Field Experience and Lab Testing of Fine-Graded Mixes: ICT Project R27-79

Presented

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Bituminous Paving Conference

I – Hotel, Urbana, IL

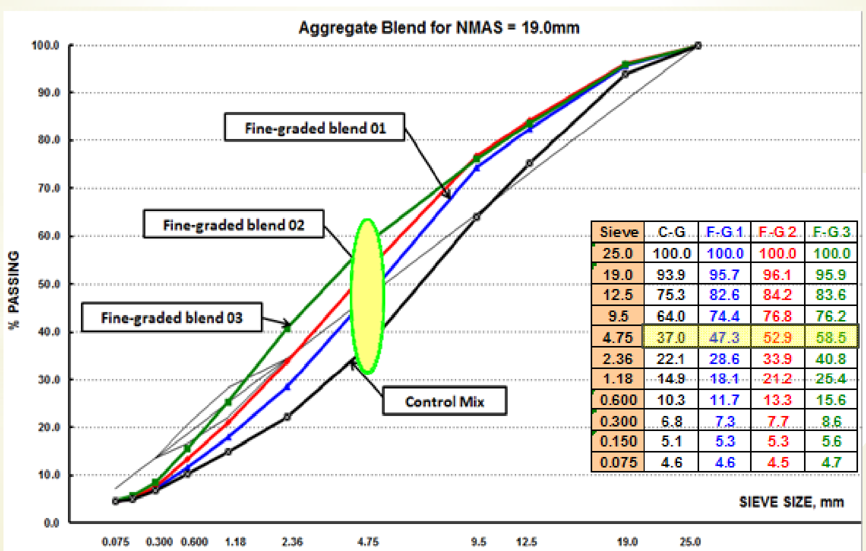
Project Objective/Definition/Scope

- ✓ **Assist IDOT in the modification of existing asphalt mixture specifications to allow the use of fine graded (F-G) hot-mix asphalt (HMA) as an alternative to coarse-graded (C-G) HMA in Illinois for binder/ surface course asphalt pavement layers**
- ✓ **Fine-Graded Mixtures are defined as having a gradation curve which passes over the maximum density line at the critical control sieve -> Easier to compact (esp. in thin lifts), less permeable**
- ✓ **This project focused on binder-course mixtures (19mm NMAS, N90), produced with aggregates local to IDOT D5, using PG 64-22 binder and no liquid antistrip.**
- ✓ **The research study includes literature review, mix design, lab performance testing, ATLAS testing, and field permeability testing.**

Mix Design Summary

Design Parameter	Control (coarsest)	BFG-01	BFG-02	BFG-03 (finest)
NMAS = 19.0 mm (Binder-course)				
N design = 90				
Height = 115 mm				
AV = 4.0 %				
AC	5.3 %	5.4 %	5.6 %	5.5 %
VMA	13.4 %	13.3 %	13.4 %	13.3 %
VFA	70.4 %	69.0 %	70.8 %	69.1 %
Dust /Tot AC	0.9	0.9	0.8	0.9
Dust/Eff AC	1.2	1.1	1.2	1.1

Aggregate Structures – 3 FG & 1 CG Control Mix



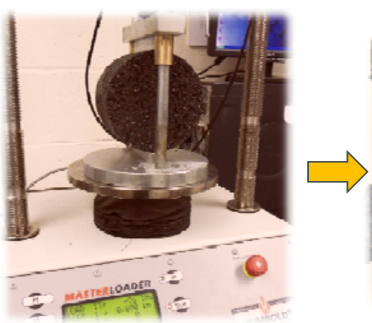
Sieve	C-G	F-G 1	F-G 2	F-G 3
25.0	100.0	100.0	100.0	100.0
19.0	93.9	95.7	96.1	95.9
12.5	75.3	82.6	84.2	83.6
9.5	64.0	74.4	76.8	76.2
4.75	37.0	47.3	52.9	58.5
2.36	22.1	28.6	33.9	40.8
1.18	14.9	18.1	21.2	25.4
0.600	10.3	11.7	13.3	15.6
0.300	6.8	7.3	7.7	8.6
0.150	5.1	5.3	5.3	5.6
0.075	4.6	4.6	4.5	4.7

