South Carolina +4BHF	3	54.4		B		3	77.3		B	
South Carolina +2BHF	3	38.8			C	3	62.0		B	
South Carolina Control	3	36.8			C	3	45.2			C
	p<0.001					p<0.001				
	R^2 = 98%					R^2 = 94%				

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Conclusions

- VMA, VCA and Film Thickness were not critical for design
- Permeability is directly related to air voids
- Addition of 2% BHF reduced Cantabro loss the equivalent of 1.0% additional AC
- A Cantabro loss of 20% appeared to be a reasonable threshold for mix design
- Optimum P-200 content should be between 2 to 6 percent
- Results show that PFC mixture durability can be improved by additional filler
  - Must ensure Air Voids and Permeability do not fall below critical levels

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Questions?

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