




RAP Mix Design Issues

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Uses of RAP

(as of 1996)



	Batch plant			Drum Plant		
	Base (%)	Binder (%)	Surface (%)	Base (%)	Binder (%)	Surface (%)
Max	70	70	70	70	70	70
Min	0	0	0	15	0	0

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Current Practice

% of RAP	PG Grade?	Assumption
• < 15% RAP	• No PG change	• RAP = black rock
• 15 to 25%	• Drop 1 PG grade	• All RAP binder usable
• > 25%	• Blending charts	• All RAP binder usable

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Constructing Blending Charts


- Solvent extraction and binder recovery needed
 - Environmental cost
 - Heat hardening?
 - Full solvent recovery?
 - Polymer modified AC?
 - Time to get results?



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Issues

- How consistent is my RAP Stockpile consistency?
- How much binder is *REALLY* contributed by the RAP?
- When do I need to change PG grade?



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Goals of Research

- Simple, quick, cost-effective test
- Fundamentally based
 - Mechanistic
- Able to answering previous questions

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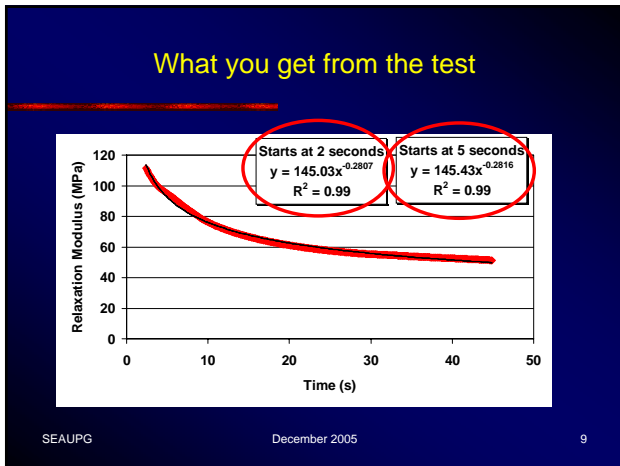
Binder Related Mix Properties

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HMA Tests

- Stress Relaxation

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The Practical Form

Replace with RS232 connection to computer for load and time data

Replace with jig with positive stop for fixed strain

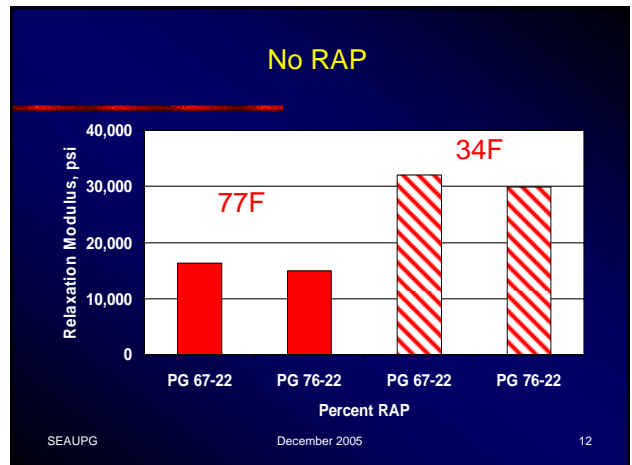
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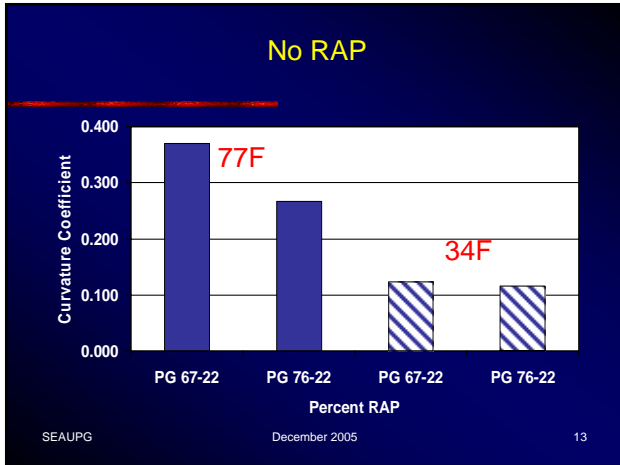
Test Summary

Task	Time
Setup	1 min.
Relaxation	45 sec.
Analysis	1 min.