Moisture Damage Test
(TSR)

Illinois-Modified AASHTO T-283

Moisture Damage Test

- ✓ **Purpose: to predict stripping susceptibility of HMA**
- ✓ **IDOT Test Procedure - Modified AASHTO T283-07**
  - **- (***No freeze-thaw cycles required***)**



- ✓ **Minimum tensile strength = 60 psi**
- ✓ **Minimum TSR =85%**

TSR Results

	BCG (coarsest)	BFG01	BFG02	BFG03 (finest)
Avg. Air Void (%)	7.3 %	7.3 %	6.6 %	6.9 %
Avg. Saturation (%)	71%	71 %	73 %	73 %
Avg. Tensile Strength (Wet), psi	82.6	102.3	106.6	110.5
Avg. Tensile Strength (Dry), psi	93.6	119.7	128.1	149.0
TSR (%) = Wet/Dry	**88.2 %**	**85.5 %**	**83.2 %**	**79.6 %**

Visual Rating	BCG		BFG01		BFG02		BFG03	
	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Wet Specimen	2	2	2	2	2	2	2	**1**
Dry Specimen	1	1	1	1	1	1	1	1

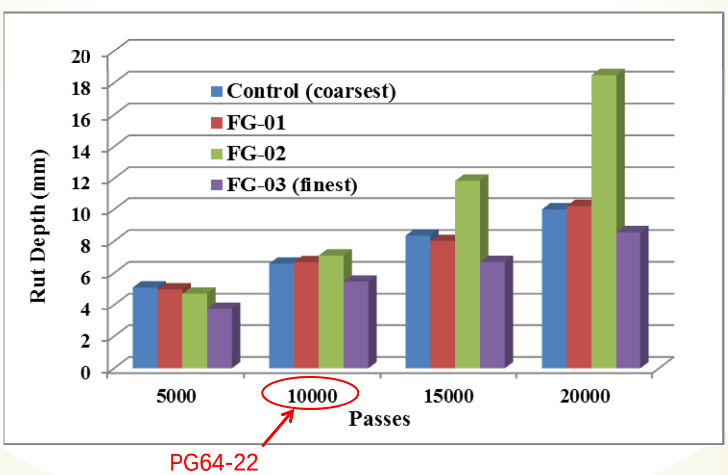
Hamburg Wheel Tracking (HWT) Test

Hamburg Wheel Tracking (Rutting)

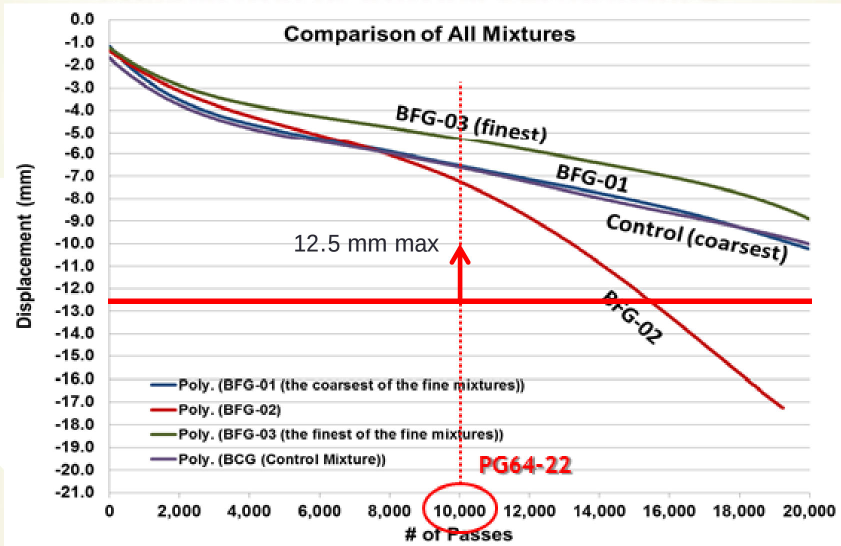
- ✓ TxDOT Specification (Tex-242-F)
- ✓ Testing Temp = 50°C
- ✓ Rut Depth Reported @ 10,000 passes
- ✓ 6 Replicates tested
- ✓ Left & Right wheels compared