Total time: < 3 min.

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Materials

- Aggregate + Black Rock Properties

Properties	Granite	Gravel	MN RAP*	AL RAP*
Bulk specific gravity	2.658	2.598	2.126	2.340
Bulk specific gravity, SSD	2.676	2.618	2.161	2.428
Apparent specific gravity	2.707	2.652	2.204	2.470
Water absorption, %	0.7	1.2	1.7	1.2
% Crushed Faces	100%	100%	100%	100%
Flat and elongated, % (5:1)	0%	0%	0%	0%
% Asphalt Binder	NA	NA	5.6%	4.3%

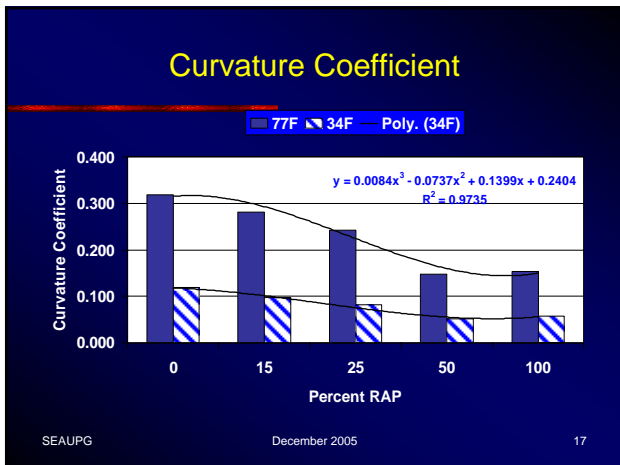
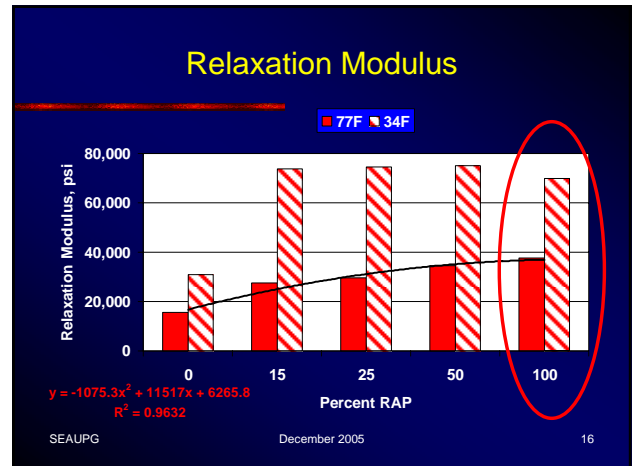
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Materials

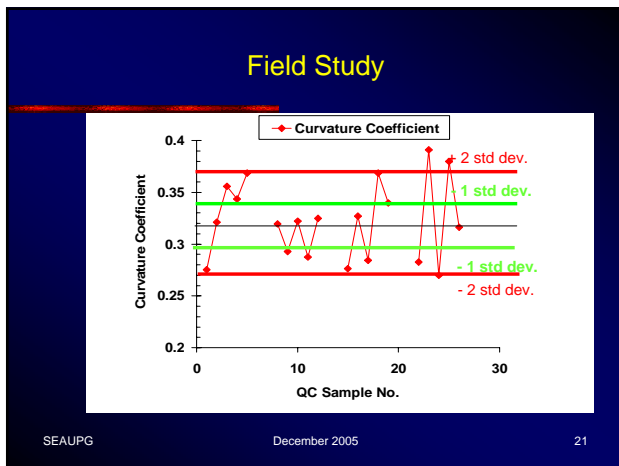
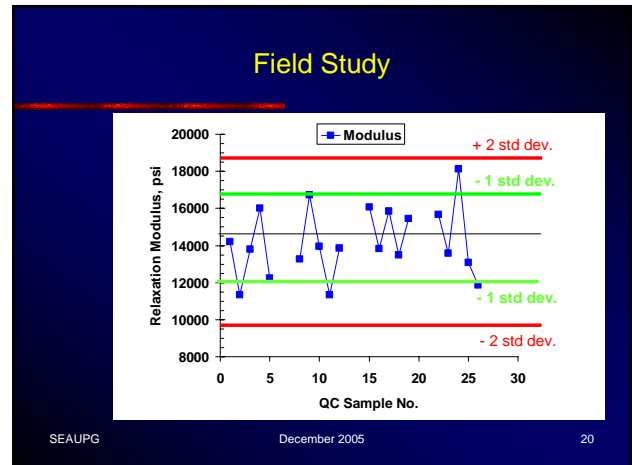
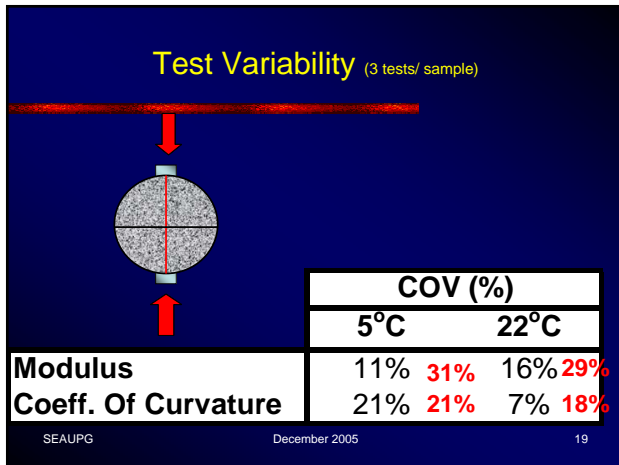
- Binder

Properties	PG 64-22	PG 76-22	Recovered Minnesota RAP Binder	Recovered Alabama RAP Binder	
G* / sin δ, kPa (RTFOT)	64C	4.228	-	-	
	76C	-	3.558	-	
	88C	-	-	4.65	2.613
Bending Beam Stiffness, S, MPa	0C	-	-	101	
	-12C	179	127	-	169
Bending Beam Slope, m	0C	-	-	0.315	
	-6C	-	-	-	0.348
	-12C	0.323	0.363	-	-
PG Grading	PG 64-22	PG 76-22	PG 88-10	PG 88-16	

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- ### Field Study
- 4 days of plant mix
 - 1 mix
 - PG 64-22
 - No RAP
 - 5 samples per bag (1 day)
 - 3 tests per samples
 - Rotation of 30° between each test
 - Avg of 3 = 1 test
 - Total Test time < 5 min.
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Back to the Issues

- How consistent is my RAP Stockpile consistency?
 - Make a set of three 100% RAP samples/day
 - Control charts
 - Relaxation modulus
 - Coefficient of curvature

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Back to the Issues

- How much binder is **REALLY** contributed by the RAP?
 - Make three samples for 0 and at the desired RAP content
 - Keep gradation constant
 - Determine % relaxation modulus and curvature coefficient
 - Use values for historically usable RAP mixes

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% Contribution of RAP

		% Contribution
Relaxation Mod.	0	15,664
	15	27,557
	25	29,718
	50	34,460
	100	37,535
Curvature Coeff.	0	0.318
	15	0.281
	25	0.242
	50	0.148
	100	0.153

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Back to the Issues

- When do I need to change PG grade?
 - Agency decision as to how much increase in modulus and decrease in curvature coefficient will be allowed
 - Test samples with desired RAP content
 - Determine relaxation modulus and curvature coefficient
 - If limits are exceeded, either reduce % of RAP or use lower PG grade and retest

Thank you