Rut Depth @ Different Passes

✓ **NOTE**: Reported Rut Depth (PG64-22) is at 10,000 passes



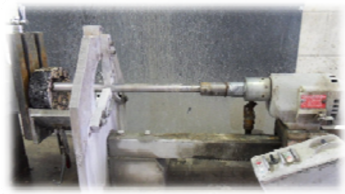
Comparison of Rutting Performance

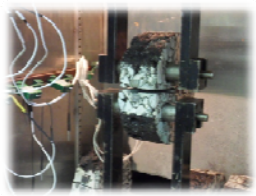


Disk-Shaped Compact Tension Test – DC(T)

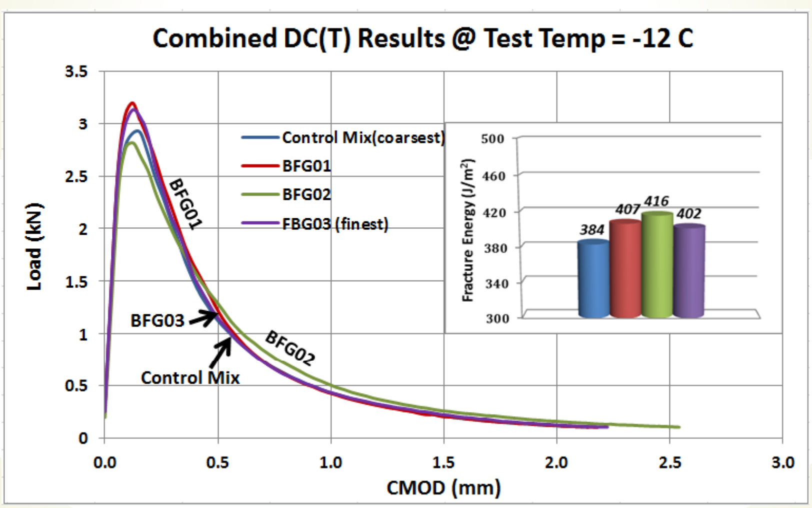
DC(T) Test – Low Temperature Crack Resistance

- ✓ ASTM 7313-07
- ✓ 6 Reps tested
- ✓ Testing Temp = 0,-<u>12</u>,-24 °C
- ✓ Minimum 400 J/m² Fracture Energy Recommended at PGLT +10 C

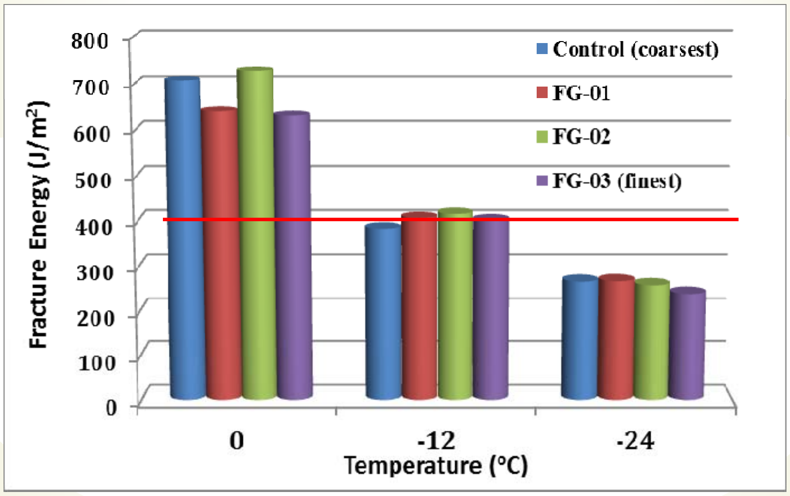






DC(T) Result (Temp = -12 °C) [PGLT+10°C]



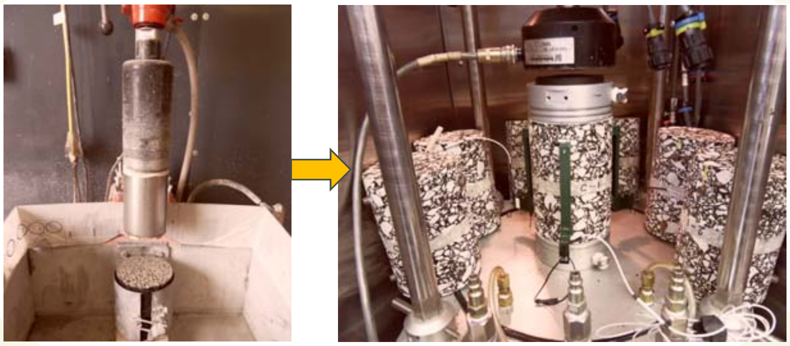
DC(T) Results



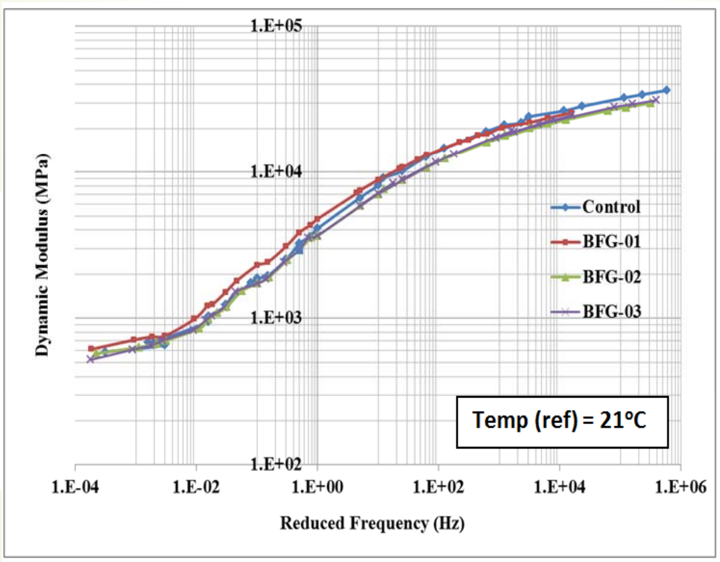
Dynamic (Complex) Modulus Test

Sample Preparation & Testing

- *AASHTO TP62-07 (Determining Dynamic Modulus of HMA)*
- *3 Replicates per mix*
- *Test specimen is 150-mm tall and 100-mm diameter*



E* Master Curve

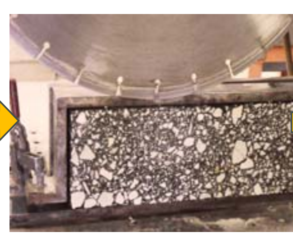


Fatigue Test

Fatigue Test

- ✓ *To determine a fatigue life* (**Nf**) *of HMA*
- ✓ *AASHTO T321-03 (Determining Fatigue Life of HMA)*
- ✓ *Test Temperature = $20^{o}C$*
- ✓ *6 Different Strain (deflection) Levels (controlled strain mode of loading)*
  (300,400, 500, 700, 800, and 1,000 microstrain)

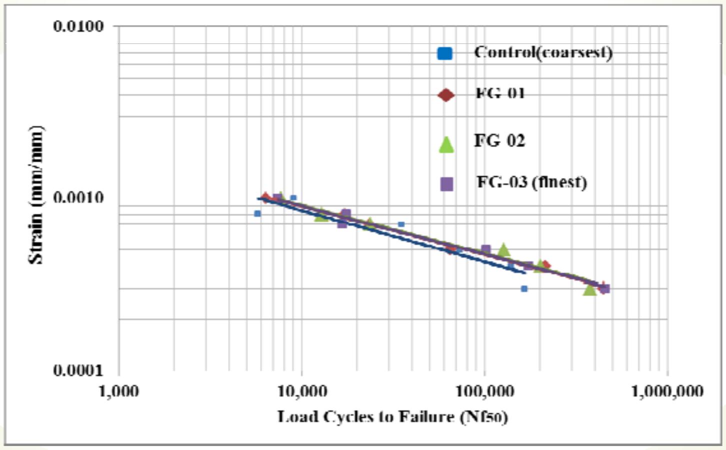
Compacted Sample
(380 x 125 x 75) mm



Test Specimen
(380 x 63 x 50) mm

Traditional Fatigue Approach

- ✓ *failure criterion = Number of cycles to 50% reduction in initial stiffness*
- ✓ *relationship between cycle at the failure (Nf50) & strain level (Fatigue Model)*



Traditional Fatigue Criterion

- ✓ *Traditional Fatigue Model*

$$Nf_{50} = f_1\left(\frac{1}{\varepsilon}\right)^{f_2}$$

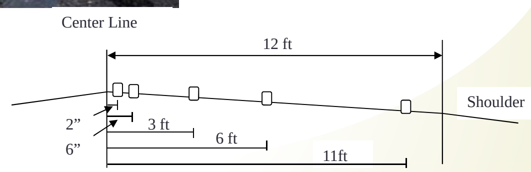
f1 and f2 are fatigue constants (experimental parameters)

- ✓ *Desired = Higher f_2 value (exponent) for more fatigue resistance*

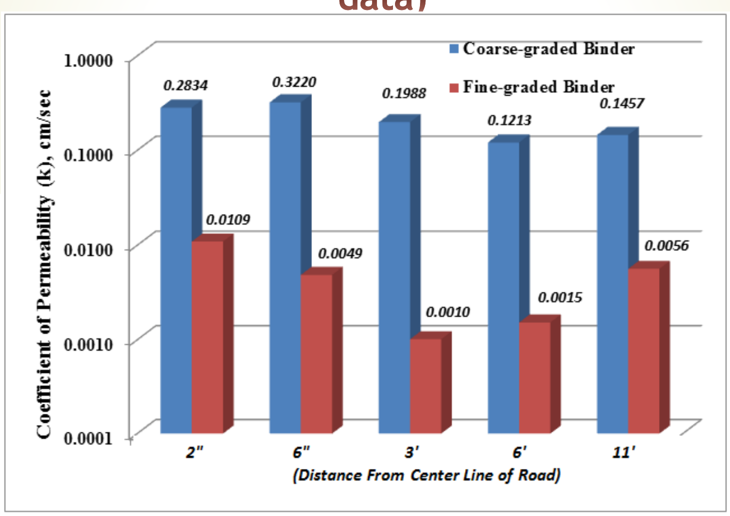
Strain (microstrain)		300	500	1,000
	Model	**Allowable Number of Cycles**		
Control (coarsest)	$Nf_{50} = 2x10^{-5}\left(\frac{1}{\varepsilon}\right)^{2.875}$	268,724	61,872	8,434
FG01	$Nf_{50} = 2x10^{-7}\left(\frac{1}{\varepsilon}\right)^{3.532}$	554,419	91,257	7,889
FG-02	$Nf_{50} = 3x10^{-7}\left(\frac{1}{\varepsilon}\right)^{3.481}$	549,873	92,898	8,320
Fg-03 (finest)	$Nf_{50} = 2x10^{-7}\left(\frac{1}{\varepsilon}\right)^{3.509}$	460,057	76,620	6,730

Field Permeability Test Results
I-57 (Pesotum, IL)

July/August 2010



Fine-Graded vs. Coarse-Graded Mix (averaged data)



On average, fine-graded mix was 25 times less permeable than coarse mix for this project

Conclusions

- ✓ Fine-graded mixtures can be made with identical effective asphalt content and VMA as coarse-graded control
- ✓ TSR strengths, visual stripping, and Hamburg results were better for FG mixes as compared to control. TSR ratios were inverse to these trends!
- ✓ Despite lower 'film thickness', FG mixtures outperformed CG mixes in low-temperature cracking and fatigue performance tests
- ✓ Significant permeability benefits can be realized FG mixes

Acknowledgements

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